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# NET ZERO LABS PILOT: NREL Roadmap to Decarbonization

NREL is a national laboratory of the U.S. Department of Energy  
Office of Energy Efficiency & Renewable Energy  
Operated by the Alliance for Sustainable Energy, LLC

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Cover photo by Joshua Bauer, NREL 59022  
 Photo by Werner Slocum, NREL 63034



NREL's Flatirons Campus is home to the National Wind Technology Center. Photo by Dennis Schroeder, NREL 44710

## EXECUTIVE SUMMARY

The National Renewable Energy Laboratory (NREL) provides foundational, innovative research that supports global leadership in the development of next-generation clean energy technologies and advances the secure, resilient, and autonomous energy systems of the future. Aligning with Executive Order (EO) 14008, *Tackling the Climate Crisis at Home and Abroad* and EO 14057 *Catalyzing America's Clean Energy Industries and Jobs through Federal Sustainability*, NREL's strategic approach to reach net-zero emissions<sup>1</sup> for its operational footprint and will occur in phases over the next decade. Decarbonizing NREL's footprint will require the elimination of greenhouse gas (GHG) emissions from all campus facilities' energy use and will be achieved through energy efficiency enhancements and the increased integration of clean energy sources. Engaging the private sector through an energy savings performance contract (ESPC) and relationships with NREL's utility providers will be crucial to NREL's implementation strategy. The laboratory will proceed with reaching the net-zero emissions goal of the EO through the phased schedule below:

- End of FY 2023: Flatirons Campus to operate at net-zero emissions
- End of FY 2026: South Table Mountain (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)

<sup>1</sup> Net-zero emissions (Scope 1, 2, and 3), on an annual basis, eliminate or offset all anthropogenic GHG emissions (measured in MTCO<sub>2</sub>e) including both direct Scope 1 emissions and indirect Scope 2 and 3 emissions to achieve carbon neutrality.



Net Zero Emissions Boundary	
Emission Type	Scope
<b>FY 2023 – Net Zero Emission Source</b>	
Flatirons natural gas – heating	Scope 1
Flatirons natural gas – process	Scope 1
Flatirons purchased electricity	Scope 2
Flatirons solar PV and wind sold RECs	Scope 2
<b>FY 2026 – Net Zero Emission Source</b>	
STM natural gas – heating	Scope 1
STM natural gas – process	Scope 1
STM purchased electricity	Scope 2
STM solar PV and wind sold RECs	Scope 2
Both campuses motor equipment	Scope 1
Both campuses fleet vehicles	Scope 1
Both campuses research vehicles	Scope 1
Both campuses fluorinated gases	Scope 1
Both campuses refrigerants	Scope 1
Both campuses purchased GHG gases	Scope 1
Both campuses on-site septic	Scope 1
T&D Losses	Scope 3
<b>FY 2030 – Net Zero Emission Source</b>	
Both campuses generators	Scope 1
All staff business travel	Scope 3
All staff commuting	Scope 3
STM wastewater	Scope 3
All landfill disposal	Scope 3

NREL’s Annual Laboratory Plan details a comprehensive campus strategy that identifies key investments in facilities, infrastructure, and equipment aligned with the three critical research objectives—*Integrated Energy Pathways, Electrons to Molecules, and Circular Economy for Energy Materials*—in its 10-year vision. NREL is incorporating the principles and outcomes of these key initiatives as tactical measures to enable the achievement of net-zero emissions for all NREL operations. Major initiatives are being tracked through NREL’s Lab Agenda Dashboard.

Net-zero emissions implementation will emphasize synergistic relationships of technology solutions and interoperability within the energy ecosystem with an ultimate goal of creating replicable processes. A critical path to attain this knowledge occurs in the utilization of 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 between the power system, vehicles, buildings, and other supporting infrastructure.

Photo by Joshua Bauer, NREL 61828



# CURRENT EMISSIONS PROFILE

## a) Major Emissions

### GRID ELECTRICITY CONSUMPTION

**Grid electricity consumption** is the largest source of GHG emissions for NREL. These Scope 2 emissions are associated with purchased electricity through Xcel Energy. Even though Xcel Energy has committed to delivering electricity with carbon emissions reductions of 80% by 2030 it does not meet NREL's timetable of utilizing electricity from clean renewable resources by 2026. So NREL must investigate options that will meet the laboratory's accelerated goals. In addition to ongoing efforts in energy efficiency through programs such as Smart Labs, NREL is developing an energy savings performance contract (ESPC) to address nearly 80 energy conservation measures (ECMs) identified during previous Energy Independence and Security Act (EISA) audits on the STM and Flatirons campuses. These efforts will reduce the overall electrical load required to serve the campus by an estimated 1,400 megawatt-hours (MWh) per year while improving operations and resilience. NREL's specific approach to reach net-zero emissions for the entirety of the remaining electrical load includes:

#### Flatirons Campus:

- Currently exports solar photovoltaic (PV) and wind energy generation (with both operational and research assets) to fully offset purchased electricity—NREL will verify that the avoided carbon emissions of exported electricity transfer to the Flatirons Campus' net-zero carbon status.
- Install energy storage to manage peak demand and capture renewable energy production to demonstrate the shift of the campus to 24/7 carbon-free energy operations for a bounded period of time.
- Update design standards to require all new facilities to be designed and constructed as net-zero energy through the incorporation of renewable energy technologies such as solar PV, wind, and energy storage.

#### STM Campus:

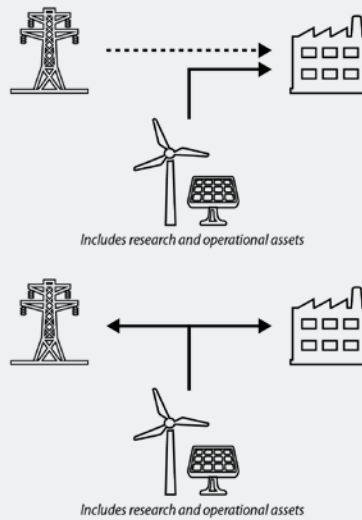
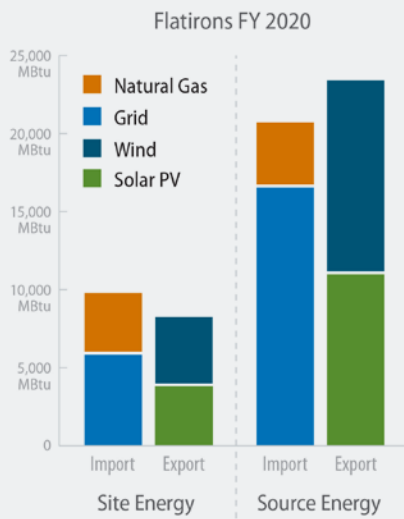
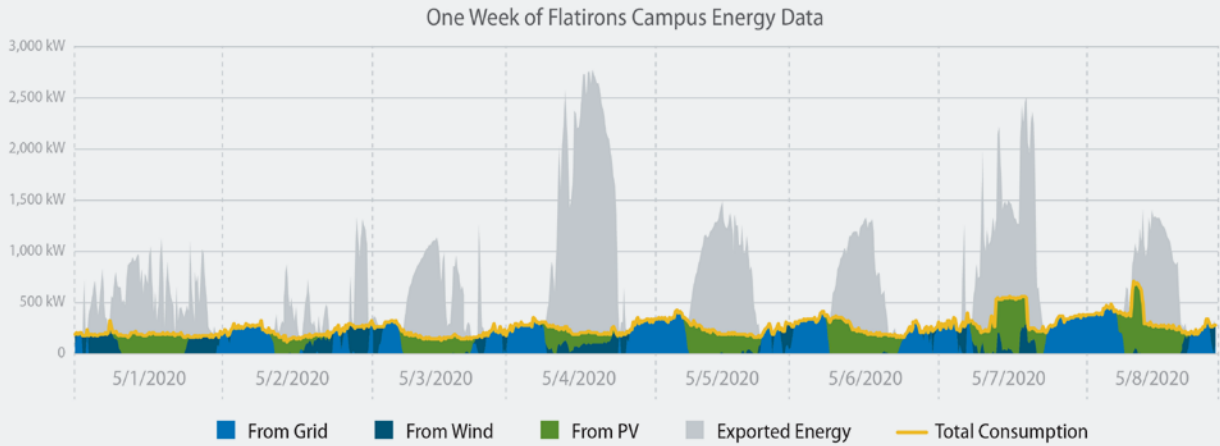
- Negotiate off-site renewable energy purchases (from Xcel Energy—NREL's utility provider— or third-party renewable energy developers) to eliminate emissions from non-renewable grid electricity.
- Maximize STM Campus on-site renewables using solar PV power purchase agreements (PPAs) and electricity storage to prevent grid export (for compliance with current Xcel agreements).

