ORNL/SPR-2022/2702

Oak Ridge National Laboratory FY 2023 Site Sustainability Plan

With FY 2022 Performance Data

Prepared November 2022

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November 2022

OAK RIDGE National Laboratory

ORNL IS MANAGED BY UT-BATTELLE LLC FOR THE US DEPARTMENT OF ENERGY

ORNL/SPR-2022/2702

Facilities and Operations Directorate
Facilities Management Division
Sustainable ORNL Program

OAK RIDGE NATIONAL LABORATORY
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Prepared by
OAK RIDGE NATIONAL LABORATORY
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ABBREVIATIONS

AFV	alternative fuel vehicles
BAS	Building Automation System
Btu	British thermal units
C&D	construction and demolition
CDU	cooling distribution unit
CEDS	Central Energy Data System
CEM	Certified Energy Manager
CFE	carbon-free electricity
CIMP	Critical Infrastructure Modernization Project
CNMS	Center for Nanophase Materials Sciences
CPU	Central Processing Unit
DOE	US Department of Energy
D&D	deactivation and decommissioning
EAC	energy attribute certificate
EAct 20	Energy Act of 2020
EBCI	Eastern Band of Cherokee Indians
ECM	energy conservation measure
EE&S	Energy Efficiency and Sustainability
EFP	FMD Excess Facilities Program
EISA	Energy Independence and Security Act of 2007
EO	Executive Order
EPA	US Environmental Protection Agency
EPAct	Energy Policy Act
EPEAT	Electronic Product Environmental Assessment Tool
EPP	environmentally preferred product
ESPC	energy savings performance contract
EUI	energy use intensity
EV	electric vehicle
EVSE	electric vehicle supply equipment
F&O	Facilities and Operations
FAR	federal acquisition regulation
FCA	facility condition assessment
FDD	fault detection and diagnostics
FEMP	Federal Energy Management Program
FIMS	Facilities Information Management System
FMD	Facilities Management Division
FPDS	Federal Procurement Data System
FY	fiscal year
GHG	greenhouse gas
G/GSF	gallons per gross square foot
GIS	geographic information system
GP	Guiding Principle
GPP	General Plant Project
GPU	graphic processing unit
GSF	gross square foot
GWP	global warming potential
HEMSF	High-Energy Mission-Specific Facility
HFIR	High Flux Isotope Reactor

HPC	high-performance computing
HTW	high temperature water
IGPP	Institutional General Plant Project
ILA	industrial, landscaping, & agricultural
IT	information technology
JCI	Johnson Controls Inc.
LED	light-emitting diode
LEED	Leadership in Energy and Environmental Design
M&V	measurement and verification
MSW	municipal solid waste
MTW	medium temperature water
NEPA	National Environmental Policy Act
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PFAS	perfluoroalkyl and polyfluoroalkyl substance
PHEV	plug-in hybrid electric vehicles
OTC	once-through cooling
P2	pollution prevention
PUE	power usage effectiveness
R2	Responsible Recycling Practices
R&D	research and development
RA	Resource Advisor
REC	renewable energy credit
SC	Office of Science
SIPRC	Stable Isotope Production and Research Center
SF_6	sulfur hexafluoride
SLI	Science Laboratories Infrastructure Program
SME	subject matter expert
SNS	Spallation Neutron Source
SPD	Sustainability Performance Division
SSP	Site Sustainability Plan
T&D	transmission and distribution
TVA	Tennessee Valley Authority
TRN	Technical Resilience Navigator
VAR	Value Added Reseller
VARP	Vulnerability Assessment and Resilience Plan
WUI	water use intensity

1. ABOUT THIS REPORT

1.1 ANNUAL DEVELOPMENT OF THE ORNL SITE SUSTAINABILITY PLAN (SSP)

At the close of each fiscal year, the US Department of Energy (DOE) Sustainability Performance Division (SPD) issues guidance documents and technical resource aids/tools necessary for DOE sites and national laboratories to complete sustainability reporting requirements. SPD is part of the DOE Office of Asset Management. As required by DOE Order 436.1, *Departmental Sustainability*, "each site will develop and commit to an annual Site Sustainability Plan (SSP) that identifies its respective contribution toward meeting the DOE's sustainability goals." SPD collects and compiles information reported by each site to develop an agency-wide *Sustainability Report and Implementation Plan*, which is used to report DOE sustainability progress to the federal government as required by all major federal agencies.

