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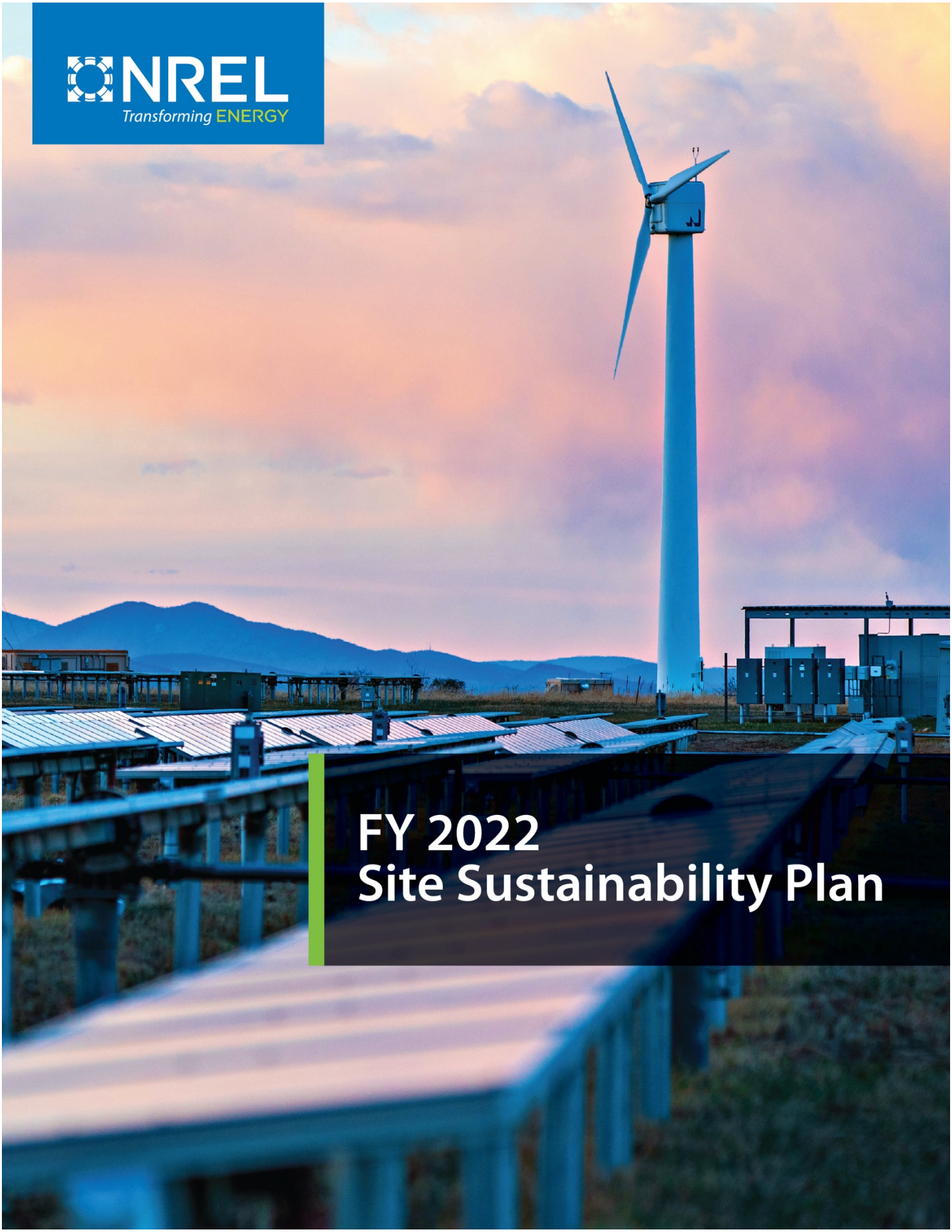

FY 2022 Site Sustainability Plan

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List of Abbreviations and Acronyms

AFV	alternative fuel vehicle
ARIES	Advanced Research for Integrated Energy Systems
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BAS	building automation system
BEV	battery electric vehicle
CAIS	Condition Assessment Information System
CARP	Climate Action and Resilience Plan
CCF	Control Center Facility
C&D	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
EVSE	electric vehicle supply equipment
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
HVAC	heating, ventilation, and air conditioning
HW	hot water
ISO	International Organization for Standardization
ITS	information technology services
kBtu	kilo British thermal units
kGal	kilo gallon
kW	kilowatt
kWh	kilowatt-hour
LEED	Leadership in Energy and Environmental Design
LPG	liquified petroleum gas

Mbtu	million British thermal units
MFD	multifunction device
MS4	municipal separate storm sewer system
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
RO/DI	reverse osmosis and/or deionized
RSF	Research Support Facility
RTD	Regional Transportation District
SERF	Solar Energy Research Facility
SKU	stock-keeping unit
SOV	single-occupancy vehicle
SRM	Supplier Relationship Management
SSEB	South Site Entrance Building
STM	South Table Mountain
S&TF	Science and Technology Facility
TMA	Transportation Management Association
TRN	Technical Resilience Navigator
VARP	Vulnerability Assessment and Resilience Plan
WHF2	Waste Handling Facility II
WUE	water-use effectiveness
WUI	water-use intensity
YOY	year over year

Executive Summary

The U.S. 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 summary table below.

In the last decade, the world has experienced unprecedented climate events, leaving multitudes of communities vulnerable. In compliance with President Biden's Executive Order 14008, NREL is committed to address the pace of climate change and build resilience—not only to reduce its own operational footprint but also to support efforts for replication of technology and processes.

Using the key report findings gained through DOE's Site Sustainability Plan process, NREL developed a net-zero-emissions road map. NREL's decarbonization efforts will support the laboratory's success by applying what is learned through research and development to campus facilities and infrastructure systems.

NREL has continually achieved sustainability targets over the past decade. However, continued improvements require funding and resources not currently identified. Financial tools such as energy service performance contracts (ESPCs), power purchase agreements (PPAs), and savings reinvestment will be crucial to implementing energy and water efficiency and renewable energy improvements across all campuses.

NREL continued to be impacted by COVID-19 during Fiscal Year (FY) 2021. Limited staff were allowed on-site to use laboratory resources, yet energy consumption increased on the campus. COVID-19 related ventilation requirements were the main driver for high energy consumption throughout the fiscal year.

NREL also forecasts immense growth across its research directorates over the next few years. The increases in mission support the construction of several new facilities. New facilities will contribute to the improvement of on-site energy efficiency and energy-use intensity with strategic planning and investment. NREL requires all new facilities to be electrified and positioned for future attainment of net-zero-energy and net-zero-emissions goals.

NREL has several high-energy-mission-specific facilities (HEMSFs), including all laboratories and a high-performance computing data center (HPCDC). NREL is developing a Smart Labs program to improve the energy efficient use of laboratories. The HPCDC is projected to expand to upwards of 9 MW over the next 10 years. NREL will capitalize on this enhancement by capturing additional waste heat from this system to deliver supplemental heating to adjacent facilities.

The Site Sustainability Plan provides foundational insight for 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.

The table below provides a high-level summary of NREL's current and planned efforts in sustainability as they pertain to specific DOE goals. Each goal is assigned a level of risk of non-attainment. Detailed descriptions of high-level risks are included in the narrative sections related to each goal category (i.e. Energy Management). Risk of non-attainment is categorized as the following:

- **High Risk:** Risk in at least one of the risk types is so significant that non-attainment of goal is likely or expected.
- **Medium Risk:** Risk in at least one of the risk types is so significant that it is moderately likely NREL may not attain the goal.
- **Low Risk:** Any risks associated with this goal are being satisfactorily mitigated such that attainment of the goal is likely.

The following defines the types of risk assessed for each goal:

- **Technical:** Technology and/or systems are not available in current facilities.
- **Management:** Management systems, policies, and/or support may require changes to policies or procedures.
- **Mission:** Major initiatives, construction, and/or changes to mission that substantially impact sustainability goals.
- **Financial:** Funds are not identified in current or forecasted years and performance contracts are not viable.
- **Supply Chain:** Interruptions to flow of material, purchased goods, and services.

DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Nonattainment
Energy Management			
Reduce energy use intensity (kBtu/GSF) in goal-subject buildings	17% increase from FY 2020 to 124 kBtu/GSF	Implement low-cost and no-cost energy conservation measures (ECMs) Implement a Smart Labs program Complete and deploy predictive analytics dashboard for facility energy consumption	High Risk
Energy Independence and Security Act (EISA) Section 432 continuous (4-year cycle) energy and water evaluations	Conducted energy and water audits at the Energy Systems Integration Facility (ESIF), Science and Technology Facility (S&TF), Solar Energy Research Facility (SERF), and Field Test Laboratory Building (FTLB)	Continue to meet EISA Section 432 compliance Develop a measurement and verification process using the Intelligent Campus platform Develop a commissioning process for all facilities	Low Risk

DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Nonattainment
Meter 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 meters, all of which are advanced meters 75% of relevant buildings have hot water 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 central plant metering and develop power-usage effectiveness (PUE) measures for heating and cooling Install pulse readers for on-site solar photovoltaic (PV) systems	Medium Risk
Water Management			
Reduce potable water-use intensity (gallons/GSF)	8% increase from FY 2020 to 23.4 gallons/GSF Completed a water balance and updated the Water Management Plan	Investigate water balance findings Install digital water meters in all STM Campus facilities Develop a campus water system for the Flatirons Campus	High Risk
Reduce non-potable freshwater consumption (gallons) for industrial, landscaping, and agricultural	NREL does not use industrial, landscaping, and agricultural water	NA	NA

DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Nonattainment
Waste Management			
Reduce non-hazardous solid waste sent to treatment and disposal facilities	55% diversion rate in FY 2021	Continue to take steps toward achieving a near-zero-waste campus Expand laboratory recycling efforts Continue to explore including cameras or other technology in waste management recycling, and refuse to reduce overall costs	Medium Risk
Reduce construction and demolition (C&D) materials and debris sent to treatment and disposal facilities	59% diversion rate in FY 2021	Add a polystyrene recycling container to the C&D waste program at the Flatirons Campus Continue to collect data on the new C&D centralized waste collection program at the STM and Flatirons campuses to assess outcomes; update and improve as needed	Medium Risk
Fleet Management			
Reduce petroleum consumption	9% decrease from FY 2020 in total petroleum fuel consumption	Electrify 100% of the fleet	High Risk
Increase alternative fuel consumption	17% decrease from FY 2020 in alternative fuel consumption	Install additional electric vehicle supply equipment (EVSE) to support fleet electrification Demo the use of a hydrogen fuel cell vehicle	Medium Risk
Acquire alternative fuel and electric vehicles	Continued to increase AFVs in the fleet	Electrify 100% of the fleet	High Risk

DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Nonattainment
Clean & Renewable Energy			
Increase consumption of clean and renewable electric energy	10% decrease from FY 2020 in consumption of clean and renewable electric energy 14,929 MWh (including wind, solar PV, renewable energy credits [RECs], and bonuses)	Install new on-site solar PV through PPAs or through an energy services agreement Continue to purchase RECs to replace those sold from on-site renewable energy projects	High Risk
Increase consumption of clean and renewable non-electric thermal energy	12% decrease from FY 2020 in consumption of clean and renewable non-electric thermal energy 18,668 Mbtu (the Renewable Fuel Heat Plant [RFHP])	Continue to optimize RFHP operations Explore opportunities for geothermal systems	High Risk
Sustainable Buildings			
Increase the number of owned buildings that are compliant with the Guiding Principles for Sustainable Buildings	57% of GSF of eligible facilities meet the Guiding Principles	Evaluate all covered facilities for their compliance with the 2020 Guiding Principles Use the Argonne Guiding Principles template from the Sustainability and Environmental Subgroup (SESG) Continue to build facilities that meet Guiding Principles	High Risk
Acquisition & Procurement			
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all sustainability clauses are included as appropriate	100% of contracts contain sustainability provisions	Report all biobased purchases for custodial and construction subcontracts Revitalize the NREL stockroom usage and processes Goal to achieve a Gold designation in the GreenBuy Award Program	Low Risk

DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Nonattainment
Efficiency & Conservation Measure Investments			
Implement life cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts	Assisted the DOE Golden Field Office (GFO) in selection of an ESCO and began steps to award energy-savings ESPCs for the STM and Flatirons campuses	Continue to support the award of an ESPC to an energy services company (ESCO) to implement energy efficiency measures Develop processes for the management of measurement and verification through the energy management information system Develop a savings reinvestment program	High Risk
Electronics Stewardship & Data Centers			
Electronics stewardship from acquisition, operations, to end of life	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	Low Risk
Increase energy and water efficiency in high-performance computing and data centers	Research Support Facility (RSF) data center PUE of 1.31 Energy System Integration Facility (ESIF) HPCDC PUE of 1.03 and water-use effectiveness (WUE) of 0.92 L/kWh	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	Medium Risk
Adaptation & Resilience			
Implement climate adaptation and resilience measures	Conducted microgrid feasibility discussions within NREL research community	Complete the Technical Resilience Navigator (TRN) pilot Integrate ongoing resilience assessment in existing planning practices	High Risk

DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Nonattainment
Multiple Categories			
Reduce Scope 1 & 2 greenhouse gas emissions	16% increase from FY 2020	Continue to explore opportunities to increase on-site renewable energy	High Risk
Reduce Scope 3 greenhouse gas emissions	38% reduction from FY 2020	Continue to implement opportunities for flexible work options for staff Continue to promote teleworking and teleconferencing	High Risk

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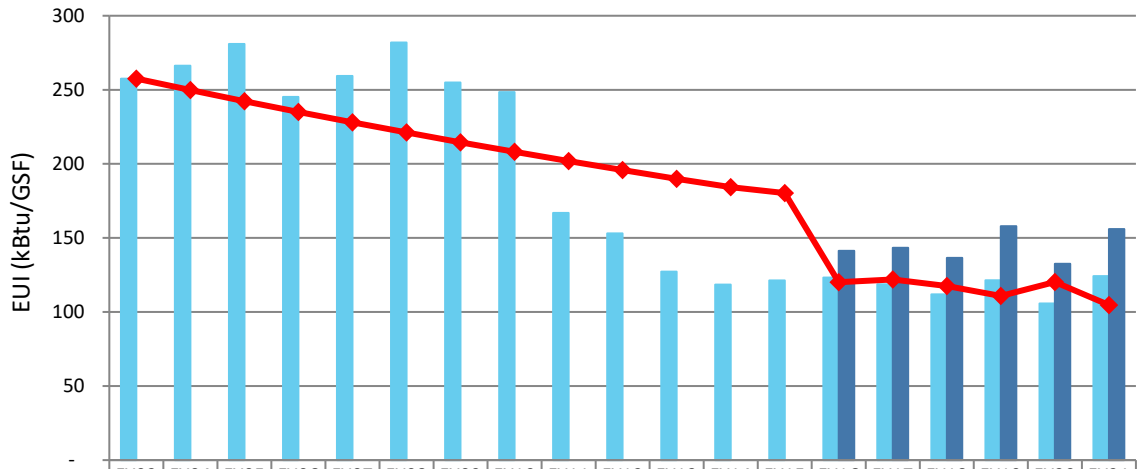
1 Energy Management

Performance Status

Energy Use Intensity

Figure 1 shows the National Renewable Energy Laboratory's (NREL's) annual energy-use intensity (EUI) history beginning in 2003. In Fiscal Year (FY) 2021, NREL continued to operate with most staff working remotely. Calculated EUI for goal-subject buildings increased 17% from FY 2020 to 124 kBtu/gross square foot (GSF). This change in EUI was driven primarily by an increase in electrical consumption and natural gas consumption throughout the fiscal year due to increased airflow requirements for COVID-19 mitigations. Total energy for both goal-subject and excluded facilities increased from 165,594 Mbtu in FY 2020 to 200,419 Mbtu in FY 2021, and corresponding greenhouse gas (GHG) emissions from facility energy (including natural gas and grid electricity) consumption increased by approximately 18%.