- Maximize Flatirons Campus on-site renewables by installing on undeveloped parcel locations and use exported energy to offset consumption of STM Campus (requires negotiation with Xcel Energy).
- Partner with federal agencies to utilize land for off-site renewables or purchase solar and wind generation via PPAs.
- Update design standards to require all new facilities to be designed and construction as net-zero energy through the incorporation of renewable energy technologies such as solar PV, wind, and energy storage.

#### Leased Facilities (Cold Climate Housing Research Center, Denver West, ReFUEL, Golden Warehouse and Washington, DC office):

- For current leased facilities where NREL pays directly for utility bills, work closely with lessors to improve energy efficiency within the facilities.
- Prioritize energy efficiency for any new lease procurements in the future.

# Flatirons Zero Energy Campus: FY 2020



**Figure 1:** Summary of net-zero energy operations at the Flatirons Campus: The campus is net-zero electricity on a site-energy basis and net-zero energy on a source-energy basis. Site energy is the total energy consumption at the campus. Source energy is the total energy consumption at the campus plus estimated delivery and production losses.

## NATURAL GAS USED FOR HEATING

**Natural gas used for heating** is another large source of emissions at NREL currently provided by Xcel Energy. At the STM Campus, NREL currently mitigates approximately 50%-55% of the emissions for district heating<sup>2</sup> through the Renewable Fuel Heat Plant (RFHP) biomass plant. NREL intends to convert all heating loads to electric or non-carbon sources, with the investigation of renewable natural gas, to reach net-zero emissions for the remaining natural gas load by campus:

### Flatirons Campus:

- Eliminate natural gas by converting four existing facilities to use electric heating.
- Update mechanical standards to require electric thermal infrastructure for all new construction (currently implemented).

### South Table Mountain Campus:

- To eliminate most of the natural gas consumption, transition to carbon-free district heating/cooling (e.g., combining geothermal, solar thermal, heat pumps, electric boilers, waste heat reuse, thermal storage).

- Design new buildings to use all electric heating (e.g., ambient loop central plant, ground-source heat pumps) and/or to utilize low-grade waste heat (95°-110°F) from the high-performance computer (HPC) or other process loads.
- Retrofit 11 existing buildings during upgrade projects to eliminate natural gas heating.
- Identify true life-cycle carbon emissions associated with wood chip biomass used as fuel for RFHP and purchase carbon offsets to cover residual emissions.
- Purchase carbon offsets for any natural gas used for research purposes that cannot be eliminated.

## EMPLOYEE BUSINESS TRAVEL AND COMMUTING

**Employee business travel and commuting** constitute the other largest percentage of emissions at NREL. These Scope 3 emissions are challenging to mitigate because they are dependent upon options and choices outside of NREL's operational control. Initial shifts to larger amounts of teleworking will have a significant impact on commuting emissions, estimated at a 15%-20% reduction. NREL's additional approaches to decarbonizing employee commuting and business travel are estimated to reduce emissions by 2%-5% annually, and the remaining emissions will be mitigated through responsible carbon offset purchases.

### Employee Commuting:

- Continue initiatives to reduce single-occupancy vehicle trips by encouraging alternative commuting options (e.g., public transit, carpooling, vanpooling, walking, biking, telework).
- Investigate opportunities for shuttle fleet emissions reductions, including replacement of existing E85 shuttles with electric shuttles and reducing the number of shuttles and shuttle trips using detailed ridership data.

<sup>2</sup> District heating and cooling refers to thermal energy, in the form of hot and chilled water, generated at the central plant and then delivered to the building.



### Business Air and Ground Travel:

- Encourage employees to take advantage of virtual options where applicable rather than traveling via air/ground for business travel.
- For local business travel, encourage the use of General Services Administration (GSA) fleet vehicles powered by renewable energy (e.g., electricity or hydrogen), when this becomes feasible.

## FLEET AND MOTOR VEHICLE EMISSIONS

**Fleet and motor vehicle emissions** are a small percentage of NREL's total emissions profile, but these emissions sources have a large impact on the Department of Energy (DOE) and those with larger fleets. NREL plans demonstrate a replicable pathway towards creating zero emissions vehicle fleet.

- Convert fleet to zero emissions vehicles (i.e., battery or hydrogen) as soon as suitable vehicles become available commercially (for owned vehicles) or on the GSA schedule (for leased vehicles).
- Leverage existing electric vehicle (EV) charging infrastructure (123 Level 2 electric vehicle chargers for workplace charging; four additional chargers dedicated for fleet vehicles) for fleet charging.
- Upgrade STM Campus hydrogen fueling station to support medium/heavy-duty vehicle fueling (in progress).
- Install EV charging for heavy-duty vehicles at the Shipping & Receiving building (STM Campus) and at the Flatirons Campus.
- Phase out diesel, gasoline, and propane motor equipment for electric motor equipment as equipment becomes commercially available and require individual justification for all motor equipment purchases that are not electric.

## BACKUP-POWER EMISSIONS

**Backup-power emissions** from on-site generators are a small percentage of NREL's overall emissions profile. However, to reach net-zero emissions, these technologies must be addressed. NREL is in a unique position as a national laboratory to focus on the deployment of zero-carbon, resilient technologies for backup power with the aim of eliminating emissions from this source.

- Replace generators with carbon-free backup power technologies, such as stationary batteries, biofuel-based generators, and hydrogen fuel cells.
- Purchase carbon offsets for any diesel fossil fuel used for emergency backup power that cannot be eliminated prior to 2023 at Flatirons Campus and 2026 at STM Campus.
- Leverage advanced backup power systems for demand management to reduce/offset costs.

Photo by Joshua Bauer, NREL 61722

## b) Emissions Profile by Scope

NREL has both direct and indirect emissions spanning operations. Table 1 summarizes the main emissions category within each scope and highlights the activities that contribute to overall emissions as discussed in more detail above.

**Table 1:** Summary of FY 2019 GHG emissions for NREL by scope.

SCOPE 1 Direct emissions from sources NREL owns or controls		SCOPE 2 Indirect emissions from purchased electricity and heating		SCOPE 3 Indirect emissions from doing business	
FY 2019: 2,539 MTCO <sub>2</sub> e		FY 2019: 23,518 MTCO <sub>2</sub> e		FY 2019: 9,948 MTCO <sub>2</sub> e	
Stationary		Purchased Electricity		T&D Losses	
natural gas	2,379 MTCO <sub>2</sub> e	Flatirons Campus	978 MTCO <sub>2</sub> e	T&D losses	1,102 MTCO <sub>2</sub> e
Mobile		STM Campus	21,993 MTCO <sub>2</sub> e	Employee Commuting	
generators	10 MTCO <sub>2</sub> e	leased buildings	518 MTCO <sub>2</sub> e	all staff	4,406 MTCO <sub>2</sub> e
fleet vehicles	92 MTCO <sub>2</sub> e	Biomass (Wood Chips)		Business Travel	
motor equipment	36 MTCO <sub>2</sub> e	Renewable Fuel Heat Plant (RFHP)	29 MTCO <sub>2</sub> e	air travel	3,823 MTCO <sub>2</sub> e
Fugitive			2,989 MTCO <sub>2</sub> e*	ground travel	433 MTCO <sub>2</sub> e
refrigerants and fugitive gases	0 MTCO <sub>2</sub> e			Waste	
on-site septic systems	9 MTCO <sub>2</sub> e			off-site wastewater treatment	8 MTCO <sub>2</sub> e
dry ice for research	13 MTCO <sub>2</sub> e			landfill	176 MTCO <sub>2</sub> e

\*biogenic emissions from the RFHP are reported but not included in totals

\*\*all scope emissions include impacts from DOE Golden Field Office (GFO) because they operate on the STM campus



# TIMELINE AND GOALS

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## a) Near-term (1–2 years) emissions-related milestones

- Operate the Flatirons Campus at net-zero emissions by end of FY 2023.
- Mitigate all electrical emissions through on-site generation and green power purchases by end of FY 2022.
- Conduct assessments and finalize plans for STM central plant conversion, distributed energy district to support STM east campus expansion, fleet electrification, and EMIS integration.
- Messaging campaign that highlights low-carbon options for employee business travel and commuting to influence behavior choices.
- Award an ESPC to implement ECMs that target emissions reductions across both campuses.
- Begin PPA development for new on- and off-site renewable energy systems.
- Participate in Technical Resilience Navigator (TRN) DOE pilot effort to update vulnerability and resilience assessment and coordinate with net-zero emissions efforts.
- Co-lead a workshop for DOE national labs on net-zero emissions 1st quarter of FY 2022 with the labs participating in the DOE Net Zero Labs pilot. Co-lead follow-on engagement activities with the DOE national labs.