DOE launched a formal Sustainability Office and annual SSP process in 2011. Each year, Oak Ridge National Laboratory (ORNL), in concert with the Office of Science (SC), provides the resources essential to fulfill its commitment to deliver a complete and accurate SSP report and quality performance data for entry into the DOE Sustainability Dashboard as managed by SPD. The performance data entered by each DOE site are then combined to disclose the progress of each DOE Program Office and are further combined to show comprehensive progress for the agency.

The Office of Asset Management provides assistance to program offices in sustaining their missions, freeing up resources by reducing waste, avoiding excess expenditure on utilities, maximizing productivity, and improving the efficiency of facilities and processes. By focusing on mission needs, programs and associated DOE sites can help the agency meet its sustainability goals, as outlined in federal statutory and regulatory requirements. In FY 2022, the SSP guidance was updated to capture requirements from Executive Order (EO) 14008*, Tackling the Climate Crisis at Home and Abroad*, the Energy Act of 2020 (EAct 20), actions outlined in DOE's *Climate Adaptation & Resilience Plan and Sustainability Plan*, and EO 14057, *Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability*. Updates in SSP guidance help to minimize and streamline reporting while simultaneously addressing updated federal requirements.

Per DOE, each SSP report should provide an overview of the site's planned actions, as well as an overview of efforts and accomplishments during the reporting period. SPD collects and compiles information reported by each site to develop DOE's *Annual Sustainability Report*, *Climate Adaptation & Resilience Plan*, and *Annual Energy Management Report* to Congress. The agency goal has been to lower the reporting burden for sites and increase and improve the consistency of information available to decision makers, allowing them to better identify projects and potential for increased efficiency, as well as to reduce waste, lower emissions, and enhance operational resilience. Sites may elect to produce a more polished publication for their leadership and stakeholders, but this step is no longer required.

The ORNL SSP narrative report (this document) and the reporting of DOE SPD Sustainability Dashboard performance data is a collaborative effort of approximately 30 subject matter experts (SMEs) from ORNL facility management and research divisions. Annually, these associates come together to provide a report that can be used by DOE to demonstrate continued agency progress in energy efficiency and sustainable federal operations.

2. EXECUTIVE SUMMARY

2.1 WHO WE ARE

ORNL Mission

Deliver scientific discoveries and technical breakthroughs needed to realize solutions in energy and national security and provide economic benefit to the nation. We address national needs through impactful research and world-leading research centers.

> ***"What we do matters and makes a lasting impact on the world."***
> Director's Message, Thomas Zacharia, Laboratory Director

ORNL, managed under contract by UT-Battelle LLC, is DOE's largest science and energy laboratory and, as such, executes the widest range of mission capabilities. Diverse expertise spans a broad range of scientific and engineering disciplines, enabling the research and science achievement to accelerate the delivery of solutions to the marketplace. ORNL supports DOE's national missions of scientific discovery, clean energy, and security. To execute these activities, ORNL has grown significantly over 75 years of continuous operations, consisting of facilities with commissioning dates ranging from the 1940s to 2021—an extraordinary set of distinctive scientific facilities and equipment. The complexities of such a variety of facilities require teamwork among divisions, a wide variety of conservation projects, and creative strategies to achieve the desired energy and water savings. Such a diverse and unique set of major facilities, totaling over 5.5 million square feet, with 6,000 employees, requires an innovative plan to accomplish advancements in operational efficiencies.

ORNL is tasked with the management of an extraordinary set of distinctive scientific facilities and equipment for DOE. ORNL is mission- driven, and its mission has grown significantly over the decades. ORNL's core research capabilities provide broad science and technology support for DOE in the areas of energy, environment, and national security. Currently, ORNL is a world leader in materials, neutron, and nuclear science and engineering, and in high-performance computing (HPC) and data analytics. These systems are further identified within various sections of this report. ORNL's vast portfolio of research facilities must be maintained and carefully upgraded to protect the country's investment in scientific analysis. The goal of sustainable operations is to enable more effective execution of ORNL's science and technology mission. Sustainable operational practices strive for enhanced results while remaining diligent in energy and environmental stewardship.