	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21
EUI	258	266	281	245	259	282	255	248	167	153	127	118	121	123	119	112	121	106	124
EUI with HPC														141	143	137	158	133	156
EUI Goal	258	250	242	235	228	221	215	208	202	196	190	184	180	120	122	118	111	120	105

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

EUI includes only goal-subject facilities; it excludes the high-performance computing data center (HPCDC), partially and fully leased facilities, and energy used to charge personal electric vehicles. EUI with HPCDC energy is also reported for reference.

The COVID-19 pandemic continued to have several large impacts on EUI. While most staff continued to telework in FY 2021, laboratory work returned to near-normal levels, such that overall energy reductions from plug and process loads were minimal and overall energy use increased the EUI by 2% compared to FY 2019 when the COVID-19 pandemic began.

NREL continued to operate facilities with modified airflow controls in efforts to enhance airflow to promote better air circulation and mitigate potential COVID-19 virus transmission. Per American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) guidance for infectious aerosols, NREL continued to override 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. NREL expects the COVID-19-related operation changes and the associated energy penalty to persist throughout at least the first quarter of FY 2022.

Some facilities continued to see a reduction in required cooling and an increase in required heating due to reduced occupancy in FY 2021; however, these effects were minor relative to those of the ventilation changes.

Natural gas consumption increased due to a combination of changes from COVID-19 related operations, increased heating degree days, and maintenance shutdowns required for the Renewable Fuel Heat Plant (RFHP). For example, the RFHP was shut down for nearly half of March due to an ongoing auger gearbox failure.

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. Planned Future of Work activities anticipate close to 30% of staff will be permanently remote. NREL supported the transition of over 1,000 personnel to more flexible work-from-home accommodations. Hotel space has also been created to support fully remote staff's when required to be on-site for work. New software has also been developed to support the efficient reservation and use of this space.

NREL developed a Smart Labs charter between its operations and safety staff to kick off a process to implement a full Smart Labs program. The focus in FY 2021 was updating and developing concurrence for laboratory design standards (particularly with regard to ventilation), development of a laboratory ventilation risk assessment process, identification of laboratories for a My Green Labs pilot program, and first steps toward the creation of a laboratory ventilation management program.

An update to the Zero Energy Dashboard for the Research Support Facility (RSF) was completed in FY 2021 (see Figure 2). The new dashboard connects directly to NREL's energy management information system (EMIS) to provide detailed information on building performance as related to net-zero energy goals. The dashboard is configured to easily be replicated for any new buildings with net-zero energy goals.

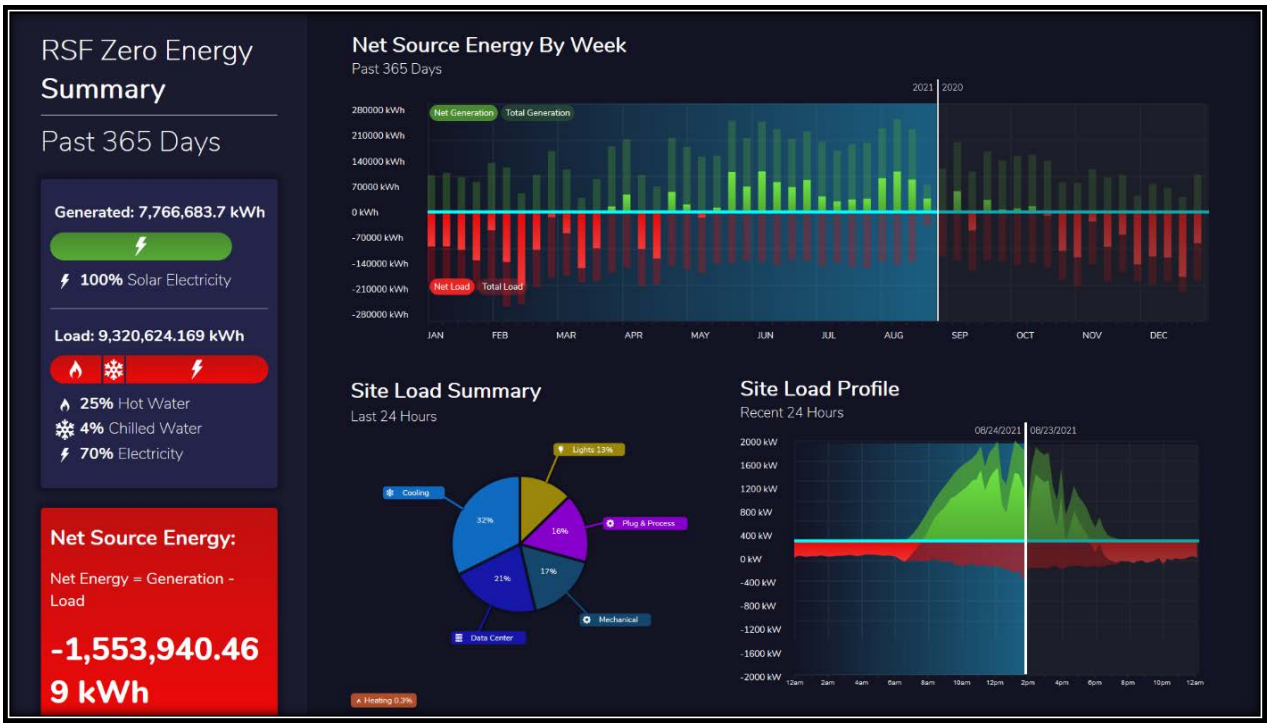


Figure 2. Snapshot of the RSF Zero Energy Dashboard.

The dashboard shows a summary of information pulled from NREL's EMIS to demonstrate the building's operational zero-energy state. Net Source Energy in the bottom left corner indicates whether the building is currently achieving zero energy per the U.S. Department of Energy (DOE) definition based on a 365-day rolling total.

Aligning with Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, in FY 2021 NREL developed a preliminary strategic approach based on an assessment of NREL current and projected performance to reach net-zero emissions[1] for its campuses and operations pursuing scalable and replicable technologies and approaches in the next 3–5 years. This effort was made possible by more than a decade of data collected for the Site Sustainability Plan.

The decarbonization plan will be used to inform future investment decision-making. Decarbonizing NREL's footprint will require the elimination of GHG emissions and will be achieved through energy efficiency enhancements, electrification of building energy consumption, and the increased integration of clean energy sources. Engaging the private sector through an energy savings performance contract (ESPC) and relationship with NREL's utility providers will be crucial to NREL's implementation strategy.

EISA Section 432 Benchmarking and Evaluations

In FY 2021, 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 2021, all

[1] Net-zero emissions (Scope 1, 2, and 3)—on an annual basis eliminate or offset all anthropogenic GHG emissions (measured in metric tons of carbon dioxide equivalent ($MTCO_2e$), including both direct Scope 1 emissions and indirect Scope 2 and 3 emissions to achieve carbon neutrality.

on the South Table Mountain (STM) Campus: the Field Test Laboratory Building (FTLB), Science and Technology Facility (S&TF), Solar Energy Research Facility (SERF), and Energy Systems Integration Facility (ESIF). Walk-throughs were completed in the spring and audit reports finalized in the early fall.

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

NREL has one ESPC with the RFHP project. The RFHP is a biomass facility used to produce hot water for the central heating system on the STM Campus. 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 2020–2021 heating season of Year 13 per the ESCO performance contract, the RFHP performance dipped somewhat due to weather-related issues and facility required shutdowns. For Year 12, the warm weather shutdown days were 70, and facility required shutdown days were 16. For Year 13, warm weather shutdown days were 76, and facility required shutdown days were 20. As a result, the RFHP delivered 18,668 Mbtu of heating energy in the FY 2021 heating season, a 12% reduction from the previous fiscal year.

In FY 2021, NREL in collaboration with the DOE Golden Field Office (GFO) crafted a notice of opportunity (NOO) to enable a second ESPC to address the energy conservation measures (ECMs) at the STM and Flatirons campuses. Through a request for proposal process an ESCO consultant was selected to develop a preliminary assessment. The ECMs identified through EISA audits beginning in FY 2012, which have not been implemented, yet still provide an attractive payback period, were shared with the ESCO as a starting point for their preliminary assessment. The ESCO team conducted 2-day site visits to both campuses to gather further supporting information for their assessment. NREL anticipates the preliminary assessment to be completed in early 2022.

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 EMIS.

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. The pulse meter installation began in FY 2021, however, the installation for the central plant continued to be delayed into FY 2022 due to a funding shortage and a nonresponsive vendor. NREL is also investigating options to expand chilled water (CHW) and hot water (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. Finally, NREL is pursuing integration of its EMIS with ENERGY STAR Portfolio Manager to incorporate utility billing data for natural gas and potable water consumption.

In FY 2021, NREL performed a quality assessment of its CHW and HW meters. Several inconsistencies were identified, and while some issues were addressed, NREL will continue to audit the performance of these meters in coming fiscal years.

NREL does not have a maintenance or scheduled replacement plan in place for existing meters. In the past year, NREL's energy management team has discovered that evolving cybersecurity requirements threaten to make otherwise operational meters functionally obsolete. In FY 2022, NREL will investigate strategies for regular meter maintenance, updates, and replacement.

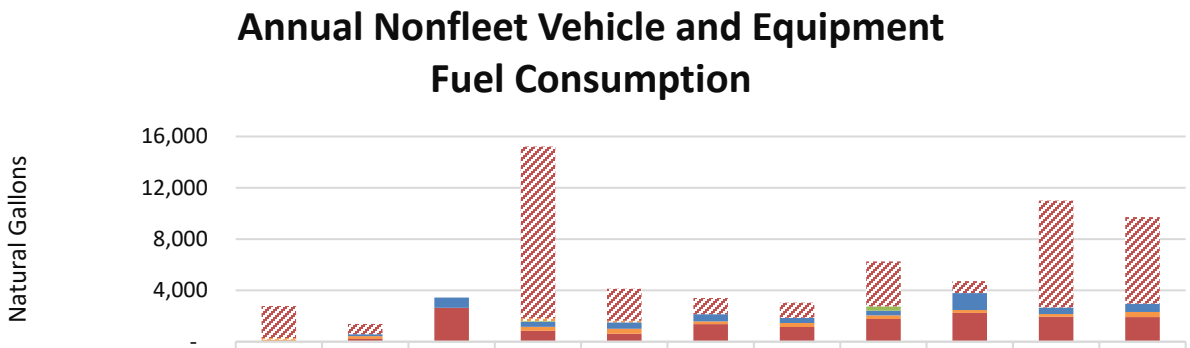
NREL continues to develop new visualization, benchmarking, and fault-detection capabilities within its EMIS software, SkySpark. In FY 2021, NREL's Intelligent Campus program continued developing predictive machine-learning algorithms that analyze building energy consumption and flag deviations from expected energy consumption. Once deployed, 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 2021, NREL used nonfleet vehicles and equipment that use gasoline, diesel, liquified petroleum gas, and electricity as fuel sources.

In FY 2021, unleaded gasoline and liquified petroleum gas (LPG) use increased on the STM Campus. Fuel consumption at the Flatirons Campus for motor equipment remained relatively consistent in FY 2021 compared to FY 2020.

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.



	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Diesel (Generators)	2,503	804	-	13,399	2,497	1,250	1,172	3,505	932	8,328	6,751
LPG (Generators)	120	-		207	125	-	12	-	-	-	-
E85	-	-		46	-	-	-	335	-	-	
Gasoline	-	153	801	402	494	566	391	360	1,317	521	640
LPG	163	217	-	320	384	216	312	280	226	207	398
Diesel	-	213	2,644	842	626	1,366	1,152	1,775	2,246	1,944	1,925

Figure 3. 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 sitewide total electrical power outage. For nearly three weeks, emergency backup generators at the Flatirons Campus supplied electrical power to the site, resulting in a total of approximately 6,680 gallons in diesel fuel consumed on-site in FY 2021. The outage spanned two fiscal years, 7,500 gallons of diesel fuel consumption on the Flatirons Campus was accounted for in FY 2020.

In FY 2021, NREL acquired a new fleet management software, Fleetio. All of NREL's drivable nonfleet and fleet assets are included in the software. The software is used to track cost information, inspections, issue tracking, maintenance/repairs, and more for each vehicle. This information will be used to develop baseline annual cost estimates to maintain and repair equipment. The cost data will help to inform NREL Fleet Management how best to manage owned equipment. Cost information will become more accurate in upcoming years as processes improve.

Overall, NREL decreased nonfleet vehicle and equipment diesel fuel consumption in FY 2021 relative to FY 2020 (see Figure 3). Associated GHG emissions decreased by approximately 13%. However, this is still more than double the emissions from FY 2019 due to the diesel fuel consumed at the Flatirons Campus during the power outage in September and October of 2020 and inclusion of the research fuel in the annual total.

Plans and Projected Performance

Energy-Use Intensity

NREL anticipates continued staff and mission growth in FY 2022 and into the future. Growth in campus energy consumption may be partially mitigated by a long-term shift to remote work,

which is an 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 4 displays historical and projected energy use on NREL's STM and Flatirons campuses categorized by facility (high-energy mission-specific facility [HEMSF], HPCDC, or other facilities). The projections, as well as those in Figure 5, and Figure 6 assume the following:

- Energy use in existing facilities increases modestly (approximately 2% per year) due to population and mission growth
- At the STM Campus, three new facilities are added:
    - In FY 2023, one new laboratory facility totaling 15,700 GSF (the Research and Innovation Laboratory [RAIL], currently under construction)
    - In FY 2024, one new support facility totaling approximately 8,000 GSF (the Waste Handling Facility II (WHF2))
    - In FY 2025, one new laboratory facility totaling approximately 100,000 GSF (the Energy Materials and Processing at Scale (EMAPS) facility)
- At the Flatirons Campus, one new facility is added in FY 2023: the Control Center Facility (CCF), totaling 8,194 GSF and currently in the design phase.
- EUI for the new facilities is based on the recently completed RAIL and CCF energy models and ranges from 36 kBtu/GSF to 101 kBtu/GSF depending on the facility. These EUI values reflect better estimates of the current state of the art for new laboratory facility performance and are significantly lower than the values assumed in prior fiscal years.
- HPCDC computing capacity increases in future years according to anticipated upgrades, ultimately to a maximum of 9 megawatts (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.
- The new ESPC under development will realize 75% of the potential energy savings identified in NREL's backlog of capital-intensive ECMs for HEMSF buildings. These savings phase in over Fiscal Years 2023, 2024, and 2025.