## b) Medium-term (by 2026) emissions-related milestones

- Operate the STM Campus at net-zero emissions by end of FY 2026.
- Operate the Flatirons Campus at net-zero emissions.
- Install on-site solar PV at the STM and Flatirons campuses to maximize on-site renewable energy production.
- Purchase responsible carbon offsets for any emissions that cannot be eliminated or replaced by end of FY 2024 for all NREL operations.
- Create carbon emission metrics and dashboards for ongoing monitoring and communication to staff and visitors on net-zero emissions progress.
- Conduct assessments to demonstrate 24/7 carbon-free energy at NREL

## c) Long-term (by 2030) emissions-related milestones

- Demonstrate the operation of 24/7 carbon-free energy at NREL's Flatirons Campus.
- Replace all on-site generators with carbon-free backup power technologies, such as stationary batteries, biofuel-based generators, and hydrogen fuel cells at both campuses.
- Develop programs and policies to reduce Scope 3 emissions for all NREL campuses as much as possible. Where opportunities exist, utilize carbon-free solutions. Purchase carbon offsets on an annual basis into the future to address remaining emissions.
- Review supply chain of all procurement to reduce embodied carbon emissions.

Photo by Joshua Bauer, NREL 61803

## ESTABLISHMENT OF BOUNDARY SCOPE AND TRACKING METRICS

NREL operates and manages two campuses: the 327-acre STM Campus in Golden, Colorado, and the 305-acre Flatirons Campus in Arvada, Colorado, which together include approximately 1.2 million square feet of facilities and support research for optimizing energy technologies and systems. NREL also leases an additional 195,000 square feet of facilities where NREL has limited operational control. NREL's operational energy portfolio incorporates production from wind, solar PV, and biomass to offset grid electricity and natural gas consumption for campus facilities (see Figure 2 for a summary of NREL's energy mix on the STM and Flatirons campuses). Xcel Energy provides grid electricity and natural gas to both NREL campuses and most all leased spaces.

NREL manages performance simultaneously from an enterprise-wide perspective and at the building level to attain a comprehensive understanding of the energy footprint of each operational asset. NREL enables this approach by capturing, monitoring, analyzing, and storing historical energy data within an open-standard modular building analytics platform. The collection of this data provides insight to continuously improve energy performance and creates the foundation of the laboratory's energy management information system (EMIS).

Additionally, NREL manages its campuses from an adaptive perspective, and, by completing its first vulnerability and resilience assessment in June 2015, the laboratory identified actions to reduce operational risks through addressing site vulnerabilities associated with natural hazards. Implementation of select initiatives identified in the *Opportunities for Emissions Reduction* section will continue to be investigated with the goal of deployment.

NREL will verify success by tracking and measuring strategic metrics including:

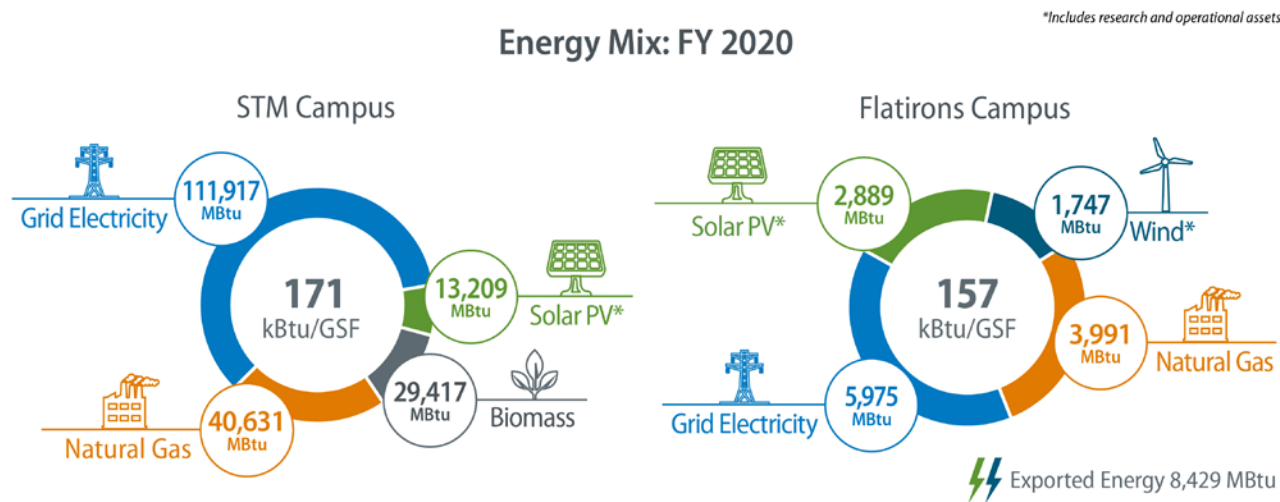
- Reduction of total annual GHG portfolio roll-up
- Utilize the EMIS to capture building energy and alignment with real-time GHG emissions
- Increase number of facilities converted to all electric
- Reduce EUI (energy use intensity) for existing facilities
- Increase total on-site MW of renewable energy production (research and operational)
- Increase total on-site battery capacity (research and operational)
- Track number of executed ECM projects and MW/MWh as well as thermal savings
- Track number of employees teleworking.



Ongoing assessments will measure and model NREL's current and future energy consumption, incorporating the laboratory's cutting-edge tools and visualization capabilities to analyze and evaluate tangible investments and infrastructure development opportunities. This will include the use of NREL's modeling tools such as Open Studio, ReOpt, UrbanOpt, TRN, and others.

NREL plans to leverage its Intelligent Campus platform, which is designed to de-risk, optimize, and secure current energy systems and provide insight into the operation and performance of future energy systems. The laboratory is pursuing a multiphase effort to

develop a "digital twin" of its own facilities, for both the STM and Flatirons campuses. Early phases will digitize static data (utility infrastructure, building plans, etc.); later phases will incorporate dynamic data, predictive analytics, simulation, active feedback and control and master planning abilities for future infrastructure investments. The Intelligent Campus platform prioritizes the use of a common, interoperable schema to maximize the flexibility and utility of the digital twin models. The campus digital twin will de-risk pilot projects by allowing their investigation in simulation prior to implementation and will support both annual lab plan investments and long-term strategic planning initiatives for campus expansion.



**Figure 2:** Summary of NREL's energy mix on the STM and Flatirons campuses. Reflects the sources of energy used for all building loads on each of the campuses.



# OPPORTUNITIES FOR EMISSIONS REDUCTION

The opportunities explained below will, in combination, bring NREL’s operations to net-zero emissions. These opportunities and goals can only be achieved with sufficient funding. Further assessment of opportunities is required to identify feasible solutions, and most of the cost estimations will require refinement once technologies and pathways are established.

## a) Direct Emission Reductions (Scope 1)

Scope 1 – Opportunities		Emissions Impact	Goal	Timeline
1.	<b>Eliminate the use of natural gas on the Flatirons Campus</b>	6% replacement of stationary emissions	FY 2023	FY 2022-2023
2.	<b>Convert the NREL fleet to zero emissions (electric or hydrogen)</b>	63% replacement of mobile emissions	FY 2023 and FY 2026	FY 2023-FY 2027
3.	<b>STM carbon-free district heating and cooling</b>	54% replacement of stationary emissions	FY 2024	FY 2023 - 2026
4.	<b>Carbon-free backup power technologies</b>	7% reduction in mobile emissions	FY 2023 and FY 2026	FY 2022-FY 2030
5.	<b>Eliminate the use of natural gas for heating on the STM campus</b>	37% replacement of stationary emissions	FY 2026	FY 2022-FY 2026
6.	<b>Electric heating for all new buildings</b>	No additional stationary emissions	FY 2026	Ongoing
7.	<b>Distributed Energy Districts</b>	No additional stationary emissions	FY 2026	Phased with construction of new facilities
8.	<b>Non-carbon wastewater treatment at Flatirons Campus</b>	41% reduction in fugitive emissions. Powered with non-carbon energy	FY 2023 - assessment will be conducted	Phased with construction of new facilities
9.	<b>Implement a Smart Labs Program</b>	5%–15% reduction in Scope 1 emissions	FY 2026	Ongoing

## OPPORTUNITY:

### ***Eliminate the use of natural gas on the Flatirons Campus***

Convert four existing facilities from natural gas heating to electric heating. All electricity at the Flatirons Campus will be generated through renewable energy on-site or through green power, thereby eliminating current GHG emissions caused by natural gas heating.