2.2 SUSTAINABLE ORNL

Continuous improvements in operational and business processes must be integrated into the fabric of the ORNL culture to maximize the return from the investment made in modernizing facilities and equipment. The Sustainable ORNL program promotes the legacy of system-wide best practices, management commitment, and employee engagement that will lead ORNL into a future of efficient, sustainable operations. ORNL leadership and Sustainable ORNL champions receive regular status reports on the progress of each project and focus area (i.e., roadmap) and periodic summary reports. More information can be found at https://www.ornl.gov/sustainable-ornl.

The Sustainable ORNL roadmap structure endorses 15 vital roadmaps. Figure 1 summarizes the current project assignments and was designed to indicate that each project contributes to the wellbeing of the whole. Continuous employee engagement and regular status reports confirm the ideals of the program.

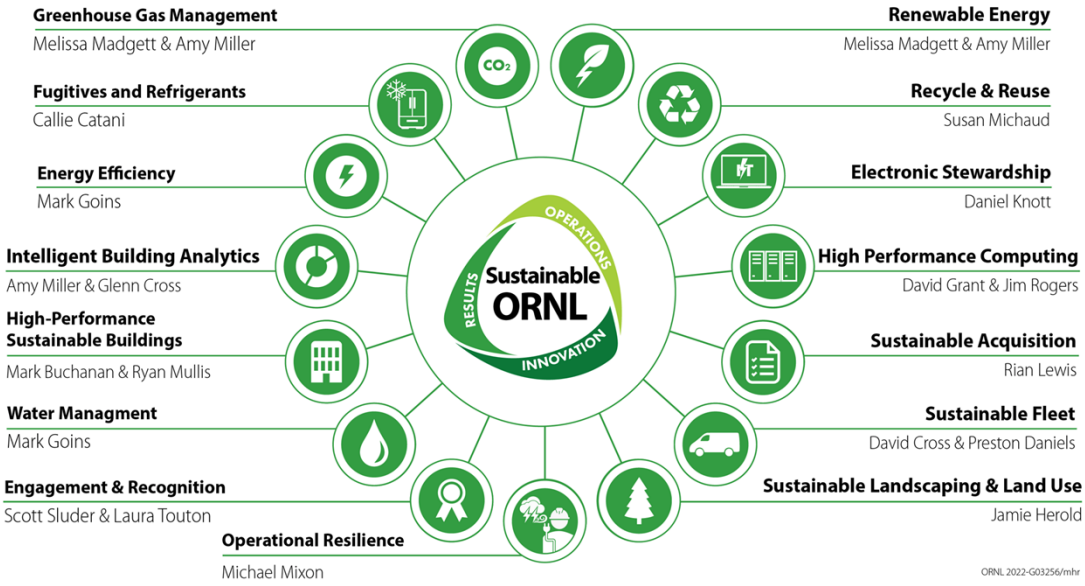


Figure 1. Sustainable ORNL focus areas (roadmaps) and subject matter experts for FY 2023.

The roadmap structure is not static; as the science mission advances and the needs of the organization evolve, the Sustainable ORNL roadmap structure elements are modified to align with developing priorities. In FY 2022, Sustainable ORNL made roadmap changes leading into FY 2023 to better align ORNL to support the new requirements that have been issued.

In 2021, EO 14008, *Tackling the Climate Crisis at Home and Abroad*, established broad strategies calling for federal agencies to take the lead in confronting the climate crisis, engage in the formation of a net-zero economy, and enhance operational resilience at federal facilities. To respond to DOE priorities, ORNL requires a comprehensive cross-cutting process to respond to EO 14008 and enhance climate mitigation efforts. The Sustainable ORNL program established a new Operational Resiliency Roadmap (shown in Figure 1) in FY 2022 in efforts to support the Vulnerability Assessment and Resilience Plan (VARP) that came from EO 14008.