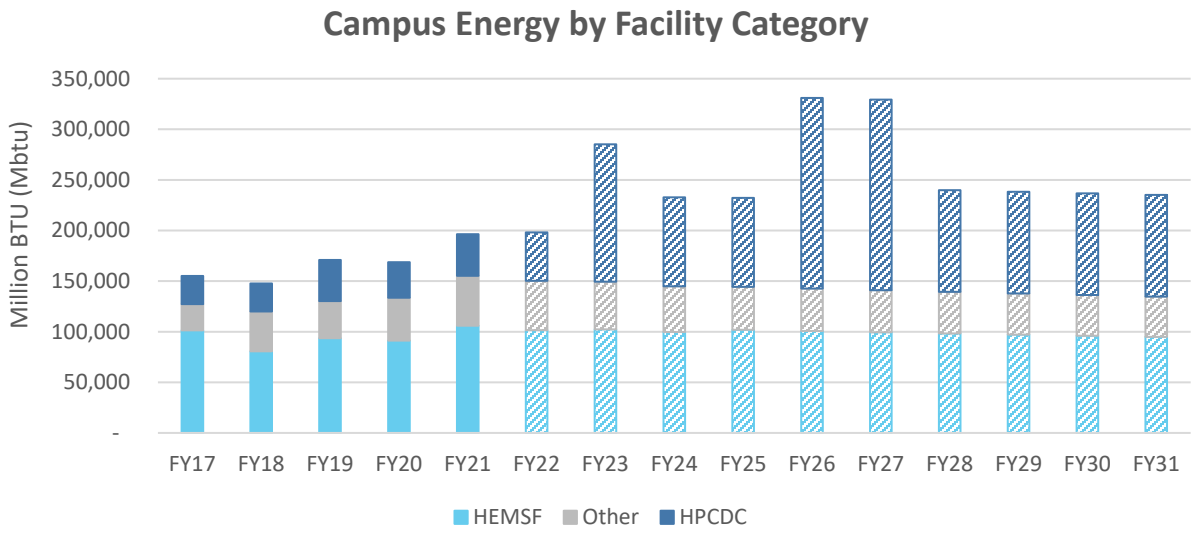


Figure 4. Annual energy use by facility category with projections to FY 2031

Includes only grid electricity and natural gas; self-consumed on-site clean energy is excluded as well as partially and fully serviced leases

NREL's HEMSFs (including the HPCDC) continue to drive overall energy consumption (Figure 5). The HPCDC alone consumes nearly 50% of the campus electricity and will increase into the future.

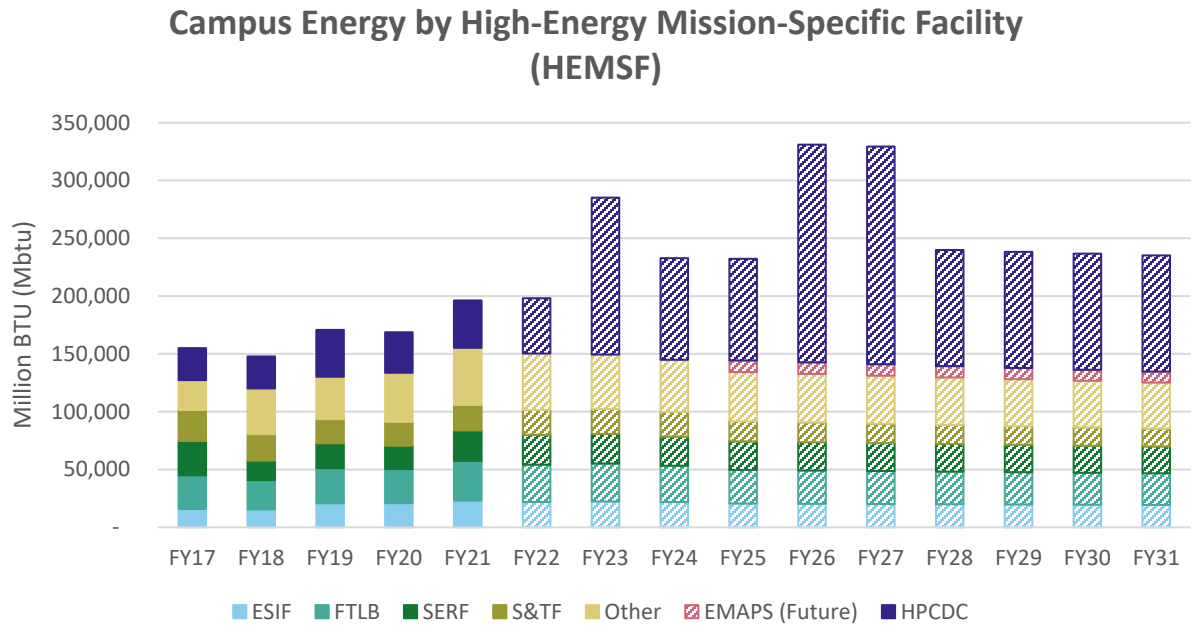
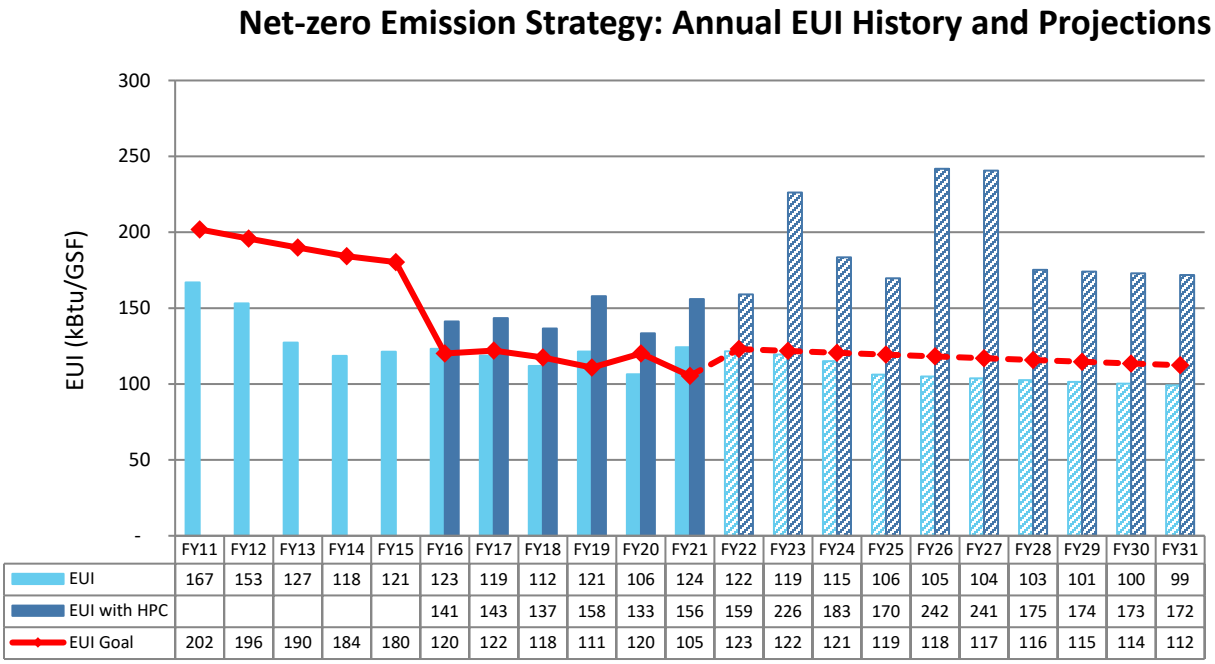


Figure 5. Annual energy use by HEMSF with projections to FY 2031

Includes only grid electricity and natural gas; self-consumed on-site clean energy is excluded as well as partially and fully serviced leases

NREL is at a high risk of not attaining future EUI goals due to current policies and procedures, mission needs, and limited funding. Current policies and practices do not exist for retrofit of existing buildings, and a lack of dedicated staff can make pursuing energy efficiency opportunities difficult. As NREL continues to grow, the incorporation of energy efficiency into new construction projects will be necessary to meet reduction targets. Additional funding for further energy efficiency and projects and support personnel have not yet been identified, which also places the laboratory's attainment of reduction targets at risk.



	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31
EUI	167	153	127	118	121	123	119	112	121	106	124	122	119	115	106	105	104	103	101	100	99
EUI with HPC						141	143	137	158	133	156	159	226	183	170	242	241	175	174	173	172
EUI Goal	202	196	190	184	180	120	122	118	111	120	105	123	122	121	119	118	117	116	115	114	112

Figure 6. Historical annual EUI from FY 2011 through FY 21, with projections to FY 2031 assuming net-zero emission strategy

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 the addition of the HPCDC energy is projected separately to demonstrate the large, expected increase in computing energy consumption over time. Strategy assumes decarbonization activities on both campuses, as well as the implementation of an ESPC and an ongoing commissioning (OCx) program are funded and staffed.

However, with significant investment in energy efficiency and decarbonization efforts, NREL could potentially meet a future compounding 1% YOY reduction target. Figure 6 displays historical and projected EUI for goal-subject buildings at NREL's STM and Flatirons campuses. Projections include assumptions of population and mission growth as well as completed decarbonization projects to convert natural gas-burning equipment to higher-efficiency electric equivalents. The addition of an ongoing commissioning (OCx) program beginning in FY 2023 assumes a conservative savings of an additional 3% of energy annually.

Decarbonization efforts are aligned with current FY 2022, FY 2024, and FY 2030 goals. NREL has plans for large-scale renovations, installation of new renewable energy systems, electrification of buildings, and efficiency upgrades that will significantly impact the EUI trajectory; however, these activities still require funding to become feasible. NREL will continue

the process of developing an ESPCs to address outstanding ECMs and future facility energy needs, with an investment-grade audit planned for FY 2022. NREL will investigate on-site renewable energy generation for all new facilities when financially feasible.

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 2022 and FY 2023:

- Implement low-cost and no-cost ECMs identified in the FY 2021 EISA audit cycle
- 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 through the laboratory ventilation risk assessments process and complete planning for a Smart Labs program
- Launch a My Green Labs pilot program in FY 2022
- 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 will implement the Smart Labs recommendations in the design and construction of future laboratory facilities. NREL will continue to develop solutions to address technical and process barriers that inhibit adoption of recommended Smart Labs practices. NREL continues to pursue process and laboratory equipment improvements that will enable adoption of the Smart Labs recommendations in the future.

In FY 2022, if funding is approved, NREL will complete projects to replace all natural gas used for heating in buildings with electric options at the Flatirons Campus. The laboratory will proceed with reaching the net-zero emissions goal of the Executive Order 14008 through the phased schedule below:

- End of FY 2022: Flatirons Campus to operate at net-zero emissions
- End of FY 2024: STM Campus to operate at net-zero emissions
- End of FY 2030: Demonstrate NREL campuses to operate with 24/7 carbon-free energy (Scope 1 and 2 only)

Meeting this aggressive decarbonization schedule will require significant funding and dramatically accelerate timelines to complete these projects. Delays in the supply chain for resources, and available staff time, could also impact the ability to meet this timeline. NREL plans to explore opportunities for off-site power purchase agreements (PPAs) as well as energy storage options to demonstrate the possibility of 24/7 carbon-free energy operations. These demonstrations are dependent on access to on-site and off-site renewable energy resources.

NREL is investigating new options for high-efficiency district energy systems to support future facilities as part of the STM Campus east campus expansion as well as noncarbon options for

central plant heating on the STM Campus. Exploration of noncarbon backup power solutions, including hydrogen fuel cells and batteries, will continue to identify the most cost-effective options and technologies. One risk is the immaturity of commercially available options for technology to replace natural gas equipment across the two campuses. NREL is also working closely with its utility provider to explore opportunities for on-site and off-site renewable electricity options.

Net-zero emissions implementation will emphasize synergistic relationships of technology solutions and interoperability within the energy ecosystem with an ultimate goal of a replicable process. A critical path to attain this knowledge occurs in the fusion of using the campus as a research instrument. In particular, leveraging the research conducted through the Advanced Research on Integrated Energy Systems (ARIES) platform provides the ability to consider opportunities and risks with the growing interdependencies and different scales of use among the power system, vehicles, buildings, and other supporting infrastructure.

EISA Section 432 Benchmarking and Evaluations

In FY 2022, NREL will continue its fourth cycle of EISA audits. NREL also plans to begin the integration of the Condition Assessment Information System (CAIS) audits with the EISA audits. The goals are to better support the effectiveness of these two programs and identify funds for energy efficiency projects. Audits are planned for the following facilities:

- Café
- Education Center
- RSF
- South Site Entrance Building (SSEB)
- Shipping and Receiving.

NREL will continue benchmarking all facilities in Portfolio Manager and will additionally submit laboratory facility information 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 OCx in feasible facilities, improving tracking of ECMs, as well as M&V using the EMIS. Limitations in the existing control system preclude effective RCx and OCx for some existing facilities.

Facility Metering

In FY 2022, NREL will complete the meter inventory and continue to 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. This maintenance includes calibration, firmware updates for cyber security, as well as functionality of the meters themselves. NREL currently lacks the expertise to adequately support the maintenance of metering systems, and stronger cybersecurity requirements will impact the use of older meters, which may not be compatible or upgradable. Future funds need to be identified to address these metering concerns to meet DOE metering goals.

In FY 2022, 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 2022 include central plant electrical metering for calculating accurate plant efficiency and the remainder of new pulse readers for utility-owned on-site solar PV generation meters at NREL's STM and Flatirons campuses. Design for these systems was completed in FY 2020, but funding and installation were not started until late FY 2021 and delayed to FY 2022 for completion.

Nonfleet Vehicles and Equipment

In FY 2022, NREL will install telematic devices on an additional 40 units (approximately), including forklifts and lifts. Currently, 34 units (utility vehicles, low-speed electric vehicles, electric cars) on the NREL campus have telematic devices installed. These devices are primarily used to track vehicle usage and location. Tracking this data will provide real-time usage data on the equipment and help reduce the reporting burden on equipment custodians. The telematic devices will also be used to improve the motor equipment maintenance program by developing service plans based on usage (e.g., engine hours).

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

2 Water Management

Performance Status

Water Usage and Management

NREL purchases potable water from Consolidated Mutual Water Company for the STM Campus. A-1 Discount Water Services provides delivery of potable water by truck to the Flatirons Campus. Cost for the STM Campus varies by building and throughout the year; in FY 2021 it averaged $6.28/kGal. At the Flatirons Campus, water averaged $61.56/kGal. The major water end uses are cooling towers, evaporative cooling equipment, laboratory equipment, irrigation, and the HPCDC.

NREL completed a water balance assessment for the STM and Flatirons campuses in FY 2021 and updated its Water Management Plan. The water balance confirmed the main water end uses on the campuses. The water balance at the STM Campus indicated at least 6%–19% of water was unaccounted for in the metering and estimation calculations. Due to the impacts of COVID-19, the water balance assessment included both FY 2019 and FY 2020 water data.