**Estimated duration:** FY 2023

**Regional engagement/benefits:** Though modest air quality improvements will be realized for employees on campus, NREL's leadership by example will provide a model for local institutions for the electrification of heating.

**Current planning state:** Planning to upgrade the four facilities currently using natural gas to electric heating by end of fiscal year 2023. Once project funding is identified and approved, the NREL Project Management Engineering and Construction (PMEC) group will execute the project plans.

**Rank:** 1 of 9

## OPPORTUNITY:

### ***Convert the NREL fleet to zero-emissions (electric or hydrogen) vehicles and serve as the proving ground for federal fleet electrification***

NREL is positioned to become the federal government's first fully zero-emissions fleet through a potential partnership between NREL, DOE, GSA, and Xcel Energy. Senator Michael Bennet stated, "The DOE's Vehicle Technologies Office (VTO), 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 due to 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 ARIES investments being pursued at NREL by DOE 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 the Federal Energy Management Program (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. NREL's goal is to reduce fleet vehicle GHG emissions by more than 95%.

**Estimated duration:** Plans to replace vehicles up through FY 2023 through FY 2027 as battery electric vehicle (BEV), hydrogen, or plug-in hybrid electric vehicle (PHEV) vehicle types become available (preference towards BEV or hydrogen).

**Regional engagement/benefits:** [NREL is partnering with Xcel Energy on its proposed fleet deployment](#) and will engage in replicable and scalable activities that can be translated to other fleets and inform Xcel Energy's \$110M transportation electrification plan.

**Current planning state:** NREL has developed an electric fleet implementation strategy that has been socialized with DOE, GSA, and utility stakeholders. This plan includes a rollout timeline for electrifying all light-, medium-, and heavy-duty vehicles that are part of the NREL fleet as well as installing several high-power chargers needed to meet the needs of medium- and heavy-duty vehicles. NREL has worked with Idaho National Laboratory, the Office of Energy Efficiency

and Renewable Energy (EERE) Deputy Assistant Secretary for Sustainable Transportation, VTO, and the Hydrogen and Fuel Cell Technologies Office to scope out an accompanying research strategy that will ensure that this fleet deployment will enable more rapid electrification of the broader federal fleet. Finally, NREL has been working with Xcel Energy to identify any utility-level activities that can facilitate EV deployment and operation (e.g., battery storage for resiliency, pilot rates, etc.). These activities are being formalized in a partnership and scope of work with Xcel Energy.

NREL is reviewing costs with GSA to determine pathways for decreasing costs.

**Rank:** 2 of 9

## OPPORTUNITY:

### ***STM carbon-free district heating and cooling***

The STM Campus has eight major facilities connected to the campus central plant. The central plant provides hot and chilled water for heating, cooling, and research needs in these facilities. NREL intends to migrate these facilities to a carbon-free district heating and cooling system.

**Estimated duration:** FY 2023 to FY 2026

**Regional engagement/benefits:** Multiple regional partners have central heating and cooling systems as well as aggressive carbon goals. Using NREL developed tools and in partnership with research teams such as the Building Technologies and Science Center (BTSC), NREL will determine the best path forward for a carbon-free district heating and cooling system. This will make NREL a resource for these types of upgrades with other organizations.

**Current planning state:** Current assessment efforts include performing simulations first to determine system type options. Further analysis will investigate delivery and equipment options, implementation phasing, and funding sources. Funding vehicles such as an ESPC will be explored as a viable path.

**Rank:** 3 of 9

## OPPORTUNITY:

### ***Carbon-free backup power technologies***

NREL will strategize a transition to carbon-free backup power technologies, starting with new facilities and gradually replacing existing diesel generators. This will begin with a feasibility study and subsequent installation of a small, carbon-free microgrid at the STM South Site Entrance Building (SSEB), replacing the existing backup generator and inefficient uninterruptible power supply. This microgrid will make the SSEB an interconnected grid-interactive efficient building, supporting the goal of achieving continuity of operations in an emergency while eliminating the use of fossil fuels in the facility. This pilot is intended to enhance NREL's understanding of microgrid system components and control requirements, with an eye toward scaling to larger facilities. In the long term, replacement backup power technologies may include stationary batteries, on-site renewables, biofuel-based generators, and hydrogen fuel cells. Such technologies can simultaneously provide demand management at NREL's campuses, including export prevention (a current Xcel interconnection requirement at the STM Campus) and peak demand reduction. These value streams may significantly reduce the cost of conversion to carbon-free backup power systems, or even make such systems cost-negative.

**Estimated duration:** Formal assessments to begin in FY 2022 with planned installation starting in FY 2025. By the end of FY 2030, NREL anticipates all backup power systems will operate from non-carbon sources.

**Regional engagement/benefits:** There are currently very limited applications for carbon-free backup power technologies. Demonstrating the feasibility of shifting to carbon-free backup power in a laboratory application, like NREL, will have benefits to other government agencies, communities, universities, institutions, and businesses looking for ways to reduce their carbon footprints.

**Current planning state:** Currently NREL is exploring opportunities and technologies to develop a formal scope of work to assess technologies and costs for future installation.

**Rank:** 4 of 9



**OPPORTUNITY:**

***Eliminate the use of natural gas for heating on the STM Campus***

Eleven facilities on the STM campus use standalone natural gas systems for heating and are not connected to the district hot water system. All these facilities are planned to be retrofitted with electric heating to eliminate the use of natural gas.

**Estimated duration:** Assessments beginning in FY 2022 with planned implementation by end of FY 2026.

**Regional engagement/benefits:** Though modest air quality improvements will be realized for employees on campus, NREL's leadership by example will provide a model for local institutions for the electrification of heating.

**Current planning state:** Assessments are planned to begin in FY 2022 to determine options and specific pathways forward unique to each building.

**Rank:** 5 of 9

**OPPORTUNITY:**

***Electric heating for all new buildings***

New facilities will be designed to use all electric heating (e.g., ambient loop central plant, ground-source heat pumps) and/or to use low grade waste heat (95°-110°F) from the HPC on the STM Campus or process loads wherever possible.

**Estimated cost:** : \$4M-\$6M in additional project costs for planned new facilities on the STM Campus.

**Estimated duration:** Ongoing as buildings are designed.

**Regional engagement/benefits:** NREL has been able to globally share its design and process to construct the net-zero Research Support Facility and the LEED Platinum Energy Systems Integration Facility (ESIF), which houses the most

energy efficient data center in the world. New facilities using innovative technologies, design processes, and structures to reach goals of all electric heating could be similarly shared to highlight the pathway to be carbon-neutral facilities.

**Current planning state:** Standards are in the process of being updated in the NREL engineering department.

**Rank:** 6 of 9

## OPPORTUNITY:

### ***Distributed Energy Districts***

As NREL expands its facilities at both the STM and Flatirons campuses, it should take advantage of the opportunity to develop distributed renewable energy districts, leveraging NREL's own research expertise on the subject. Alternative thermal energy sources such as ground-source heat pumps, air-source heat pumps, and other electric HVAC technologies that reduce emissions will be evaluated for their potential to support buildings that serve simultaneously as research projects and operations assets. Implementing an autonomous (islanded) distributed energy district on an NREL campus is a long-term goal that requires a phased approach to manage risks associated with disconnecting from the electrical grid.

At the Flatirons Campus, supported by ARIES, NREL has an opportunity to investigate a utility-scale energy district with bidirectional electricity flows, allowing research into both practical operation (such as demand management, district-scale microgridding, and black start) and financial factors (such as utility rate structures and load flexibility). At the STM Campus, which is capacity and export constrained, a distributed energy district would investigate behind-the-meter design and control strategies to minimize utility energy costs and maximize flexibility within interconnection constraints. At both campuses, providing energy system resilience by enabling islanded operation is a key long-term strategy to address climate vulnerabilities.