Sustainable ORNL also made efforts to better align the structure with the SSP requirements. In doing so, two new roadmaps were added: Fugitives and Refrigerants, and Electronic Stewardship (Figure 1). This aligns most of the roadmaps with supporting the critical topics of the SSP and greenhouse gas (GHG) reporting. The carbon-free electricity (CFE) and net-zero goals are cross-cutting for all roadmap owners, but the Greenhouse Gas Management and Renewable Energy Roadmaps will capture ORNL's holistic approach toward achieving these goals.

Net-zero initiatives do not operate in isolation; rather, they work in conjunction with other priorities to reach a number of agency objectives. Throughout the ORNL campus, projects are evaluated on several sustainability priorities, including energy and water savings (and cost savings) from energy conservation measures (ECMs), net-zero initiatives, and operational resilience. ORNL has an opportunity and a responsibility to lead by example and integrate climate and sustainability into all aspects of its operations.

2.3 ORNL SSP SUMMARY OF GOALS AND PERFORMANCE

Many DOE sustainability goals build on prior successes and strive for additional annual improvements.

DOE goal	Current performance status	Planned actions& contribution	Overall risk of non-attainment
Energy management			
Reduce energy use intensity (EUI) defined as Btu per gross square foot (GSF) in goal-subject buildings.	ORNL's FY 2022 calculated EUI is 234,194 Btu/GSF. This is a cumulative reduction of 35.6% since FY 2003 and a decrease of 2.8% from FY 2021. ORNL continues to improve identification of energy consuming facilities.	Continued EUI reduction for goal-subject facilities is seen as attainable by concentrating on the best mix of ECM projects for energy savings and by incorporating net-zero strategies into all levels of lab planning efforts.	**Low**
EISA Section 432 continuous (4-year cycle) energy and water evaluations.	In FY 2022, ORNL started the next 4-year energy audit cycle by conducting 22 audits throughout the year to cover approximately a fourth of the buildings eligible for audit. To assist with this process, ORNL F&O management hired a new engineer to support EISA audits and EAct 20.	ORNL will continue the current 4-year cycle of auditing and assessments to align with work priorities. In FY 2023, ORNL will start the third year of the 4-year energy audit cycle.	**Low**
Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	In FY 2022, ORNL added 75 new advanced utility meters (including computational metering and Electrical Utility Distribution metering), migrated 7 new data streams from other systems across the lab, and replaced 6 meters. ORNL meter installations include electrical, steam/hot water, natural gas, chilled water, and potable water. During the past few years, efforts have been made to create an updated master metering report/plan.	ORNL will continue to use the metering plan for guidance in installation of additional advanced utility meters, where cost-effective and appropriate, on all utilities. ORNL will continue learning more about the 24/7 CFE requirements and determining if there are metering needs necessary to meet the CFE goals. ORNL will also emphasize water metering as the lab is furthest from 100% metered for water within facilities.	**Medium** Cost, installation connections, and configurations combine to create a challenging task for meter installations.
Water management			
Reduce potable water use intensity (WUI) defined as gallons per gross square foot (G/GSF).	Annual water consumption resulted in a WUI value of 137.6 G/GSF in FY 2022, which is an increase of 1.7% from FY 2021, missing the 0.5% reduction goal compared to the previous year, despite overall reduction in water consumption. Continued improvements in the identification of water-consuming facilities yielded an 3% reduction in GSF, contributing to the increased WUI.	ORNL's WUI is subject to rise because of increased demands for cooling tower makeup water to support growth of HPC systems. With continued modernization activities that include the elimination of old facilities and the addition of new facilities, ORNL will consider more water-efficient systems and maintain a focus on water management best	**High** Without exclusions, the potential to meet WUI goals is not obtainable for DOE sites with critical mission growth.