Additionally, the water balance assessment process uncovered a discrepancy in estimated water consumption for the Flatirons Campus as well as a potentially significant water leak. Previously, an estimated truck delivery value was used because the vendor does not provide a gallons-delivered value, only a cost per delivery. A combination of a manual meter read and estimated delivery (where meters were unavailable) highlighted the magnitude of the known leak and improved the accuracy of water reporting

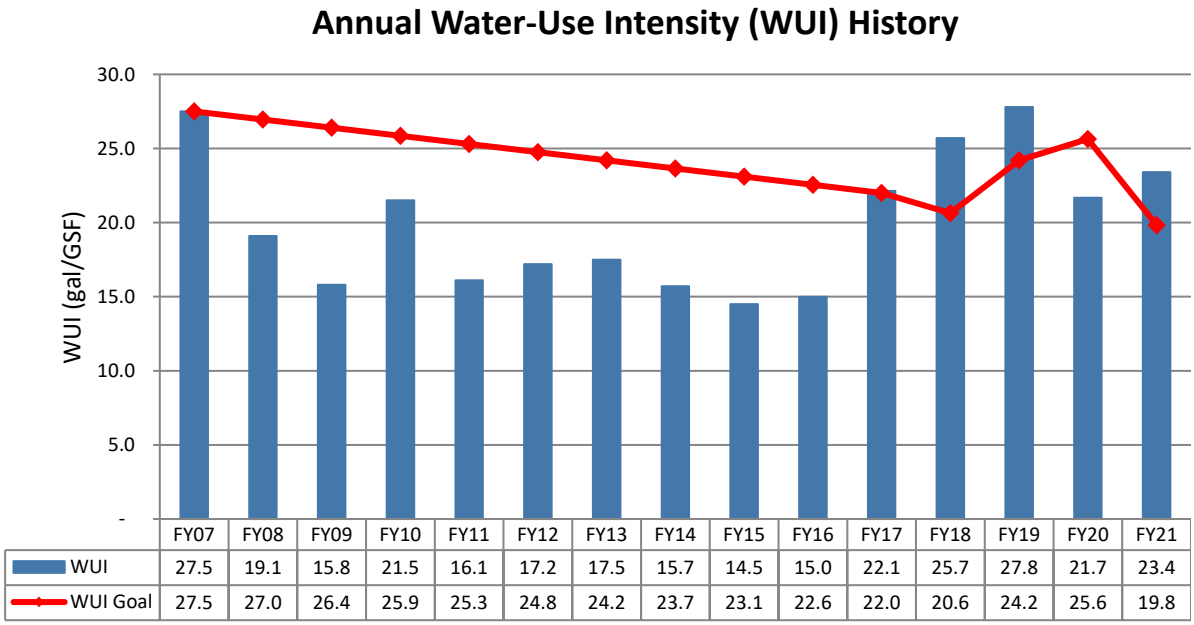


Figure 7. Total NREL WUI for the STM and Flatirons campuses

Figure 7 shows NREL's water-use intensity (WUI) and water consumption history. Total water consumption increased from FY 2020 to FY 2021. In FY 2021, NREL calculated WUI increased to 23.4 gal/GSF. This increase in WUI was primarily driven by an increase in laboratory equipment and reverse osmosis and/or deionized (RO/DI) water as well as evaporative cooling.

Limited by Colorado water law, NREL has been able to identify ways to reduce water consumption. RO reject water used in creating DI water is reused, where possible, 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 approximately double.

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.

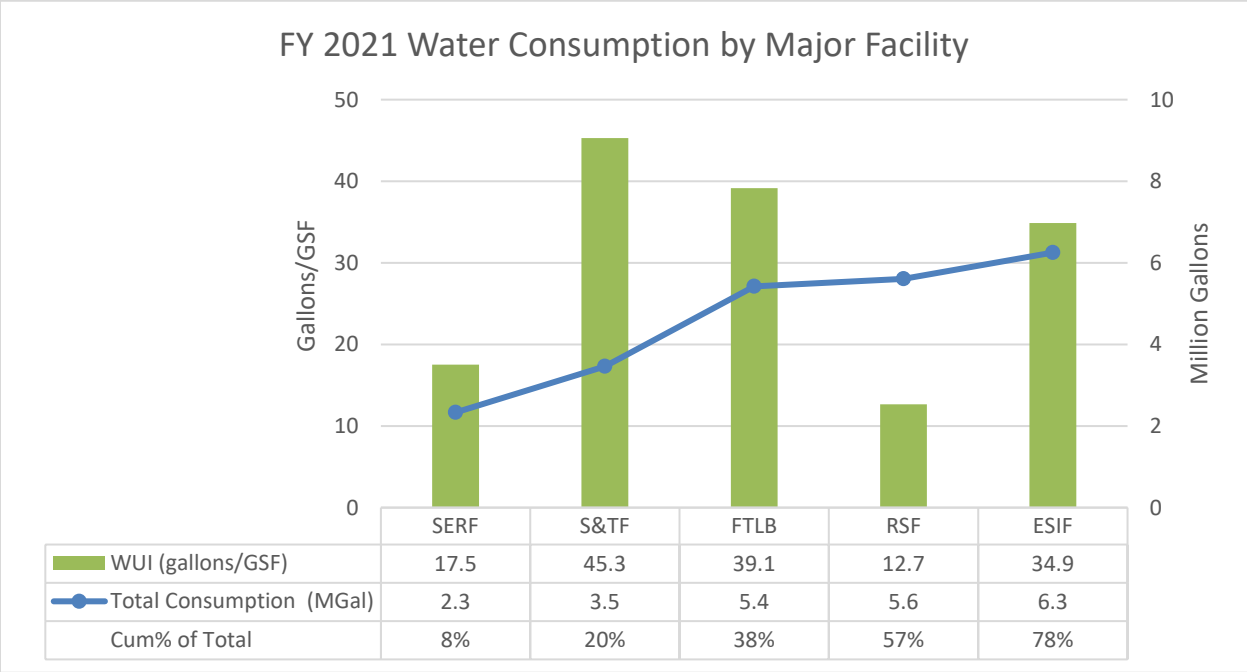


Figure 8. WUI and total water consumption for the facilities that account for 78% of NREL's total water consumption

As shown in Figure 8, NREL's facilities that accounted for 78% of total potable water consumption in FY 2021 are (in ascending order of consumption):

1. **SERF**, which is a wet laboratory facility, includes clean rooms, and houses one-half of the STM Campus' central plant
2. **S&TF**, which is a wet laboratory facility and uses a significant amount of water in its clean-room operations

3. **FTLB**, which is a wet laboratory facility and houses one-half of the STM Campus' central plant
4. **RSF**, which uses water for irrigation (including irrigation for the S&TF and SERF facilities that are currently being established), domestic uses (such as showers and toilets), and evaporative cooling (the use of which increased significantly due to COVID-19 related ventilation changes)
5. **ESIF**, which houses the water-cooled HPCDC and a number of laboratories including laboratories focused on hydrogen research.

NREL continued to irrigate the landscape improvements adjacent to the SERF and S&TF, which will need potable water for the next two growing seasons to establish the vegetation community.

NREL continues to prioritize the management of stormwater on its campuses. Text pertaining to Municipal separate storm sewer system (MS4) permit requirements was developed for seven existing NREL training programs and was formally incorporated into three programs in FY 2021. Also developed in FY 2021 was a clause, which now appears in NREL subcontract agreements that identifies contractor liability for noncompliance with the MS4 permit and Clean Water Act-related requirements. NREL also began developing an operations and maintenance manual, the purpose of which is to ensure stormwater management infrastructure is properly maintained, thus ensuring protection of downstream water quality.

Water Metering

All NREL buildings on the STM and Flatirons campuses that consume water have either an NREL or a Consolidated Mutual Water meter installed to monitor the whole building water consumption. NREL also has about 50 water meters that monitor specific loads on the campuses, such as cooling tower water consumption, RO/DI water consumption, and irrigation. Most of these meters are pneumatic and are physically read and recorded monthly by staff. The remaining water meters are connected in the BAS. There is an ongoing project to replace the pneumatic water meters with digital water meters. Funding and technical issues with meter placement have stalled the project throughout FY 2021.

Plans and Projected Performance

Water Usage and Management

The water balance assessment for the STM Campus had a concerning amount of water that could not be identified through current metering or estimation. In FY 2022, NREL will reassess water consumption and balance at the building level, where possible, to identify possible leaks, and review possibilities for future water savings measures. Facilities where additional information is needed will also be identified. The deep dive into the water balance assessment will also help NREL better understand the impact of the growing population and the 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 2% per year due to population and mission growth
- At the STM Campus, three new facilities are added:
    - In FY 2023, one new laboratory facility totaling 15,700 GSF RAIL (currently under construction)
    - In FY 2024, one new support facility totaling approximately 8,000 GSF (WHF2)
    - In FY 2025, one new laboratory facility totaling approximately 100,000 GSF (EMAPS)
- At the Flatirons Campus, one new facility is added in FY 2023: the CCF, totaling 8,194 GSF and currently in the design phase.
- Baseline WUI for all new laboratory facilities ranges from 5.4 to 25 gal/GSF; this usage is consistent with NREL's expectation of water consumption at the facility level
- HPCDC computing capacity increases in future years according to anticipated upgrades, ultimately to a maximum of 9 MW peak usable capacity; HPCDC water use varies proportional to its energy consumption
    - Beginning in FY 2022, HPC water use doubles due to anticipated replacement of the thermosyphon system with conventional cooling towers (a necessary modification to achieve adequate cooling within the available roof area, as described below).

Out-year WUI goals follow a 1% YOY reduction progression starting from FY 2021.

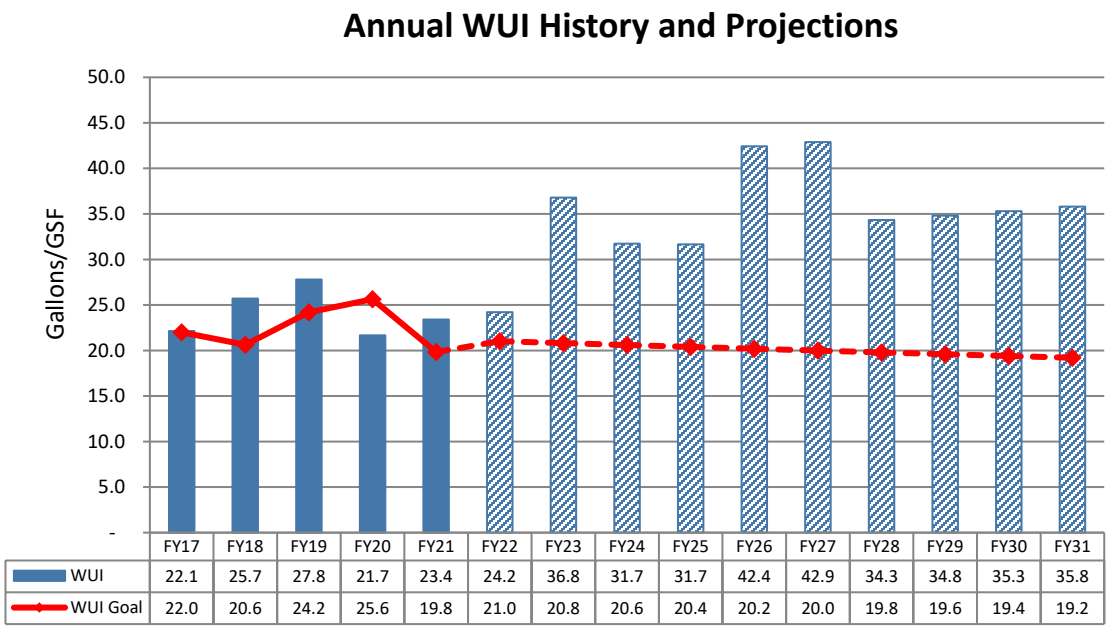


Figure 9. Total WUI for the STM and Flatirons campuses, including projections through FY 2031

Text pertaining to MS4 permit requirements will be developed for the four remaining training programs and is expected to be updated and rolled out in FY 2022. Development will continue on the operations and maintenance manual to improve the management of stormwater infrastructure and protection of downstream water quality.

Due to current policies and procedures, mission needs, and limited funding, NREL does not anticipate being able to meet current water savings goals in future fiscal years. Mission growth as the HPCDC expands and new facilities come online will continued to increase water consumption. In the next expansion of the HPCDC, due to increased needs for cooling tower space, the thermosyphon will need to be removed from the ESIF. This will significantly increase water consumption and is estimated in NREL's projected water consumption totals. There is also currently, no dedicated expertise or staff to manage water efficiency across the site. Water costs also remain extremely low on the STM Campus, which can make it difficult to find cost-effective water efficiency projects.

Since its opening in the late 1970s, 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 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 working 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 NREL staff at the Flatirons Campus. The scope of the project will be to design and construct a raw water line between the Flatirons Campus and the Francis 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.

Water Metering

The installation of real-time water meters at the STM Campus, continuing into FY 2022, 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.

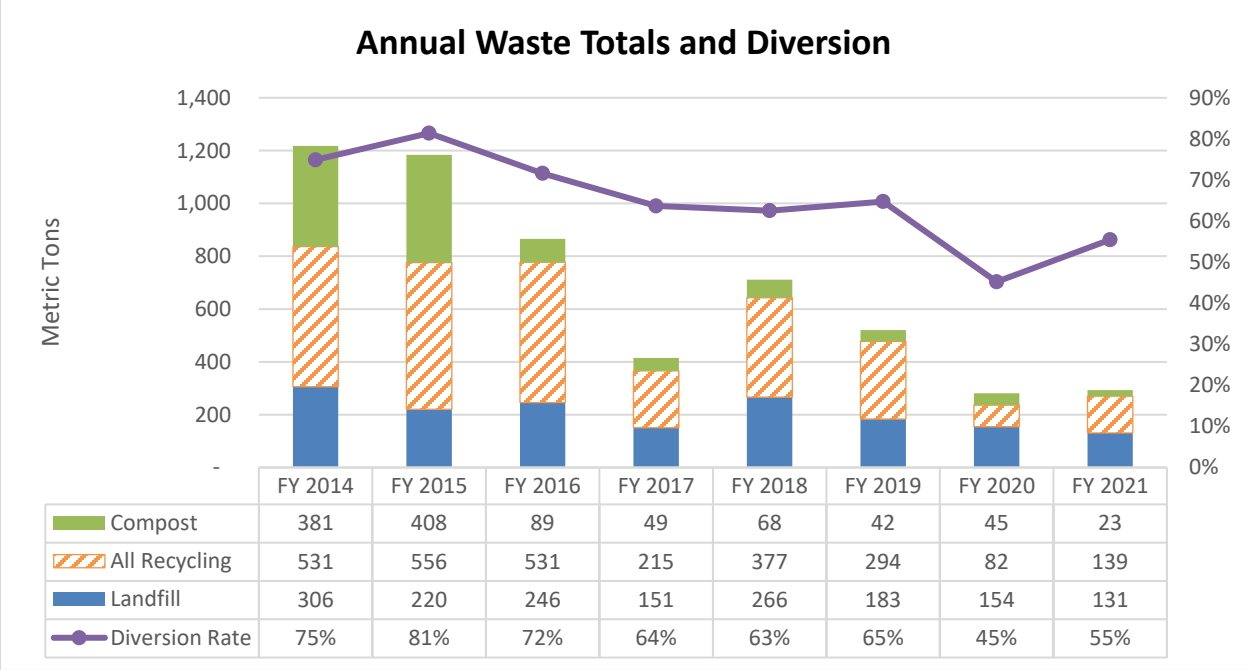
In FY 2022, NREL intends to implement a large metering project for water management. This project will include the purchase and installation of digital water submeters to monitor large water consumers, including cooling systems, reverse osmosis, the HPCDC, and other water-intensive operations across the STM Campus. The project continues to be limited by the availability of staff to oversee the metering decisions as well as a lack of funding to make the meter installations as higher than expected costs were identified during the request for proposal process.