**Estimated duration:** Ongoing as building and campus expansions are planned.

**Regional engagement/benefits:** Many communities around the nation are starting to engage in discussion to implement these types of systems, which are particularly applicable to remote and islanded communities who are limited or unable to connect to a local utility. The fabrication of a district energy system on NREL's campus provides a testing and validation venue to advance interoperability, performance, resilience, and cybersecurity operations. The NREL Site Operations team collaborates with the BTSC, Energy

Security and Resilience, and others. Through these research groups, NREL will align with the Building Technology Office (BTO)'s intention and direction.

**Current planning state:** Initial analysis has been conducted for the STM Campus. NREL researchers are currently finalizing the scope of an assessment for the eastern expansion of the STM Campus to determine the most efficient options for a distributed energy district given NREL's programmatic and infrastructure needs.

**Rank:** 7 of 9

## OPPORTUNITY:

### ***Non-carbon wastewater treatment at Flatirons Campus***

The Flatirons Campus water system is targeted for upgrade in the next few years. Once that upgrade is complete, NREL will have met its capacity for leach field space and will require a new wastewater treatment plant. This future treatment system will serve the campus's office buildings and research facilities. NREL is seeking a viable alternative to conventional systems to shift from mere disposal to reuse and recovery to 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 will ultimately showcase what will be built to pilot advanced technologies for wastewater treatment.

**Estimated duration:** Conducting assessment in FY22 for technology solution. Funding not currently allocated. Estimated FY 2026.

**Regional engagement/benefits:** Application for remote or islanded communities because this will be an example of a closed-system application.

**Current planning state:** Conducting an assessment for design and construction of innovative on-site wastewater treatment systems. Next step is to provide a system assessment report evaluating multiple wastewater treatment technologies for future use at the Flatirons Campus.

**Rank:** 8 of 9

## OPPORTUNITY:

### **Implement a Smart Labs Program**

After NREL's participation in the Better Building Smart Labs Accelerator, NREL's Site Operations and Environment, Safety, Health, and Quality organizations partnered to develop a Smart Labs program in FY 2021. Laboratory buildings are complex, challenging to operate, and use large amounts of energy to provide safe and controlled workspaces for researchers. Smart Labs provides a systems-based management approach that optimizes laboratory performance to improve safety and health and reduce energy consumption.

**Estimated cost:** Costs are estimated at \$5M–\$10M and will be determined by individual building assessments.

**Estimated duration:** Ongoing. NREL is finalizing a pilot of the program in the ESIF in FY 2021 and will roll out the program to existing laboratories and new laboratories going forward.

**Regional engagement/benefits:** NREL collaborates on Smart Labs initiatives with other national laboratories, local universities, and other federal partners. Improvements of

laboratory operations reduce energy use and improve safety for researchers and the community. NREL has a corporate membership with the International Institute for Sustainable Laboratories and will continue to present case studies and lessons learned through their regional and national events.

**Current planning state:** The ESIF pilot is underway, and NREL is currently developing plans for long-term sustainability of the program.

**Rank:** 9 of 9

## b) Indirect Emission Reductions (Scope 2)

Scope 2 – Opportunities	Emissions Impact	Goal	Timeline
<b>1. ESPC/Savings Reinvestment Program</b>	4%–10% reduction of purchased electricity and stationary emissions	FY 2023, FY 2026, and FY 2030	FY 2022 assessment, FY 2023–2026 implementation
<b>2. Green Power Purchase</b>	100% replacement of purchased electricity emissions	FY 2023 and FY 2026	FY 2022- Flatirons FY 2026-STM and leased spaces
<b>3. On-Site Renewable Electricity</b>	5% replacement of purchased electricity emissions	FY 2023, FY 2026, and FY 2030	FY 2022 assessment with FY 2026 installation
<b>4. Off-Site Renewable Energy</b>	Up to 100% replacement of purchased electricity emissions	FY 2023, FY 2026, and FY 2030	FY 2022 exploration and FY 2025-2030 installation
<b>5. Creation of New Standards and Master Planning</b>	Emissions reduction incorporated into building design and campus planning	FY 2023, FY 2026, and FY 2030	Ongoing
<b>6. Monitoring-Based Commissioning</b>	2%–10% reduction of purchased electricity and stationary emissions	FY 2023, FY 2026, and FY 2030	Ongoing
<b>7. 24/7 Carbon-Free Energy Operations</b>	100% replacement of purchased electricity emissions	FY 2030	Ongoing, demonstration in FY 2030

## OPPORTUNITY:

### **ESPC/Savings Reinvestment Program**

NREL is utilizing the financial mechanism of an ESPC to implement an extensive list of backlogged ECMs. NREL's team found that, through the installation of approximately 80-100 identified ECMs across both the STM and Flatirons campuses, it will be possible to achieve significant cost savings as well as implement cybersecurity and reliance measures. Additionally, NREL is pursuing a Savings Reinvestment program, which would allow NREL to capture the savings from energy conservation projects and use those savings to fund future projects.

**Internal:** Once ECMs are identified and enacted, NREL operations will maintain energy savings.

**Partners:** The contracted energy service company (ESCO) will identify ECMs and upgrades to reduce overall energy consumption and thereby emissions.

**Estimated duration:** ESCO assessment to be conducted in FY 2022 and implementation through the end of FY 2026.

**Regional engagement/benefits:** The implementation of ECMs by an ESCO will support regional clean energy jobs.

**Current planning state:** An ESCO has been selected by DOE GFO to conduct a detailed assessment. If that assessment is adequate, DOE GFO will move forward with contracting with the ESCO for an ESPC.

**Rank:** 1 of 7

## OPPORTUNITY:

### **Green Power Purchase**

NREL will purchase green power through Xcel Energy to mitigate Scope 2 emissions that cannot be replaced through current opportunities of on-site or off-site renewable energy systems. These purchases will signal to NREL's utility provider the demand for additional renewable energy options.

**Internal:** Identify estimated total MWh to be mitigated through the program.

**Partners:** Xcel Energy to provide green power options and pricing.

**Estimated duration:** NREL anticipates the purchase of green power for the Flatirons Campus beginning in FY 2022. Plans to purchase green power for the STM Campus and leased spaces in FY 2026. Future purchases are dependent on on-site and off-site renewable energy installations.

**Regional engagement/benefits:** Support for green power plans with Xcel Energy sends a market signal to increase the renewable energy options at the utility scale. Increasing renewable energy at the utility level benefits all customers in the region.

**Current planning state:** Xcel Energy has provided a quote for the premises in NREL's operations. Costs for the Flatirons Campus are in the planned utilities budget for FY 2022.

**Rank:** 2 of 7

## OPPORTUNITY:

### **On-Site Renewable Electricity**

NREL plans to maximize opportunities for the installation of on-site renewable energy (mainly solar PV) systems on the STM and Flatirons campuses. This amounts to an estimated 1.5 MW of solar PV on STM campus. NREL plans to utilize PPA mechanisms for these installs and include electricity storage to increase resilience.

**Internal:** NREL staff to develop the request for proposal (RFP) and requirements for on-site systems with coordination and support from DOE GFO and internal research staff.

**Partners:** Support from the Western Area Power Administration (WAPA) to facilitate PPA contracts between the installer and DOE GFO will be required as well as support and cooperation with Xcel Energy to permit the project and renegotiate the STM tariff to allow for energy export.

**Estimated duration:** Conduct assessments in FY 2022 and installation by the end of FY 2026.

**Regional engagement/benefits:** Finding new options for the Xcel tariff on the STM Campus could benefit other businesses as use of renewable energy increases.

**Current planning state:** Analysis has been completed for estimated totals for installation. Beginning discussions with WAPA, Xcel, and DOE GFO on potential for developing an RFP for PPA and installation.

**Rank:** 3 of 7

## OPPORTUNITY:

### **Off-Site Renewable Energy**

NREL is exploring opportunities to develop off-site renewable energy purchases (from Xcel Energy or others) to eliminate emissions from non-renewable grid electricity. A multitude of ideas are being considered and explored including floating solar PV, partnering with tribal communities, and partnering with the state or other entities interested in solar PV and renewable energy development. One option will be to partner with federal agencies within the local and GSA Region 8 region to utilize land and combined purchasing power for off-site renewables.

**Internal:** Determine potential partners for off-site solar PV or other renewable energy systems and investigate opportunities.

**Partners:** Xcel will be an important partner in determining how off-site-system renewable energy credits and energy can be attributed to NREL. Cooperation with other partners such as Denver Water, Consolidated Mutual Water, Colorado State office, Jefferson County, tribal entities, and others will be considered as options are explored. This opportunity requires the use of land outside of NREL's control and therefore is dependent upon relationships and negotiation with other community entities. GSA and other GSA Region 8 partners will need collaboration with Xcel Energy (or other utilities) to resolve contractual structures for ownership and operation. Could require additional cooperation with the Public Utilities Commission and the state government of Colorado (or others) dependent on size, location, and system type. There is also the intention to partner with tribes within the state of Colorado to create mutually beneficial partnership.

**Estimated duration:** Begin exploration in FY 2021 and, depending on project size, location, and partnership, could extend into FY 2025–2030.

**Regional engagement/benefits:** Expand renewable energy production throughout the state and develop new or expanding relationships between NREL and the wider community. Coordination with other federal agencies will be enhanced and will leverage NREL's support of FEMP to achieve energy efficiency in federal buildings.

**Current planning state:** Developing and exploring ideas for further feasibility assessment in FY 2022.

**Rank:** 4 of 7

## OPPORTUNITY:

### ***Creation of New Standards and Master Planning***

NREL intends to develop campus facilities and infrastructure master plans for both the STM and Flatirons campuses. This effort will establish a process to translate NREL goals, objectives, and design principles into a framework to guide short-term and long-term physical development of the STM and Flatirons campuses to support NREL's strategic intents identified in its annual plan and 10-year Campus Master Plan. Additionally, NREL will update design and construction standards, requiring all new facilities to be constructed to utilize electrification only, have reduced embodied carbon, and operate as net-zero-energy facilities. For new retrofit projects, standards will be updated to require all facility retrofit construction projects to implement all-electric, high-efficiency, carbon-free backup power and PV-ready improvements.

**Internal:** Requires coordination with NREL Project Management, Engineering, and Construction (PMEC) as well as other planning entities within NREL. Will also require direction and discussion with DOE GFO.

**Partners:** Design-build teams and other subcontractors will be tasked with implementing this direction and design. Utility providers such as Xcel Energy and Consolidated Mutual Water will be critical in determining possible pathways and options for expansion.

**Estimated duration:** Plans to update standards by end of FY 2022; unknown timeline for master planning.

**Regional engagement/benefits:** The development of a campus master plan offers an opportunity to enhance awareness, communication, and coordination with planning of regional stakeholders such as the city of Golden, Jefferson County, the state of Colorado, and nearby neighborhoods.

**Current planning state:** Standards for electrification have been updated for the Flatirons Campus, and additional standards will be reviewed going forward. Master planning has been identified as a need at NREL.

**Rank:** 5 of 7

## OPPORTUNITY:

### ***Monitoring-Based Commissioning***

NREL will establish a monitoring-based commissioning (MBCx) program to continuously assess and optimize facility energy performance using NREL's Intelligent Campus platform. The MBCx program's first task will be to thoroughly address outstanding ECMs identified in prior year EISA audits. The team then will manage future year EISA audits, retrocommissioning (RCx), and ongoing commissioning (OCx) to identify and resolve new ECMs and improve performance across all NREL facilities. The program will perform measurement and verification of energy savings and track cumulative savings in support of an energy savings reinvestment program, which can fund capital-intensive ECMs as well as control systems improvements needed to perform effective RCx and OCx in existing NREL facilities.

**Internal:** Overall reductions in energy consumption will reduce energy load and thereby reduce total emissions. NREL will continue to prioritize energy efficiency and reduce emissions wherever possible.

**Partners:** Xcel Energy will be a main partner in this effort. As Xcel moves toward its goal of providing 100% carbon-free electricity, this will reduce the emissions attributed to NREL from a regional GHG accounting perspective and eventually will reduce the eGRID calculations as well.

**Estimated duration:** Ongoing.

**Regional engagement/benefits:** Analytics and savings identified through monitoring will further enable ECM implementation and therefore regional clean energy jobs. Coordination with other federal agencies will be enhanced and will leverage NREL's support of the FEMP to achieve energy efficiency in federal buildings.

**Current planning state:** Idea developed. Requires funding and dedicated staff to execute.

**Rank:** 6 of 7

## OPPORTUNITY:

### ***Demonstration of 24/7 Carbon-Free Energy Operations***

NREL plans to install energy storage at the Flatirons Campus to manage peak demand and capture renewable energy production. Through this technology, and potentially others, NREL will shift the campus load to demonstrate 24/7 carbon-free energy operations.

**Internal:** NREL will assess the campus profile of renewable energy and energy storage systems to develop a strategy for 24/7 carbon-free energy.

**Partners:** Xcel Energy will be a key partner in this operational goal.

**Estimated duration:** Ongoing development. Demonstration planned for FY 2030.

**Regional engagement/benefits:** NREL's leadership by example will provide a model for local institutions to implement 24/7 operations through renewable energy and energy storage solutions.

**Current planning state:** Currently in initial discussions and planning.

**Rank:** 7 of 7

## c) Indirect Emissions Reductions (Scope 3)

## OPPORTUNITY:

### ***Virtual Work Opportunity and Reductions in Single-Occupancy Vehicles Trips***

NREL will continue to encourage employees to take advantage of teleworking whenever possible and virtual options where applicable rather than traveling via air/ground for business travel. Initiatives to reduce single-occupancy vehicle trips for commuting will be continued by encouraging alternative commuting options (e.g., public transit, carpooling, vanpooling, walking, biking, and/or remote work). There is potential to reduce emissions by 2%–5% annually. NREL will purchase carbon offsets for any emission that cannot be eliminated.

**Internal:** Operations, Human Resources, and Communications staff will need to update information and programming to support initiatives to inform employees of alternative commuting options. IT and Operations will need to provide support for continued teleworking and hoteling options.

**Partners:** Regional Transportation District, NREL's local transit agency, had to limit bus routes during COVID, and NREL staff will need to advocate for connections to NREL and buses (such as the GS route) to be restored. Way to Go is an ongoing partner for alternative commuting events like GoTober and Bike to Work Day. Potential partnership with Enterprise could be explored to provide more efficient options for business vehicle rentals.

**Estimated duration:** Ongoing.

**Regional engagement/benefits:** Reducing single-occupancy vehicle trips reduces overall traffic congestion in the local Denver-metro area and, for vehicles using fossil fuel, reduces impact to local air-quality emissions. Denver continues to have high-ozone alert days throughout the summer months, and reductions in business travel and commuting at NREL would positively impact the surrounding community.

**Current planning state:** NREL is continuing current programs and expanding information and clarity of offerings through a planned upgrade to NREL's intranet information on transportation. New policies on teleworking have been approved for NREL as well. Planning for additional efforts and advocating for transit options began in FY 2021.

# ADDITIONAL ANALYSIS NEEDED

NREL will require additional assessments and feasibility studies to determine the most efficient and practical pathway forward to net-zero emissions. As the campus footprint expands, building functions change, occupancy fluctuates, and new technologies become available, NREL will rely on resilience planning, monitoring-based commissioning, maintenance, and ongoing enhancements to operational practices to continue to meet net-zero emissions goals.

To conduct these analyses, NREL will leverage its ongoing activities to conduct research and develop tools and resources in support of DOE EERE program areas, including FEMP, BTO, Solar Energy Technologies Office (SETO), VTO, and others. NREL anticipates experiences gained through its efforts to reach its net-zero emissions goals will inform future support research NREL provides to these programs.

## a) Significant Assumptions and Challenges

### I. REQUIRED FUNDING FOR PROJECTS AND UPGRADES

The pathway to net-zero emissions is dependent upon opportunities for funding. The projects identified in this report require \$250M–\$300M to reach Scope 1, Scope 2, and Scope 3 emissions replacement and reduction goals. Significant and dedicated funding and staff time is required to meet NREL's ambitious goals. NREL will utilize assessments and pilots to investigate the feasibility of a capability to substantiate proof of concept and extendibility at scale to ensure effective and efficient use of funds. Exploration of creative funding options, such as the ESPC, will also be reviewed.

### II. GREEN POWER AVAILABILITY

The overall goal is for NREL to produce electricity through on-site renewable energy systems, off-site renewable energy systems, or green power purchases. Green power opportunities are currently offered through NREL's utility provider, Xcel Energy. Xcel Energy is also on a pathway to net-zero emissions for the entire electrical grid under its control. Xcel Energy's goal is to be 80% carbon free by 2030 and 100% carbon free by 2050. While these goals will support NREL's efforts in net-zero emissions, they are not aggressive enough to meet NREL's FY 2023 and FY 2024 targets. NREL's current approach to net-zero emissions relies heavily on the conversion of natural gas and other fossil fuels to renewable electricity. NREL's strategy assumes the availability of green power options to mitigate any electricity that cannot be mitigated through on-site or off-site power purchase agreements or owned renewable energy systems. Partnership with Xcel Energy will be critical to achieving these goals.