3 Waste Management

Performance Status

Waste Management Strategies

In FY 2021, NREL continued its construction and demolition (C&D) waste program. All the construction subcontractors dispose of their waste by using the centralized containers provided at the STM and Flatirons campuses. Most of the construction-generated waste was captured at the centralized areas. The NREL-provided waste containers located in centralized areas were monitored and measured by Site Operations at the campus level. This effort appears likely to nearly eliminate the need for project-based waste reporting and will greatly improve the accuracy of C&D waste diversion. For projects with waste streams too large to be handled centrally, C&D 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.



	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Compost	381	408	89	49	68	42	45	23
All Recycling	531	556	531	215	377	294	82	139
Landfill	306	220	246	151	266	183	154	131
Diversion Rate	75%	81%	72%	64%	63%	65%	45%	55%

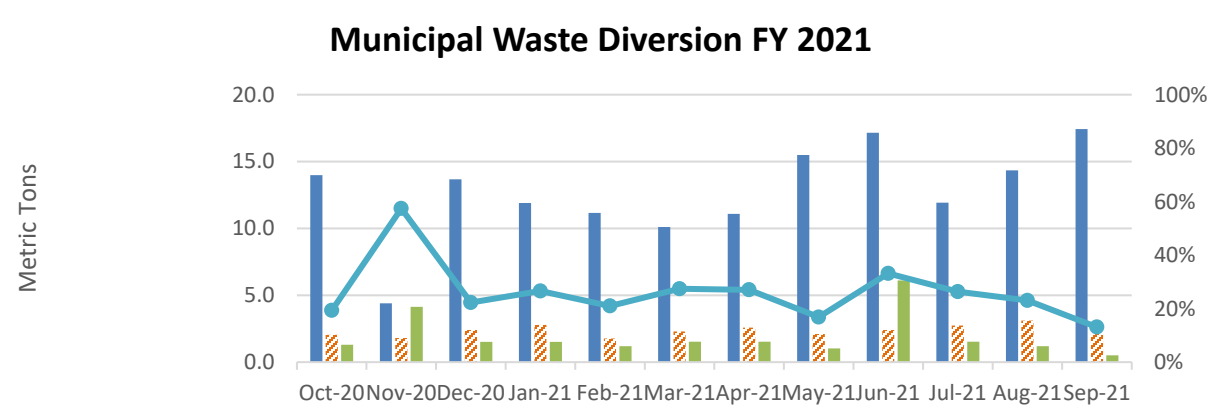
Figure 10. Annual waste totals broken out by disposition type

NREL continued its program of monitoring the wood recycling bin at the STM and Flatirons campuses in FY 2021. 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 landfills. The wood recycling bin was contaminated seven times in FY 2021, and the contaminated contents comprised 51,000 pounds of waste, leading to landfill disposal instead of properly recycling the container contents.

In FY 2021, NREL continued to use Waste Management for its recycling and refuse. Waste Management uses its Smart Truck Technology, which has drastically improved its customer service. The vendor provides GPS mapping and dedicated cameras to show every bin that is

serviced at NREL. Using this technology, Waste Management analyzes the container dumps and weights to right-size campus service and frequency. The vendor also supplies monthly haul reports that show the diversion rate, total weights, and number of pickups.

NREL's waste management program was affected by COVID-19 in FY 2021. The laboratory had less recycling and refuse than anticipated due to the reduction in staff working on campus (see Figure 11). NREL did see increase in recycling and refuse between May and August as part of NREL's Future of Work initiative, as some staff were allowed to briefly return to campus to clean out their desks and transition to a more flexible remote work status. NREL was not able to meet many performance goals due to the impact of COVID-19. Goals not met in FY 2021 will be assigned to FY 2022 with hopes for a speedy resolution to the pandemic and the return of some staff to campuses.



	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21
Landfill (metric tons)	14.0	4.4	13.7	11.9	11.2	10.1	11.1	15.5	17.2	11.9	14.3	17.4
Recycle (metric tons)	2.0	1.8	2.4	2.8	1.8	2.3	2.6	2.1	2.4	2.7	3.1	2.1
Compost (metric tons)	1.3	4.1	1.5	1.5	1.2	1.5	1.5	1.0	6.1	1.5	1.2	0.5
Diversion %	19%	57%	22%	27%	21%	27%	27%	17%	33%	26%	23%	13%

Figure 11. Municipal waste diversion for the STM and Flatirons campuses

Includes only the main STM and Flatirons campus recycling, compost, and landfill program; does not include specific recycling streams (e.g., aerosol cans, batteries, electronic waste)

Landscape and Pest Management

In FY 2021, NREL continued its comprehensive landscape management program. To promote biodiversity and integrated pest-management efforts, NREL obtained knapweed weevils from the Colorado Department of Agriculture and released them on one acre at the Flatirons Campus to control diffuse knapweed, a state-listed noxious weed. This continuation of previous biocontrol efforts appears to be reducing not only the quantity and spread of diffuse knapweed but also the need for chemical control. Due to the success of past weed control 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.

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.

Due to the decrease in staff on-site throughout FY 2021, NREL experienced an increase in animal activity across the campus. Rodent infestation increased in NREL's RSF facility since staff left the campus without an understanding of the length of time they would be gone, and many offices were left with food or in an untidy state. NREL operations staff cleaned, removed food stores, and used bait stations to control the rodent activity. NREL also had a den of young coyotes and several bobcats that were making homes on the STM Campus. NREL Environment, Safety, Health, & Quality (ESH&Q) staff applied mountain lion urine around the FTLB and middle drainage area, as well as the RSF front entrance, which discouraged the animals from continuing to use the campus as their den and home.

Green Chemicals

NREL continues to use green chemicals for research and operational activities where possible. Chemical waste minimization is one of the tenets of NREL's approach to work. Most bench-scale research generally requires the use of hazardous chemicals to understand physical and chemical properties, with any eye toward developing processes for scale-up or commercialization that rely on less hazardous materials or are less energy- and resource-intensive.

To better understand chemical types and usage, enhancements to the chemical management and inventory processes were initiated that will facilitate workers' ability to identify green chemical availability and reduce the acquisition of hazardous chemicals.

Plans and Projected Performance

Waste Management Strategies

In FY 2022, NREL will add a polystyrene recycling container to the C&D 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. The polystyrene recycling container at the Flatirons

Campus initially planned to be added in FY 2021, but due to a contract recompete was delayed to FY 2022. In subsequent fiscal years, any updates to the program to improve diversion rate and accuracy will be ongoing.

In FY 2022, 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, NREL will redesign the waste and recycle stations to create content to display on the televisions 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 staff 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 goals are to maximize compostable material, reduce overall plastic consumption and produce as little landfill waste as possible at the Café.

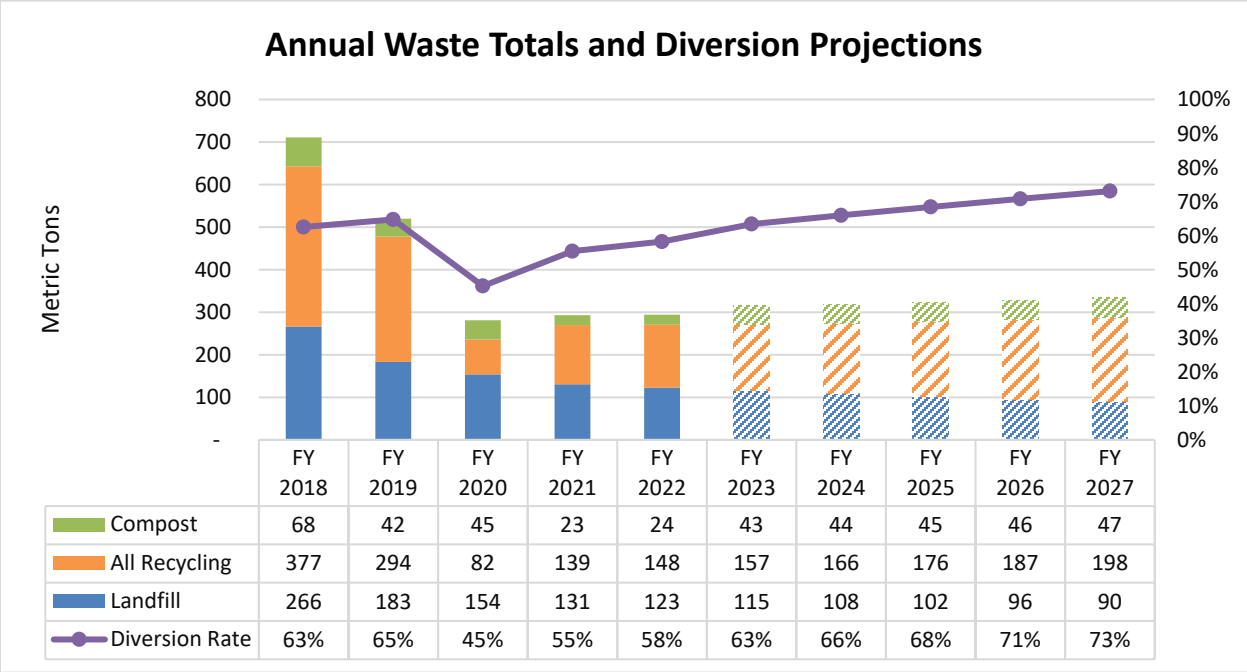
In FY 2022, NREL will consider adding cameras to wood recycling containers at the STM and Flatirons campuses. The addition of cameras will reduce costs by decreasing landfill haul amounts, detect for contamination and divert less trash to the landfill, reduce carbon footprint from hauling activities, 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 such as office waste or kitchen waste and provide targeted recycle stations across the laboratory for collection.

NREL is at a medium risk for falling short of future waste reduction targets due to current policies and procedures, mission, financial, and supply chain concerns. Increasing staff, which could lead to increased waste streams and total waste volume, as well as limited funding opportunities to address recycling and composting programs could make improvements difficult to achieve. Finding opportunities for cost-effective recycling streams could also hinder efforts to meet long-term waste diversion targets. 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 staff 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 toward near-zero waste on its campuses, with a targeted goal of a 87% waste diversion rate in 5 years (see Figure 12) NREL's solid waste plan will meet this goal through the development of service standards, contract adoption, and deployment of waste management awareness campaigns. To achieve these aggressive waste management goals NREL

will need staff and resources to develop an outreach, education, and engagement campaign for employees, customers, visitors, and subcontractors.



	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027
Compost	68	42	45	23	24	43	44	45	46	47
All Recycling	377	294	82	139	148	157	166	176	187	198
Landfill	266	183	154	131	123	115	108	102	96	90
Diversion Rate	63%	65%	45%	55%	58%	63%	66%	68%	71%	73%

Figure 12. Projected waste diversion and total metric tons over the next 10 years

Assumes a step-down decrease in waste to landfill until reaching a goal of zero waste to landfill in FY 2031. Recycling and compost are assumed to increase over the next decade at a slightly slower rate than landfill reduction, assuming some waste is not generated in the future.

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.

In FY 2022 NREL will conduct a technology assessment for the future installation of a non-carbon wastewater treatment plant at the Flatirons Campus. This campus has met its capacity for leach field space and requires a new wastewater treatment plant. The future treatment system would serve existing and future Flatirons Campus office buildings and research facilities. To facilitate a shift from a focus on disposal to reuse and recovery, NREL is seeking a viable alternative to a conventional wastewater treatment system. A more progressive system focused on reuse and recovery of wastewater would mitigate wastewater emissions and provide other environmental benefits. The plant will also be powered from non-carbon energy sources. In addition to creating ground-breaking science, NREL would ultimately showcase a pilot in advanced technologies for wastewater treatment.

Landscape and Pest Management

Efforts in FY 2022 and beyond will be a continuation of FY 2021 activities and may include a reintroduction of biological controls, such as insects, mites, and fungi to manage landscape pests.

Green Chemicals

As the lab's mission expands and funding increase, the use of hazardous chemicals is likely to increase. The work planning process will continue to advocate for the elimination or substitution of hazardous chemicals where feasible.

A pilot with the My Green Labs program will begin in FY 2022. Five labs have opted to participate in the program. One element of the My Green Labs assessment is to review options for green chemistry.

4 Fleet Management

Performance Status

Fleet Management Strategies

NREL campus and fleet operations were impacted by COVID-19 in FY 2021 and will continue to be impacted until NREL 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 remained in place until late May 2021 and 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.

NREL continued to train all fleet vehicle drivers (Fleet Custodian and Operator Training) in FY 2021 and has had almost 200 staff complete the training. This biannual and new-hire training provides an overview of the current fleet policies, operator responsibilities for driving and maintaining fleet vehicles, and 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 2021, NREL worked with the General Services Administration (GSA) and Geotab to retrofit the majority of its GSA leased vehicles with the GSA FedRAMP telematic devices. All new vehicles arriving in the NREL fleet are also equipped with the GSA FedRAMP telematic devices. 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 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 data is used to identify opportunities for vehicles to be shared amongst groups to increase the per-vehicle utilization.

In FY 2021, NREL Fleet Management collaborated with NREL electric vehicle (EV) researchers to review the telematics data and the duty cycle of the vehicles for the last 2 years. They reviewed fuel use, trips, and mileage to assess which vehicles in the NREL fleet could be converted to EVs. This review indicated that all NREL vehicles could be converted to battery electric vehicles (BEVs) once available on the market. Although there may be a few days a year where a vehicle would need to charge during the workday, based on the utilization and mileage data, most vehicles will only require overnight charging to meet their charging needs.

NREL continues to expand its EV charging infrastructure to meet the needs of its growing EV fleet. In October 2021, NREL added two Level 2 EVSE charging stations to the RSF to support fleet EV charging and is in the process of adding two additional Level 2 EVSE charging stations to RSF. In addition, fleet drivers can use the workplace charging 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 2022 and beyond, NREL plans to continue its electric and zero-emissions vehicle demonstrations when research opportunities arise. As a part of the laboratory's net-zero emissions goals, NREL has a goal to electrify 100% of its fleet in the next 2 years. NREL is at a high risk of not achieving future fleet goals due to technological and limited funding. The primary challenge to NREL's fleet electrification plan will be the availability of BEVs on the GSA schedule that are suitable replacements for the internal combustion engine currently in the fleet. Identifying costs required to transition the fleet will also be a challenge.

NREL is positioned to have the federal government's first fully electrified fleet through a potential partnership among NREL, DOE, GSA, and Xcel Energy. Senator Michael Bennet stated, "The Department of Energy's Vehicle Technologies Office, NREL, and GSA's own Proving Ground and Emerging Technology program can aid this effort by providing technical support on charging use cases and needs."

NREL is equipped to be a leader in fleet EV adoption and is an ideal pilot location because of its existing EV charging infrastructure and smart charge management software, the size and diversity of its fleet vehicles, vehicle duty cycles that are conducive to electrification, and staff willingness and technical expertise to pursue this project. The proximity to other federal agencies at the Denver Federal Center and the ARIES investments DOE is pursuing at NREL provide further opportunity for NREL to serve as an outreach and technical proving ground to facilitate federal fleet electrification and validation of future EV technologies. NREL also serves as the lead laboratory in providing technical support to FEMP's Federal Fleet Management program, which provides a clear conduit to communicate lessons learned and ensure that NREL's fleet electrification efforts are tethered to those of other federal partners.

In FY 2022, NREL plans to install additional Fleet EVSE at the Shipping and Receiving building on the STM Campus and near the Structural Technology Laboratory at the Flatirons Campus to meet the future needs for its Fleet Electrification Plan.