### III. ENERGY STORAGE FOR RESILIENCE

Resilience is an important consideration in a shift to a predominantly electricity-operated campus. The availability of energy storage will be a critical cornerstone of the net-zero emissions and resilience efforts at NREL.

### IV. POPULATION

In alignment with national needs and goals, NREL anticipates continued mission growth and corresponding expansion of staff and facilities. During the next three to five years, the laboratory expects to increase by an additional 1,100 staff (approximately 200-300 new employees per year). Multiple GHG emission metrics are solely dependent upon the number of staff at NREL and cannot be mitigated, in current calculations, without reducing population. However, growth in campus energy consumption due to occupancy is partially mitigated by a ~35% shift in NREL's population towards remote and hybrid work arrangements. The COVID-19 pandemic demonstrated the feasibility of continued performance with remote work, and it is expected the shift will continue when operations return to full on-site utilization post-pandemic. The option for remote working provides many employees with a more flexible, efficient, and effective day-to-day work environment and generally shifts the paradigm of the physical laboratory as a gathering place for collaboration. This shift in occupancy will contribute to reduced campus emissions and limit the need for additional leased office space. This reduction will counterbalance expanded on-campus research that must be conducted within laboratories at increased energy loads.



## V. REAL ESTATE

NREL's STM and Flatirons campuses have limited real-estate sites available for the additional installation of dedicated renewable energy systems. At the most, NREL is forecasts capacity of 4.5 MW on the STM Campus and 3-10 MW on the Flatirons Campus. Additional research systems may be installed or contribute to the net-zero emissions goals, but these systems are research dependent and cannot be relied upon to meet NREL's goals.

## VI. PURCHASE OFFSETS

If, after significant effort, it is determined emissions cannot be eliminated through substitution

or carbon-free energy, NREL will purchase unbundled RECs or carbon offsets on an annual

basis to meet net-zero emissions targets. As part of these purchases, NREL will review carbon offset projects to determine the appropriate and effective source for carbon offset purchases. NREL has not purchased carbon offsets in the past and will need to research viable options for this service.

## VII. CHANGE MANAGEMENT

NREL's goals of meeting net-zero emissions targets require a cultural shift in operations and approach. While NREL has incorporated sustainability into building design and operation, this new direction and opportunity requires a shift of all Facilities and Operations staff to a more integrated approach to planning and conducting operations. More awareness and support from staff about the operation of a net-zero emissions laboratory will require a campaign of understanding to identify areas of concern and opportunities to collaborate and lead through NREL's research and missions.

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## b) Other Emissions

### I. RESEARCH-REQUIRED EMISSIONS

Some process emissions from natural gas and other chemicals used in research are required to meet mission. These emissions will require the purchase of carbon offsets to meet net-zero emissions goals.

### II. WASTE

On-site septic system and off-site sewer systems are emissions calculated based on population. As population increases, these emissions will also increase. NREL will have to purchase carbon offsets to meet net-zero emissions goals. Landfill emissions can be reduced, and in the future eliminated, through a net-zero-waste approach. However, limitations in recycling and costs of hard-to-recycle items may necessitate some ongoing waste to landfill.

### III. BIOMASS

NREL's RFHP uses biomass to generate hot water for district heating on the STM Campus. The RFHP provides about 56% of the STM campus's district heating throughout the October-to-May heating season. Biomass has both biogenic emissions (from the biomass itself) and anthropogenic emissions (from the burning of the biomass) that NREL is responsible for reporting on an annual basis. Biogenic emissions do not count toward the GHG goals of net-zero emissions, as these are typically assumed to be carbon-neutral emissions.

# REGIONAL ENGAGEMENT

## a) Local Utilities

NREL's main energy utility is Xcel Energy. Xcel provides grid electricity and natural gas to both the STM and Flatirons campuses as well as a few leased facilities. Xcel has committed to providing carbon-free electricity by 2050 with an interim goal of 80% carbon free by 2030. NREL leadership is meeting with Xcel Energy leadership to discuss potential partnership and efforts.

To develop on-site PPAs, NREL will also work closely with WAPA to develop contracts and agreements.

NREL is collaborating with FEMP HQ to become a pilot site to demonstrate the different PPA alternatives encompassed into this proposal. These efforts would showcase tactical process, contract mechanisms, and implementation achievements.

## b) Local Government

NREL will enter discussions with the state of Colorado to explore leasing options of mesa-top land adjacent to the STM Campus, owned by the state, to potentially locate new solar PV arrays for renewable energy generation for NREL's STM Campus.

NREL, DOE, the state of Colorado, and Jefferson County have an extensive stakeholder engagement group to create a Global Energy Park (GLO) where leaders from around the world come together to tackle the planet's most complex and urgent energy issues. The GLO will be a cornerstone facility to catalyze the future of energy, in the heart of Colorado's internationally recognized innovation ecosystem. The GLO will convene industry, government, and academia to lead the transition towards clean, renewable, sustainable, and equitable solutions, while creating advanced-industry workforce opportunities and engaging students of all ages. Harnessing the power of collaboration, the GLO will foster inclusivity and innovation in a living laboratory, catalyzing new research and technology that will fuel NREL's future. The land, a parcel of 9.27 acres, to locate such a facility is being negotiated in a two-stage land acquisition between Jefferson County, DOE GFO, and the state of Colorado.

In a historic year for the Colorado legislature, several energy-related bills aim to reduce GHG emissions

and encourage energy efficiency. From utility and weatherization assistance for Coloradans to efforts to support the modernization of infrastructure, these efforts are informing NREL's strategies:

- Senate Bill 21-264 — Adopt Programs Reduce GHG Emissions Utilities
- Senate Bill 21-246 — Electric Utility Promote Beneficial Electrification
- House Bill 21-1238 — PUC Modernizes Gas Utility Demand Side Management Standards
- House Bill 21-1286 — Energy Performance for Buildings
- House Bill 21-1303 — Global Warming Potential for Public Project Materials
- Senate Bill 21-260 — Sustainability of the Transportation System
- House Bill 21-1266 — Environmental Justice Disproportionate Impacted Community

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## c) Industrial and Commercial

As NREL develops new technologies and approaches, NREL will develop partnership opportunities through avenues such as incubator programs with private-sector partnerships.

NREL will create partnership agreements to test and validate pioneering technologies, so they have the greatest impact and transference for real-world application.

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## d) University Engagement

Engagement with universities has been part of NREL's approach since the laboratory was founded. What NREL does would not be possible without relationships with universities in terms of ideation and innovation, student and faculty engagement, and resource mobilization. Two hallmark programs known throughout the DOE ecosystem are the Solar Decathlon and the Zero Energy Design competition, for which NREL has played a founder or leadership role for many years. For the Net Zero Labs Pilot, NREL will leverage the cutting-edge applied research, state-of-the-art facilities, and NREL's visibility to work with universities engaging with students and faculty in experiential learning; conducting collaborative research; sharing best practices; and leading by example in Colorado and the region more broadly.

There is a well-established research consortium, the Colorado Energy Research Collaboratory, that includes the state's three leading universities—Colorado School of Mines, Colorado State University (CSU), and University of Colorado-Boulder—and NREL, that will be a key part of the Net Zero Labs Pilot. NREL will be able to draw

upon the exceptional record of research and education offered through the Collaboratory as well as create talent pathways for students and faculty. In addition, there will be an intentional focus to collaborate with minority-serving institutions in Colorado and the region, including Hispanic-serving institutions, tribal colleges, and community colleges.

NREL will stay true to its mission to expand its strategic engagement with universities to help build and strengthen research, faculty, and student connections in a way that promotes diversity and inclusion across the research portfolio. NREL will continue to strengthen our existing relationships, including Metro State University, CSU-Pueblo, Fort Lewis College, University of New Mexico, New Mexico State University, and the more than 20 community colleges in Colorado to become part of the Net Zero Labs Pilot. This might include technology showcases on campuses; internships and mentoring for students working side by side with NREL scientists; translating best practices from the pilot into other settings; and incorporating different perspectives into the pilot design.

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## e) Description of Engagement Strategy for Compliance

NREL has a strong [history of compliance](#) with permitting and collaboration with Jefferson County, the city of Golden, the state of Colorado, and the Environmental Protection Agency (EPA). NREL plans to meet the net-zero emissions requirements informed by extensive knowledge of Colorado and EPA air regulations and an accurate emission inventory of facility equipment and emissions.

NREL encourages use of generators that utilize the maximum number of control devices and meet air pollution regulations, as well as using alternative fuels. NREL has a limited number of allowable emissions that impact air quality, and researchers are encouraged to utilize alternative fuel sources. NREL will rely on this history and partnerships to ensure effective coordination for future installations and efforts related to net-zero emissions.

# ENERGY & ENVIRONMENTAL JUSTICE APPROACH AND STAKEHOLDER ENGAGEMENT

Collaborative, inclusive development of culturally responsive and adaptive technologies, strategies, and solutions enables communities to harness transformative technologies and innovations to best fit community needs. In turn, the lessons and insights that emerge from these successes inform early-stage research that gives rise to new equity-

centered innovations. NREL understands that net-zero emissions efforts, as an example to NREL's community and stakeholders, must be equity informed. This validated technology development is what will deliver the benefits of clean energy to a broader set of stakeholders. NREL will apply what is learned in this area to the net-zero emissions initiative.

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## a) Non-CO<sub>2</sub>-Related Air Quality Improvements

NREL has very small local air quality impacts in current operations. GHG emission limits set by the EPA are tracked and reported to DOE GFO annually, but NREL has emitted far less than the maximum limits set by EPA and does not anticipate exceeding these caps. The net-zero emissions effort will continue to lower total emissions and support continued improvements to air quality.

The largest quantities of regulated emissions from NREL are carbon dioxide (CO<sub>2</sub>) and nitrous oxide (NO<sub>x</sub>) emissions from the 12 diesel generators and 12 natural

gas boilers in operation between both campuses. The state of Colorado recently passed a new law regarding air permitting, reducing the total amount of allowable tonnage of emitted NO<sub>x</sub> to 50 tons per year (down from 100 tons per year). Currently, NREL emits about 34 tons per year. In addition to reducing overall CO<sub>2</sub> and NO<sub>x</sub> emissions, and by transitioning generators and natural gas boiler operational equipment to electrical alternatives, NREL will further reduce overall CO<sub>2</sub> and NO<sub>x</sub> emissions while allowing for the less-restrictive use of required mission-critical infrastructure.

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## b) Anticipated External Benefits to the Community

The lessons learned in reaching net-zero emissions for the NREL campuses will help streamline system-wide benefits for all, including accelerating innovations in vehicle technologies, increasing transportation

efficiency, and optimizing and integrating transportation, buildings, the grid, and renewables to realize system-wide benefits.

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## c) Identify Any Planned Engagement With Community

One barrier to the adoption of advanced technology—particularly among historically disadvantaged communities—is familiarity. Many low- and moderate-income and frontline communities have few opportunities to engage with advanced technologies. That, in turn, leaves many historically disadvantaged communities more vulnerable to either being left behind in energy transition or taken advantage of by developers who exploit this lack of familiarity. This presents a unique opportunity for NREL—which operates as a living laboratory—to engage local community members on advancing net-zero technology. NREL, through its Education Center, public tours, educational curriculum development, and an ongoing lecture series, already engages with the community. NREL can aid communities in addressing

the familiarity barrier by combining current work in community engagement with NREL's commitment to the Net Zero Labs Pilot. This type of engagement also has potential for longer-term impact in addressing diversity, equity, and inclusion—namely through introducing local students to clean energy technologies, research, and workforce opportunities.

All NREL campuses in Colorado and Alaska also have the opportunity to work with American Indian Tribes and Alaska Native Villages within their respective states. This includes engaging with local communities on net-zero campus development, hiring Indigenous staff as researchers and technicians, and ensuring that Native businesses have access to compete in various procurement processes.

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## d) Internal Engagement and Reporting Staff Engagement Plan

The NREL Communications Office has extensive experience developing tailored and effective staff communication and engagement efforts. Engagement through collaboration is one method NREL plans to utilize to bring all voices to the table. This will be done via a three-pronged approach.

First, an internal website where staff can learn the latest about how net-zero emissions efforts relate to national goals and to their own working life at the laboratory. Second, NREL is developing an online submittal tool where staff can provide ideas and input on how to reach net-zero emissions for the campuses. From researchers to support staff, NREL's employees are passionate about walking the talk, and the team will evaluate, rank, and deploy the ideas submitted. Third, through an internal

communications campaign, the team will mobilize support and interest via appropriate channels starting with internal newsletters and other channels and finally looking outward at social media and other NREL channels to engage with the public.

A large portion of NREL's indirect emissions is directly related to staff behavior and choices, specifically related to business travel and community. NREL plans to create a modernized approach to behavior change management to achieve an integrated ecosystem where people, processes, tools, tasks, and deployment of technologies are applied in the construction and operation of facilities and infrastructure.



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## e) Formal Reporting

### SITE SUSTAINABILITY PLAN (SSP) AND THE VULNERABILITY AND RESILIENCE PLAN (VARP)

NREL will continue to report annually through the SSP and the CARP to the Sustainability Performance Division (SPD) at DOE HQ. NREL and the other members of the Net Zero Labs Pilot will need to coordinate with SPD to ensure metrics and baselines for the net-zero emissions effort align with ongoing reporting through the DOE Sustainability Dashboard and SSP and CARP. NREL will report on all GHG emissions as well as projects related to net-zero emissions.

### PEMP REPORTING

NREL will report through the Performance Evaluation and Measurement Plan annual review process on mid-year and end-of-year progress to DOE GFO on goals and strategic metrics related to net-zero emissions.

### NREL LEADERSHIP AND DOE GFO

Ongoing updates on milestones and project uncertainties throughout the year.

### AIR EMISSION AND GHG INVENTORY

NREL will continue annual reporting on permitting and EPA requirements related to local air emissions and GHG impacts. These reports are related to the net-zero emission goals; however, they are driven by regulations and compliance requirements.

### ONGOING UPDATES THROUGH NREL INTRANET

As projects and assessments are completed, NREL will share internally, through the laboratory's intranet, updates on impacts to overall emissions and progress toward our goal of net-zero emissions.

# PUBLIC ENGAGEMENT

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## a) Public and Local Engagement Strategy

Following onto NREL's internal engagement efforts, NREL's Public Affairs and Government Relations teams are evaluating the best methods to engage and mobilize the surrounding community. Through social media, community meetings, and other applicable methods, NREL will find the right balance to ensure NREL's neighbors, wider community, and state and local delegations are involved every step of the way.

A staged public outreach strategy will be implemented that promotes the effort in phases over the course of the project. This effort will be coordinated with aligned messaging and collaboration with the other participating national laboratories as well as with DOE and its relevant offices. The plan will be revised and updated as messaging and priorities change for specific milestones such as the project launch, key accomplishments along the way in specific aspects of effort, and successful completion of the project.

Outreach vehicles and methods will vary depending on the specific milestone but will include:

- Press releases distributed to NREL in-house media lists and the news wire
- Identification of expert spokespersons at the laboratory who can speak to the technical specifics and impacts of the project; targeted pitching of the story and interview opportunities with those

spokespersons using press releases and other assets to earn media placement in national, local, trade, and industry media

- Social media campaigns promoting the effort and specific milestones leveraging large and engaged audiences on Twitter, Facebook, Instagram, and LinkedIn
- The development of news and feature stories telling the story and highlighting the effort and key milestones, which will be posted on NREL's website and can be shared with the general public, key stakeholders, partners, and collaborators and published by the media directly
- The development of outreach tools such as webpages, fact sheets, and videos to share information on the project
- Events on the NREL campus to highlight and showcase the work being done to accomplish this goal at the laboratory; events could include sustainability focused tours, workshops, public open houses, and press events
- Providing key outreach support and collaboration to DOE and its relevant offices, the other participating national laboratories, and NREL stakeholders and partners in the project to help ensure a successful outcome for all public engagement.

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## b) Positive Impacts (e.g., Industry, Society, Financial/Cost Savings)

The goal, and expected impact, of outreach efforts on the project will be to create national and local public awareness and appreciation of this effort by the laboratory, DOE, and federal government. Additionally, public outreach will position NREL staff as thought leaders and experts on this important topic

to be a resource for others seeking similar goals and to demonstrate that a significant campus-level net-zero emissions effort is an attainable goal that can be accomplished reliably, resiliently, efficiently, and affordably.



APRIL 2022

# NET ZERO LABS PILOT: NREL Roadmap to Decarbonization



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