As part of a collaboration between DOE and Hyundai, in FY 2022 Hyundai will provide NREL with a Hyundai NEXO fuel cell vehicle to use for a campus demonstration project as well as both internal NREL and external community outreach. The vehicle will be used primarily 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.

5 Clean and Renewable Energy

Performance Status

Renewable Energy Strategies

NREL had no new renewable installations in FY 2021. NREL's PPA systems continued to experience some technical issues in FY 2021, including an outage over several months involving the large Mesa Top 1-axis tracking system, which experienced inverter and meter communication failures. In addition, in April 2020 NREL disabled solar 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.[2] With most NREL staff working remotely because of COVID-19, the disablement of the system was necessary to eliminate the possibility of solar 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 NREL's current interconnection agreement with Xcel Energy, its utility provider. The solar PV system was restored to operation in January 2021; however, there were several inverter issues that caused production to drop for several months throughout the remainder of FY 2021.

NREL is investigating controls upgrades that would allow dynamic curtailment of solar PV systems to prevent electricity export rather than wholesale curtailment of entire solar PV systems. NREL continues to monitor PPA system performance to identify production issues quickly and work with PPA vendors to resolve them promptly.

In FY 2021, NREL began installing pulse meters for the STM and Flatirons campus solar PV systems that did not already have direct meters. The pulse meters will allow NREL to have real-time information on all solar PV production across its sites. Installation is anticipated to be complete in FY 2022.

Wind production reported as renewable generation includes the DOE-owned General Electric turbine and the Controls Advanced Research Turbine at the Flatirons Campus, for which NREL retains the renewable energy credits (RECs). (NREL has no ownership of the RECs for wind production from the Siemens and Gamesa turbines because of their ownership structure and research agreements.) Wind production from these turbines fluctuates from year to year based on research requirements.

Other sources of renewable energy include the operation of the RFHP, which provided 45% of the district heating on the STM Campus (see Section 2, Energy Management). During the RFHP off-season, waste heat from ESIF is utilized to provide morning boiler warm-up, reducing natural gas consumption. NREL also continued to purchase replacement RECs to reclaim environmental attributes that were associated with RECs sold from on-site solar PV systems. (These

[2] 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.

replacement RECs allow NREL to claim all PV generation and wind production on the STM and Flatirons campuses as renewable.)

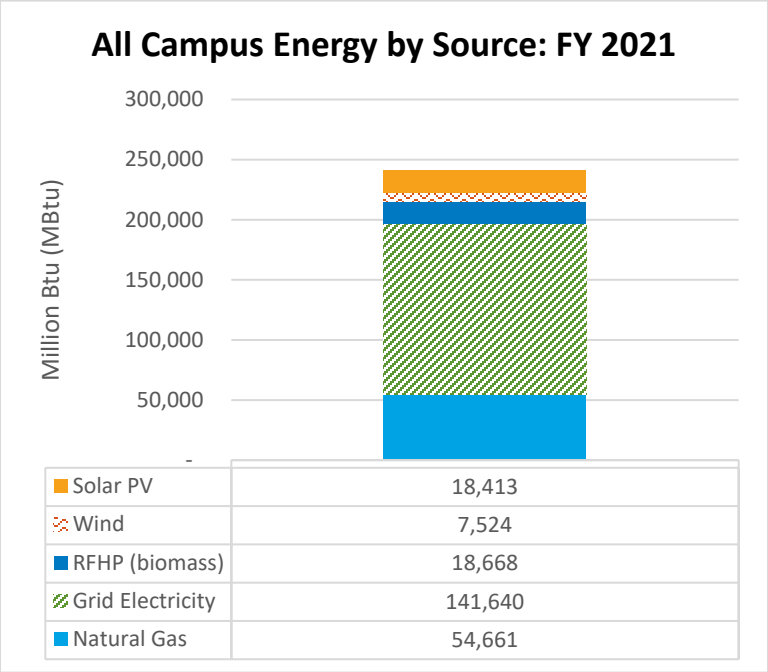


Figure 13. Total NREL campus electricity and all energy by source, including on-site renewable energy production

NREL made no clean-power purchases in FY 2021. Only energy from NREL's STM and Flatirons campuses is included here (i.e., it does not include leased facilities). RECs are not shown in this chart.

Table 1 shows clean and renewable energy totals, retained RECs (which is a bonus accounting by the federal government that doubles the total energy of renewable systems on federal and tribal land with retained RECs), and replacement RECs purchased for solar PV and wind generation. (Inclusion of replacement RECs and bonus RECs in the clean energy percentage calculation is for consistency with the calculation method used by the DOE Sustainability Dashboard; the table should not be used for other renewable energy reporting purposes.) Total grid electricity includes leased facilities.

Table 1. Renewable Energy and Electricity Use

	All Energy		Electricity	
Energy Source	**Mbtu**	**Clean Energy (%)**	**MWh**	**Clean Energy (%)**
Grid Electricity	144,939		42,479	
Natural Gas	55,479			
RFHP (biomass)	18,668	7.8%		
Solar PV	18,413	7.7%	5,396	11.1%
Wind[a]	1,859	0.8%	545	1.1%
Clean Power Purchase (RECs)[b]	0	0.0%	0	0.0%
Replacement RECs	*26,238*	*10.8%*	*7,690*	*15.4%*
Retained RECs (bonus)	*4,429*	*1.8%*	*1,298*	*2.6%*
TOTAL[c]	**239,357**	**29.1%**	**48,420**	**30.8%**

[a] Includes production from DOE GE and CART turbines only to avoid double counting hosted wind turbines which are accounted for in REC purchases (1,660.56 MWh of production).

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

[c] 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.

NREL continues to refine master planning for the eastern expansion of the STM Campus, investigating a distributed energy grid 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. Additionally, since the central plant will not supply heating and cooling demands for the east campus, all facilities must be constructed with self-contained heating, ventilation, and air conditioning (HVAC) systems. Alternative thermal energy sources, such as ground-source heat pumps, other electric HVAC technologies, and hydrogen fuel cells that reduce emissions, are being evaluated for their potential to assist buildings during peak demand or islanding events. Additionally, these technologies simultaneously support research projects and operational assets. Implementing an autonomous (islanded) distributed energy grid on the NREL campus is a long-term goal that requires a phased approach to manage risk associated with disconnecting from the electrical grid.

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.

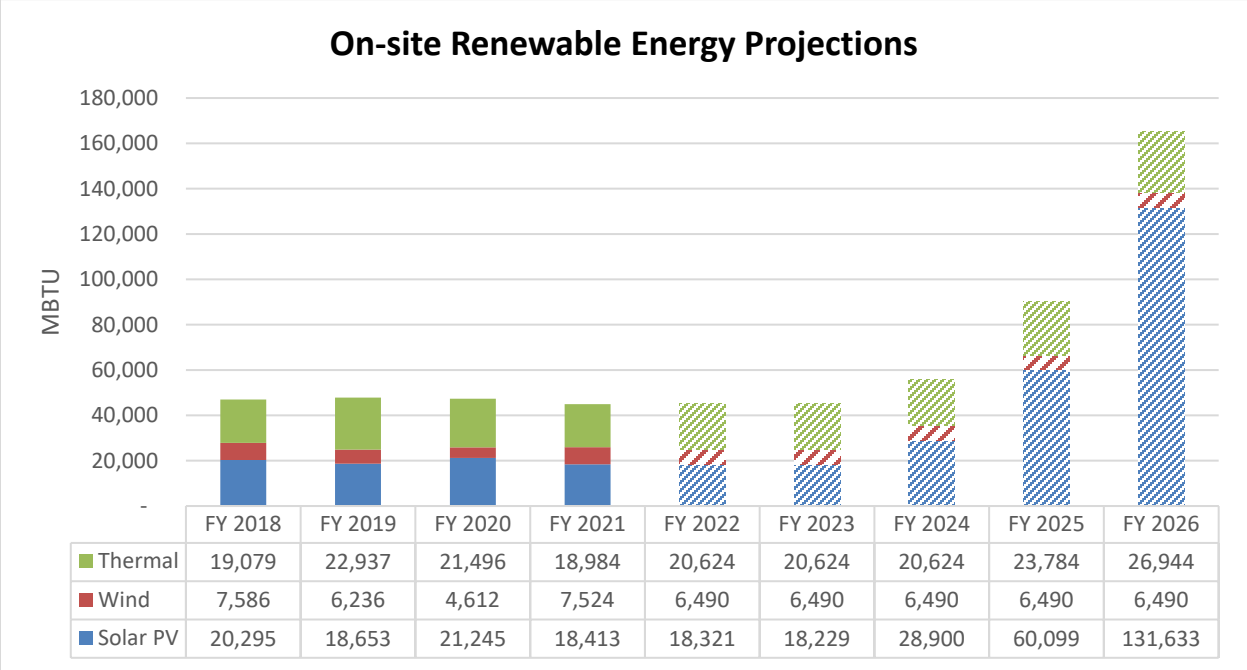
NREL will continue to pursue options to procure on-site renewable energy when financially feasible. As part of NREL's net-zero emissions effort, NREL is exploring opportunities to install on-site solar PV systems as well as systems adjacent to the STM and Flatirons campuses. System size and feasibility, including the addition of batteries, will be evaluated in FY 2022. These systems are included in the on-site renewable energy projections in Figure 14 but meeting these

clean energy goals is a high risk for NREL due to a lack of available funding for decarbonization efforts and net-zero energy buildings. These options are being explored in partnership with NREL's utility provider, Xcel Energy. Xcel Energy is working toward a goal of 100% carbon-free electricity by 2050 with an interim goal of 80% by 2030.

Where financially feasible, NREL is requiring the installation of solar PV and battery storage for new buildings as well as the electrical configuration required for emergency back-up power and microgrids for these facilities. At minimum, new buildings are required to be solar PV- and microgrid-ready. With limited rooftop availability and space for operational renewable systems on its campuses, NREL has opted to prioritize solar PV instead of solar water heating systems due to the more efficient use of space relative to energy generation with solar PV systems.

In FY 2022, NREL continues to explore the feasibility of a small microgrid installation at the SSEB, a small-scale entrance facility. This pilot is intended to enhance understanding of system components and advanced control for the operability and scalability of larger microgrid projects in support of resilience. This project will incorporate energy storage and renewable generation as the main energy resources.

NREL will also continue to purchase RECs to replace RECs sold for on-site renewable energy installations as well as on-site renewable energy installations owned by third parties for research purposes. This ensures NREL can accurately account for renewable energy production for on-site systems.



	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
Thermal	19,079	22,937	21,496	18,984	20,624	20,624	20,624	23,784	26,944
Wind	7,586	6,236	4,612	7,524	6,490	6,490	6,490	6,490	6,490
Solar PV	20,295	18,653	21,245	18,413	18,321	18,229	28,900	60,099	131,633

Figure 14. On-site renewable energy projections

Projections include all solar PV, wind energy, and thermal energy, including the RFHP and geothermal systems. Any increases in on-site renewable energy systems are contingent on funding.

NREL will continue to refine master planning for the eastern expansion of the STM Campus, investigating a distributed energy approach. NREL will identify the most efficient and feasible technical solutions and integrate these distributed energy systems into future buildouts of the campus. Funding is required to implement these solutions.

6 Sustainable Buildings

Performance Status

Guiding Principles

In FY 2021, NREL began updating its processes for compliance with the 2020 Guiding Principles. The current compliant facilities are represented in the table below and will require future reassessment. In FY 2022, NREL plans to develop a road map for facility assessment and reassessment cycles. 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.

Table 2. Summary of Facilities Compliant with Guiding Principles

Guiding Principle Compliant Facilities		
Facility	**Assessment**	**Guiding Principles**
Café	LEED Platinum FY 2013	2008 version
ESIF	LEED Platinum FY 2014	2008 version
Integrated Biorefinery Facility	LEED Gold FY 2011	2008 version
RSF	LEED Platinum FY 2011/FY 2012	2008 version
S&TF	LEED Platinum FY 2006	2008 version
SSEB	LEED Platinum FY 2013	2008 version

New Building Design

In FY 2021, NREL finalized the design and began construction of the RAIL facility on the STM Campus. 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 incorporates innovation in energy technologies, environmental performance, and advanced controls using a "whole building" integrated design approach. NREL anticipates that construction of the RAIL facility will be completed in late calendar year 2022.

Additionally, NREL began developing design requirements for the EMAPS facility. The facility will provide much-needed laboratory space and collaboration opportunities for research.

The design for the CCF began in FY 2021. The CCF will be the cornerstone for the future expansion of the ARIES initiative by providing additional collaboration space, a control and data room, and a low power device characterization lab at the Flatirons Campus.

Programming for the WHF2 began in FY 2021. The facility will be fully funded in FY 2022 with construction planned for FY 2023. The facility will support mission growth in laboratories to ensure the compliance and safe disposal of hazardous chemicals.

Plans and Projected Performance

Guiding Principles

In the next 5 years, NREL will develop a plan for reassessment and existing building compliance with the 2020 Guiding Principles. Based on these evaluations, NREL will gauge the potential for bringing as many buildings as possible into compliance with the 2020 Guiding Principles. Lack of additional funding beyond typical operational expenses puts NREL at a high risk of failing to bring existing buildings into compliance with the Guiding Principles. Limited staffing is a barrier to addressing the Guiding Principles in existing facilities because the evaluation and cost estimates for compliance will take significant staff time that is not currently available.

NREL will also utilize the template for Guiding Principles compliance developed by Argonne National Laboratory's consultants through the Energy Facility Contractors Group Sustainability and Environmental Subgroup. This template will improve the process of documentation for the Guiding Principles as well as support the communication of the Guiding Principles requirements with subcontractors.

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 most current baseline ANSI/ASHRAE/IESNA Standard 90.1. In addition, once staff resources can be identified, NREL plans to integrate the Smart Labs and the 2020 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.

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 natural 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. These advances will provide opportunities to develop and monitor buildings as both research projects and operations assets, while bolstering NREL campus security and building resilience.

7 Acquisition and Procurement

Performance Status

Sustainable Acquisition Strategies

In FY 2021, NREL continued modernization of its sustainable acquisition systems and processes with enhancements that will continue through FY 2022. These include improvements to data collection and revised processes to adequately support sustainable acquisition requirements and initiatives. In FY 2021, NREL sustainable acquisitions reporting focused on custodial services and construction contracts. Only one construction contract is reflected in the data due to NREL's ongoing efforts to improve and implement a more comprehensive approach to gathering the necessary information from all future construction subcontractors. These include collaborating with other national labs and internal stakeholders to develop a template that guides construction subcontractors on how to properly procure biobased materials where appropriate and report such purchases. NREL's sustainable acquisition strategies are all designed to help improve NREL's supply chain GHG emissions.

NREL fully implemented the Oracle Procurement Cloud (paperless solution) in FY 2021 and continues to monitor import and export of procurement information to ensure the system is working properly.

NREL's standard terms and conditions are included with all NREL-awarded subcontracts and purchase orders. Federal Acquisition Regulation clauses are incorporated in their entirety (see Table 3). These clauses require the use of products that have biobased content, are energy efficient, or have recycled content. This includes the procurement of ENERGY STAR, FEMP-designated, WaterSense, U.S. Department of Agriculture Bio Preferred, Electronic Product Environmental Assessment Tool (EPEAT)-registered, Supplemental Nutrition Assistance Program, Safer Choice, and SmartWay-designated products when cost-effective.

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 (HFCs)
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 Environmental Protection Agency (EPA)-designated Items in Service and Construction Contracts

All NREL staff procurements are required to be conducted in compliance with federal green procurement requirements to purchase certain products unless they do not meet mission needs or are cost-prohibitive. Lists of these types of products, along with resources, can be found in internal acquisition services guidance for all staff with purchasing power at NREL. This guidance includes the major product categories and requirements along with links to the external guidance and resources.

Table 4 summarizes NREL's performance in sustainable acquisition. The total number of eligible contracts and contract dollars includes all purchase orders greater than the simplified acquisition threshold of $250,000.

Table 4. Sustainable Acquisition Progress in FY 2021

FY 2021 Sustainable Acquisition Progress	
Metric	**Total**
Number of Eligible Contract Actions	140
Number of Contract Actions w/ SA Clauses	140
Percent of Contract Actions w/ SA Clauses	**100%**
Total Eligible Contract Dollars ($)	$102.4 M
Total Contract Dollars ($) w/ SA Clauses	$102.4 M
Percent of Contract Dollars w/ SA Clauses	**100%**

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

Biobased Product Purchase and Targets (# of actions)	
FY 2021	**FY 2022**
2	132

NREL worked with one construction subcontractor in FY 2021 to develop a new process for reporting on biobased products. 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.

Plans and Projected Performance

Sustainable Acquisition Strategies

In FY 2022, NREL will report all biobased purchases (product type, category, description, and spend) from its custodial and construction subcontractors to the Federal Procurement Data System. To do so accurately, NREL plans to collaborate with internal architects, technical monitors, and subcontract administrators, as well as other stakeholders, to develop a new sustainable acquisition (biobased products) purchases reporting system. NREL has begun outreach to other national labs to create a coalition that shares ideas and works together toward making the laboratories' respective construction subcontractors' reporting duties as seamless as possible.

Over the next 5 years, a new Supplier Relationship Management (SRM) program will involve a scorecard mechanism to track the performance of NREL subcontractors. Among the metrics

tracked in the scorecards will be a sustainability score, which will include BioPreferred/biobased spend reporting. This will allow NREL to have a historical record of how subcontractors have performed in supporting sustainability goals, improving the ability to award contracts quickly and efficiently. The scorecard will also allow NREL to take corrective actions with suppliers sooner in the form of a sustainability plan if their sustainability scores don't reflect NREL goals. Overall, the SRM program will be designed to enforce the sustainability reporting listed in the provisions of each contract.

After careful analysis of stockroom usage and processes, NREL has developed plans for revitalizing stockroom use through process improvement. The main objectives of this effort, began in FY 2021, and include: (1) improve the stockroom catalog stock-keeping unit (SKU) mix, (2) eliminate the paper order form—go digital, (3) implement inventory management software that simplifies the stock room team's responsibilities, and (4) continually improve SKU mix through periodic reviews of SKU movement.

The GreenBuy Award Program recognizes leadership and continuous improvement in transitioning to more sustainable products. In FY 2022, NREL plans to review acquisitions with a goal of achieving the GreenBuy Gold designation. This would signify meeting the goals of a minimum of nine products in at least five categories designated by GreenBuy.

Implementation of internal NREL purchasing catalogs over the next few years across groups of items such as IT hardware, laboratory supplies, and tools & hardware will improve operational efficiency by reducing the number of touches required in procuring frequently ordered products. The catalogs will also assist in reducing the "maverick spend" that occurs in the open market using P-Cards by utilizing a smaller subset of suppliers linked directly to these specific products. The use of catalogs will also allow for improved reporting of purchased items.

NREL will continue to leverage software solutions in FY 2022 to increase efficiency in managing projects. This should provide a boost to operational efficiency by allowing clear visibility into project progress and clearly communicate expectations to team members on tasks that need to be completed to move projects forward. This will also help with tracking all active projects to make sure they are being completed. Future project management software will allow for each project to be grouped based on the strategic goal it is designed to help achieve.

8 Efficiency and Conservation Measure Investments

Performance Status

Efficiency and Conservation Measures

All efficiency and conservation measures are identified in the EISA 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 FY 2021. These were completed in four facilities at the STM Campus:

- ESIF: 188,517 ft^2
- S&TF: 76,454 ft^2
- SERF: 133,161 ft^2
- FTLB: 138,526 ft^2.

From the completed audits, NREL identified 60 energy- and water-saving measures for these four facilities, representing 25,876/year Mbtu of energy savings. Of the 60 identified measures, 39 were zero-cost or low-cost measures. These consist primarily of correcting control problems in existing systems. NREL will pursue these measures with internal resources. NREL began calculating the life cycle cost-effectiveness of ECMs in FY 2021 for capital projects and will use that information to determine project viability.

NREL does not conduct comprehensive M&V for most implemented 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 blended electricity charge is approximately $0.07/kilowatt-hour (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 2021, the GFO, with NREL's support, publicly released a NOO and identified an ESCO to begin the process of developing a potential ESPC. The ESCO began its preliminary assessment in FY 2021. NREL provided a list of about 80 potential ECMs that had been scoped in the EISA audit process as far back as FY 2012. The ESCO visited the STM and Flatirons campuses for two days to walk through the facilities, validate potential ECMs, and look for other opportunities. NREL continued to work with the ESCO through the end of FY 2021 and expects the final preliminary assessment to be submitted in the second quarter of FY 2022.

Appropriations/Direct Obligations

Applicable NREL projects consider water- and energy-savings opportunities as part of the design process. Currently NREL has only budgeted for the ongoing costs of EISA audits.

Training and Education

In FY 2021, NREL Intelligent Campus and engineering staff completed training on a variety of topics, including energy efficiency and energy management. Since the Energy Exchange conference was virtual in FY 2021, NREL was able to send several staff to the training. NREL currently has two certified energy managers on staff in Site Operations.

Plans and Projected Performance

Efficiency and Conservation Measures

NREL has previously relied on the simple payback of ECM evaluations to determine project viability. The majority of capital projects identified in EISA audits were not addressed in the past and NREL is at a high risk of not meeting future ECM targets due to current policies and procedures and limited funding. NREL needs to develop a process to accurately identify and implement life cycle cost-effective ECMs within 2 years of identification. Additional staff support and funding will be required to make these improvements. The EMIS 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. Additionally, in FY 2022 NREL plans to pilot a merger of the CAIS and EISA audit processes to better support these two assessments and streamline planning for equipment maintenance and upgrade.

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. Additionally, NREL plans to develop a specific threshold at which M&V is required for capital projects and low- or no-cost projects.

Performance Contracts

In FY 2022, the GFO and NREL will review the preliminary assessment developed by the ESCO. If the measures prove feasible, the ESCO can proceed to develop and submit an investment grade audit by the 4th quarter of FY 2022.

As part of the ESPC exploration, NREL has indicated interest in exploring energy services agreement opportunities as well as the potential to develop an all-renewable microgrid pilot at the SSEB.

Appropriations/Direct Obligations

NREL does not currently allocate specific funds to energy- and water-conservation measures. In FY 2022, 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.

In FY 2022, NREL will continue developing a savings reinvestment program. This financial vehicle allows for the energy and water cost savings from efficiency projects to be invested into future projects. A savings reinvestment program would create a funding stream to invest in identified life cycle cost-effective efficiency and conservation measures. Barriers for development include the difficulty of identifying an appropriate financial mechanism and process to meet the program goals. NREL also currently lacks the staff to support maintenance of this program which will require significant detailed review of projects to ensure they meet the fiduciary guidelines.

Training and Education

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

9 Travel and Commute

Performance Status

Business Travel Strategies

Mission-essential travel approved during FY 2021 comprised just 171 domestic trips and 7 foreign trips. The low number of trips was due to the restriction in business travel related to the COVID-19 pandemic. FY 2021 business travel was restricted to essential travel with management approval from NREL as well as the GFO.

These unprecedented times have uniquely changed conference attendance. Prior to COVID-19 NREL travel did not track virtual conferences because a virtual format was not typically offered to attend conferences. However, since the pandemic the number of virtual events has been astonishing. FY 2021 virtual conference participation was reported by 1,566 staff, nearly double the number that reported attending a virtual conference in FY 2020.

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 continued to prove effective in FY 2021, with a large majority of staff working from home as the COVID-19 pandemic continued to limit staff levels on campus.

In FY 2021, NREL staff worked with their line managers to determine their Future of Work arrangement once restrictions for on-site work are lifted. Options included full-time on-site, hybrid, or full-time remote working configurations. Based on the commuter survey feedback from staff, approximately 25% of staff will be returning to full-time on-site work, 60% will be hybrid, and 15% will be full-time remote.

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 2021, NREL's shuttle service subcontractor continued to work with TripShot, a mobility management software system, to electronically track passenger ridership by time of day and boarding/alighting stop location. In 2021, Tripshot passed the cybersecurity review, and NREL transitioned from the pilot system to allowing NREL staff to access the mobile app through single sign on. The mobile app 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 restrictions continued to have a major impact on transit ridership in FY 2021. As a result, RTD modified its service plan to discontinue three routes that previously connected directly to the STM Campus. Route 20 and Route 125 were discontinued in May 2020, and in January 2021, the GS route was also discontinued. In September 2021, Route 20 was reinstated in a limited capacity with AM and PM peak period service. NREL is continuing to discuss options with RTD to improve transit access to NREL. 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, Denver Regional Council of Governments, 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.

Since FY 2020, NREL has participated as a member of the working group reviewing the Employer-based Trip Reduction Program (ETRP) legislation 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. While the state of Colorado did not pass the ETRP, in FY 2021, NREL continues to follow the status of the legislation and anticipates that either a voluntary or nonvoluntary regulation will be enacted in the next few years that will require employers to track and report on SOV trips.

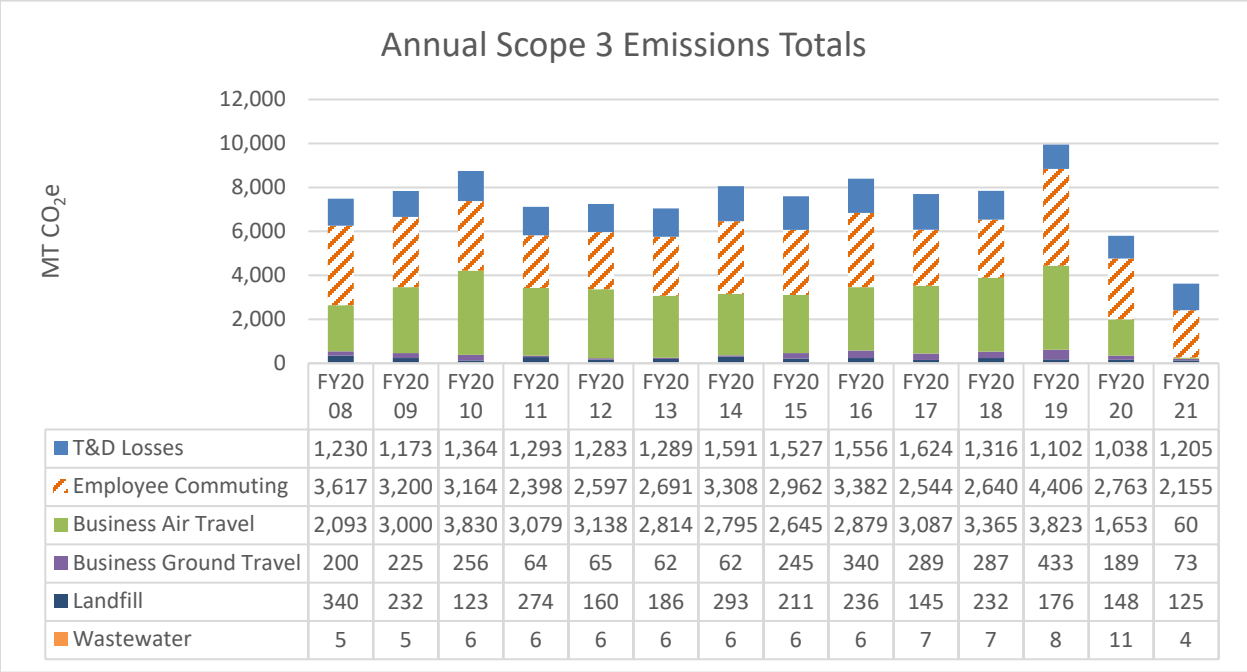
In FY 2021 NREL also officially joined the West Corridor Transportation Management Association (TMA). As a member, NREL is supporting the TMA's effort to help employers understand the needs of their current and future workforce, including work-from-home and remote work programs, commitment to vehicle electrification, and alternative transportation options that match commuting requirements and preferences—including vanpools, carpools, bike libraries, and car share. The TMA coordinates with policy makers to encourage them to consider the needs of the people and businesses in the TMA territory, including the TMA's work to improve the region's air quality. Lastly, the TMA works to secure reductions in vehicle miles traveled, reductions in single-occupant vehicle use, and investment in infrastructure that serves walkability and bikeability across the region.

NREL conducted a commuter survey in October 2021, to collect FY 2021 commuter information as well as information on expected commuter behaviors once campus restrictions are lifted and staff return to campus. With almost 1,600 responses from NREL staff and 150 responses from the GFO staff, the survey had a response rate of approximately 60%.

In October 2020, 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 and won the challenge for suburban companies. There were more than 100 participants.

Overall, GHG emissions counted in the Scope 3 inventory decreased by 2,180 $MTCO_2e$, or 38%, from FY 2020 to FY 2021. This is largely due to the drastic reduction in business travel and employee commuting discussed in this section. Figure 15 illustrates the trends in Scope 3 GHG emissions that result from NREL operations.



	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021
T&D Losses	1,230	1,173	1,364	1,293	1,283	1,289	1,591	1,527	1,556	1,624	1,316	1,102	1,038	1,205
Employee Commuting	3,617	3,200	3,164	2,398	2,597	2,691	3,308	2,962	3,382	2,544	2,640	4,406	2,763	2,155
Business Air Travel	2,093	3,000	3,830	3,079	3,138	2,814	2,795	2,645	2,879	3,087	3,365	3,823	1,653	60
Business Ground Travel	200	225	256	64	65	62	62	245	340	289	287	433	189	73
Landfill	340	232	123	274	160	186	293	211	236	145	232	176	148	125
Wastewater	5	5	6	6	6	6	6	6	6	7	7	8	11	4

Figure 15. Annual Scope 3 emissions broken down by emission type

Plans and Projected Performance

Business Travel Strategies

With continued COVID-19 restrictions in place into FY 2022, business travel restrictions (both foreign and domestic) allow for essential travel only. Travel deemed essential will continue to require approvals from management. It is unclear when these restrictions will change.

Given the unparalleled challenges NREL faces because of the COVID-19 pandemic, the forecast for travel remains uncertain. According to the travel industry experts, it may take 5 years before business travel is back to where it was prior to COVID-19. The uncertainty of business travel makes it impossible to fairly assess travel goals into the future. NREL will continue to promote remote options such as virtual meetings, conferences, and workshops.

Commute Strategies

NREL will continue to promote alternative commuting with staff through several venues in FY 2022 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 2022 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.

In October 2021, NREL was selected as a Best Workplace for Commuters based on the alternative commuting strategies put in place as of FY 2021. The list of employers that met this standard of excellence will be announced in January 2022.

When NREL returns to normal operating conditions, NREL's Campus Mobility Specialist plans to perform a feasibility study to evaluate new alternative commuting programs, including a vanpool analysis that groups employees who live near one another and are interested in vanpooling services. To promote vanpooling, NREL plans to host lunch-and-learns with interested staff to provide an overview of the vanpooling program and incentives offered by NREL. NREL will also perform a return-on-investment analysis on the alternative commuting program to identify where improvements can be made in the program to decrease single-occupancy vehicle commuting trips to the 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 2021 saw reduced GHG emissions from employee commuting. These emissions reductions on NREL's campuses are offset by increased GHG emissions occurring off campus due to staff working remotely (e.g., from their homes), which are currently not accounted for in NREL's GHG emissions inventory. Since 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.

10 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 2021, no refrigerant leaks occurred from refrigeration or electrical equipment.

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 2021.

The management of fugitives and refrigerants during FY 2021 included:

- Updating the detailed refrigerant inventory at NREL facilities
- Updating the SF_6 inventory
- Participating in the HFC Subcommittee of the DOE Clean Air Working Group reviewing EPA regulations regarding phase out of the manufacture of HFC refrigerants.

Bulk refrigerants are accounted for on an ongoing basis throughout the year to document use in FY 2021. NREL captures and recycles refrigerants from HVAC equipment.

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 2022, NREL will implement and comply with any changes to the EPA regulations.

The plans and projected performance for FY 2022 include the following:

- Continue to update the SF_6 and refrigerant inventories and obtain additional data for equipment identified in FY 2022
- 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 HFC Subcommittee 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 continue to assess methodologies for tracking SF_6 and refrigerant inventories to inform best operational practices for the management of these substances.

11 Electronics Stewardships and Data Centers

Performance Status

Acquisition Strategies

In FY 2021, NREL received the 2021 Four-Star EPEAT Purchaser Award for its exceptional commitment in support of the laboratory's mission to ensure that FY 2020 purchases met established EPEAT ratings wherever possible. If EPEAT certified products are not available, NREL makes an effort to purchase ENERGY STAR rated products wherever possible.

Operations Strategies

In FY 2021, NREL enabled power-management settings on all eligible personal computers, laptops, and monitors before they were 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 2021 NREL expanded its program for IT equipment reutilization by developing a process for reclaiming and reutilizing eligible IT peripherals, as well as computers. A new procedure was initiated to have all separating employees return their computers and peripherals to ITS for evaluation and reutilization. Circumstances surrounding remote work also provided an opportunity to reclaim some spare and secondary computers and peripherals. As a result of these initiatives, the pool of computers available for reutilization grew to more than 500, and more than 100 monitors were repurposed and redeployed.

In FY 2021, with the majority of NREL staff working remotely due to COVID-19, the load on multifunction devices (MFDs) has been significantly reduced. No MFDs required replacement 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 140 out of 153 devices being eligible for such functionality.

End of Life Strategies

The Site Operations and ESH&Q Offices work in cooperation with one another to ensure the responsible stewardship of electronics designated as having reached end of life at NREL. The management of electronic 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. Subsequently, if 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 one of NREL's Responsible Recycling (R2)-certified local vendors. The vendors also have the e-Stewards, ISO 9001, ISO 14001, and OHSAS 18001 certifications.

FY 2021 activities comprised the routine handling of equipment relinquished to Property Management as excess (e.g., computers, peripherals, tablets, cellular phones) as well as the disassembly and recycling of one supercomputer from the ESIF, which included the certified inventory and destruction (shredding and recycling) of more than 3,000 individual hard drives. Of note, contracting certified shredding services in accordance with prescribed data destruction requirements is costly, and staff managing similar nonroutine efforts in the future will be advised to budget accordingly to allow for this component of the overall project cost.

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 2021, and 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 6.4 million gallons of water during the last 5 years and currently operates with a water-use effectiveness (WUE) of 0.92 L/kWh.

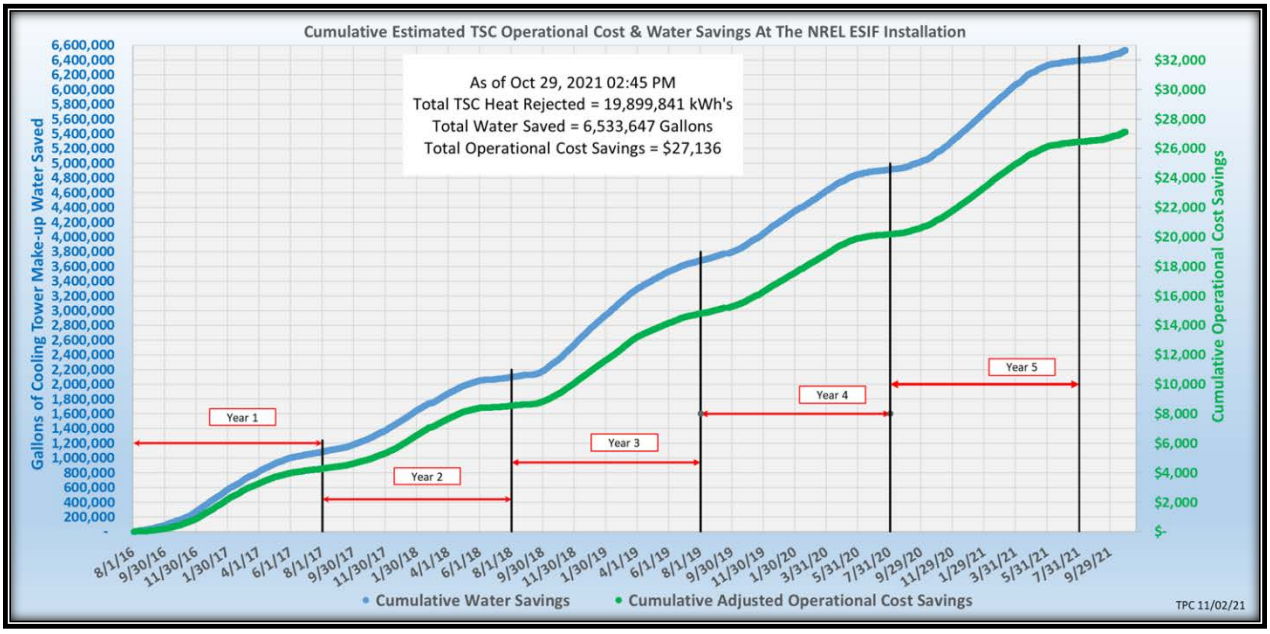


Figure 16. Estimated total cumulative water consumption and savings for the HPCDC.

Summary of water consumption and savings taken over 5 years based on average water costs per gallon at the STM Campus. Cumulative savings exceed 6.5 million gallons.

The RSF data center is mature at 11 years old and continues to operate at high levels of energy efficiency. The PUE for the data center was 1.31 in FY 2021. There was a 6-kilowatt (kW) load increase in the total energy of the RSF data center in FY 2021 due to NREL's growth. This will actually help reduce the PUE, since the cooling system is already running at the minimum possible.

Plans and Projected Performance

Acquisition Strategies

In FY 2022 and beyond, NREL will continue to strive to purchase EPEAT-rated devices and work with manufacturers and EPEAT to add necessary hardware to EPEAT. NREL plans to develop a centrally managed system for computer and IT purchases. This change in how computers are purchased and provided to employees will ensure higher reutilization of computers in lieu of new computers where appropriate.

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, obsolete equipment is replaced, and a greater percentage of the laboratory's hardware inventory becomes centrally managed.

NREL is in the process of implementing a multiyear IT asset management strategy, which will continue to enhance the operations, inventory management, and reutilization of IT equipment to improve efficiencies and effect more holistic life cycle management.

End of Life Strategies

As the reutilization program continues to expand in coming years, ITS will revamp how computers are purchased and provided to staff. 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 2022 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

Preparation is underway for NREL's next-generation HPC system that will be installed in 2022, with production use starting in 2023. The HPCDC facility is being upgraded to support this next HPC system alongside NREL's current flagship system named Eagle (that went into production January 2019). In FY 2022, NREL plans to complete the HPCDC facility upgrade project to support the next HPC flagship system. This incremental expansion will upgrade the facility to 7.5 MVA (transformer capacity), with a targeted 6.5 MW usable for IT equipment. Future

expansion of the HPCDC is expected to continue until it reaches 10 MVA (transformer capacity), with a projected 9 MW usable for IT equipment. NREL will continue to maintain and operate the HPCDC with an annualized average PUE of 1.05 or lower.

Additional cooling towers are necessary as part of the 7.5 MVA HPCDC facility upgrade and will be added. Unfortunately, these cooling towers must occupy the area in which the present thermosyphon system is located. The thermosyphon will be removed as late as possible in FY 2022, which will cause water consumption to increase at least 50%. 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. Maximizing HPCDC waste heat reuse on NREL's campus reduces waste consumption, and this will be a focus area, as the next HPC flagship system should improve conditions for waste heat reuse.

HPCDC computing capacity will increase in future years according to anticipated upgrades, ultimately to a maximum of 9 MW peak usable capacity. HPCDC peak load varies by year according to anticipated upgrades. 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.

In FY 2022, NREL anticipates another load increase of at least 6 kW in the RSF data center due to NREL's continued growth. This will help to reduce the PUE, since the cooling system is already running at the minimum possible. Addressing the minimum possible cooling loads in the facility could also serve to reduce the overall PUE of the data center.

12 Adaptation and Resilience

Performance Status

Resilience Strategies

NREL completed its first vulnerability and resilience assessment in June 2015 and has taken steps to implement specific individual projects at the STM and Flatirons campuses identified in that assessment. NREL recently joined a cohort of other DOE pilot sites using the FEMP Technical Resilience Navigator (TRN), a water and energy resilience planning tool being developed for government sites. In FY 2021, NREL kicked off the process, assembling a core team, identifying stakeholders, developing a set of resilience priorities, and developing a scope and boundary for the assessment. The assessment will include the STM and Flatirons campuses and is anticipated to be completed in FY 2022.

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 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. The scope of work for an ESPC was part of a NOO NREL issued in FY 2021. The GFO selected an ESCO that will perform a feasibility assessment in FY 2022 for NREL to select an ESPC that will enable implementation of energy/cybersecurity 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 developed a scope of work and awarded a design services contract for the Flatirons Campus Water System project. Design work began and is nearing the 30% milestone. The project team has determined the location of the on-site facilities for water treatment and fire water storage, and the route of the new water line from Francis Smart Reservoir to the Flatirons Campus. NREL, the GFO, and Consolidated Mutual Water Company are working on the Raw Water Supply Agreement that will allow NREL to source water from Francis Smart Reservoir. The GFO has contracted with an environmental consultant to work on the environmental assessment that is required for the National Environmental Policy Act process and right-of-way application. This is the next step in the process for constructing the new infrastructure planned for FY 2022/2023. The water system upgrade addresses one of the key vulnerabilities identified in NREL's 2015 resilience assessment.

In FY 2021, NREL initiated activities to explore the feasibility of utilizing a solar PV PPA as a financial vehicle for adding renewable energy technologies at both the STM and Flatirons campuses. Results from the assessment will inform future investment decisions in the next few years.

In response to new Executive Orders, NREL staff also responded to the DOE call for support in the development of the DOE Climate Adaptation and Resilience Plan (CARP). Each agency was tasked with developing a CARP and, in doing so, embedding adaptation and resilience planning and implementation throughout their operations and programs. NREL provided technical

expertise in development of the DOE CARP and in subsequent implementation guidance, including the Vulnerability Assessment and Resilience Plan (VARP).

COVID-19 continued to test and prove NREL's adaptability to changing conditions. The following are specific actions worth highlighting:

- **Community Vaccination Site**—In response to local conditions and in alignment with the Colorado Department of Public Health and Environment and Jefferson County, NREL's pandemic response team established NREL as a community vaccine distribution site. Excess capacity in NREL's parking garage was temporarily used to create drive-through vaccine clinics on multiple days. Several NREL staff directly supported the events with facilities, equipment, medical, safety, and security planning and logistics, and hundreds of other NREL staff volunteered to support with traffic flow, check-in, and other logistics on the day of the clinics, representing thousands of hours of volunteer time. In total, more than 3,700 people were vaccinated at the NREL clinics, which included more than 1,700 NREL employees/household members, 185 DOE/GFO employees/household members, and 1,865 underserved community members targeted by the county. In addition to serving NREL staff and need-based populations of the surrounding community, NREL also learned some important lessons that benefited its own operations, including how to improve its annual flu shot clinics.
- **Planning for the Return to/Future of Work**. Throughout FY 2021, NREL exercised DOE's "mass teleworking" practice. On-site work was limited to those with specific critical need to be on-site. In preparation for the return-to-office phase of the COVID-19 plan, the NREL Leadership Team evaluated what has been learned about working remotely because of COVID-19 and considered how to establish a more flexible, efficient, and effective workplace that supports NREL into the future. NREL management, in turn, reevaluated its space planning approach and explored how to enable laboratory growth and create work environments that better foster collaboration through thoughtful design of spaces on campus. A few of these activities included:
    - Implementing new policies and procedures and technology enhancements that provided new employment categories (on-site, hybrid, and remote) and allowed staff to opt out of an assigned office space and use hoteling and collaboration spaces instead. This activity resulted in over 1,000 staff opting out of assigned office space and transitioning to the hybrid and remote work categories, thus allowing a revaluation of space needs and consolidation that will help reduce the space constraints NREL was facing prior to the pandemic for at least a couple years. It will also allow for greater logistical functionality and reduce costs by creating swing spaces that can be utilized instead of having to lease off-site office space during large staff moves.
    - Shifting to an on-demand shuttle service with mobile app that enables ride hailing and working proactively with NREL's shuttle service provider to be able to quickly adapt to changing needs as staff return.
    - Working internally and with external partners to enhance alternative commuting tools such as vanpool coordination and communications to make up for lost regional bus service (that may not return in near future).

Taken together, these actions continue to support NREL in maintaining a safe, secure, and efficient workforce and work site while simultaneously planning to modernize the work site to continue delivering quality work product and meeting project milestones well into the future.

Plans and Projected Performance

Resilience Strategies

In FY 2022, NREL plans to complete the TRN pilot. At the end of the pilot in spring 2022, NREL will have identified and prioritized resilience strategies for the STM and Flatirons campuses. These results will be used to complete the VARP for September 2022 reporting. A top priority of the TRN pilot is to evaluate ways to integrate resilience planning and strategies into current NREL operations, policies, and procedures as this is an area of high risk to meeting future resilience goals.

In FY 2022, NREL plans to obtain approval for potential solar PV PPAs and issue a request for proposals for the projects.

The design of the Flatirons Campus water system project is planned for completion in FY 2022, and the entire project is planned for completion in FY 2023. The addition of this local water supply, connected to the Francis Smart Reservoir, will also include improvements to existing on-site water distribution systems. The lack of a connected water supply was identified as a key vulnerability for the Flatirons Campus. This project will significantly improve the resilience of the campus.

In FY 2022, NREL plans to determine the possibility of offering the COVID-19 booster shots to staff and the community; similar to the process described for the original vaccine distribution on the STM Campus.

For the next 3–5 years, NREL will continue to implement decarbonization and fleet electrification plans. Resilience will be a key consideration in all of these projects.

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