DOE goal	Current performance status	Planned actions& contribution	Overall risk of non-attainment
		practices to meet future WUI reduction goals.	
Reduce non-potable freshwater consumption for industrial, landscaping, and agricultural (ILA.)	N.A. No ILA usage at ORNL.	No change expected.	N.A.
Waste management			
Reduce non-hazardous solid waste sent to treatment and disposal facilities.	In FY 2022, ORNL's diversion rate for municipal solid waste (MSW) reached 52.8%.	ORNL will continue to identify source reduction opportunities.	**Medium**
Reduce construction and demolition (C&D) materials and debris sent to treatment and disposal facilities.	In FY 2022, ORNL's C&D diversion rate for waste building materials and deactivation and decommissioning (D&D) debris is 70.8%. This is a considerable increase from FY 2021.	ORNL will continue to employ terms and conditions within construction contracts to manage construction waste and recycling. C&D recycle rates will vary as the proper characterization of debris dictates.	**Medium**
Fleet management			
Reduce petroleum consumption.	ORNL continues to optimize utilization, purchase vehicles with improved fuel economy and EV options when available, and purchase vehicles with anti-idling technology.	ORNL will launch a passenger-carrying vehicle pooling project, encourage using the ORNL taxi service, and continue replacing vehicles with improved fuel economy vehicles.	**Low**
Increase alternative fuel consumption.	82% of all ORNL vehicles are alternative fuel vehicles, with 90% of all replacements over the past 2 fiscal years being alternative fuel or EVs. Also, 100% of light-duty vehicles operate on alternative fuels, exceeding DOE fleet management goals.	ORNL will continue to purchase alternative fuel vehicles and limit accessibility for non-alternative fuel at ORNL gas pumps.	**Low**
Acquire alternative fuel and electric vehicles	ORNL is currently meeting the AFV requirement. If an alternative fuel vehicle or EV has been available and met mission requirements, it has been purchased or leased during the replacement process.	ORNL will continue the effort of replacing vehicles with any alternative fuel vehicles or EVs if available and meet the mission requirements.	**Low**
Clean & renewable energy			
Increase consumption of clean and renewable electric energy.	ORNL purchased renewable energy credits (RECs) to supplement on-site renewable energy generation, representing 9.6% of the lab's electrical energy	ORNL will remain compliant, via means of REC purchases as on-site renewable energy projects are expected to remain cost- prohibitive. ORNL will continue to	**Medium** The numbers of RECs/EACs to purchase will increase with mission growth.

DOE goal	Current performance status	Planned actions& contribution	Overall risk of non-attainment
	consumption, exceeding the 7.5% statutory requirement.	explore innovative renewable energy projects. REC purchase will reflect significant mission growth in the near future but will transition to EACs) to also work toward carbon free electricity requirements.	REC/EAC pricing may become volatile, creating budgetary issues, as the demand for EACs increases while the market attempts to provide.
Increase consumption of clean and renewable non-electric thermal energy.	N.A. under current statutes.	N.A.	N.A.
Sustainable buildings			
Increase the number of DOE- owned buildings that are compliant with the Guiding Principles for Federal Leadership in Sustainable Buildings.	ORNL's Sustainable Buildings inventory did not increase in FY 2022. With the new requirement of a 25,000 ft^2 building, ORNL has 7 sustainable buildings that are GP-certified. If ORNL includes buildings 5,000 ft^2 and greater, ORNL has 21 buildings that are GP-certified.	ORNL plans to have at least two new construction buildings to add to the sustainable building count in the next 5 years. ORNL plans to reassess the 7 sustainable buildings in the next 3 years, maintaining the 7 GP-certified buildings inventory.	**Medium**
Acquisition && procurement			
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all sustainability clauses are included as appropriate.	ORNL maintained 100% compliance in FY 2022. All subcontracts contain multi-statutory terms and conditions that invoke requirements for sustainable acquisitions as defined in the UT-Battelle prime contract as flow-down requirements.	ORNL will continue mission commitment to include all applicable federal acquisition regulation (FAR) clauses and provisions in each new contract. ORNL will maintain compliance with DOE Order 436.1 and assist with the supply chain risk assessment moving forward.	**Low**
Efficiency & conservation measure investments			
Implement life-cycle cost effective efficiency and conservation measures with appropriated funds and/or performance contracts.	The ORNL EE&S program, on average, funds over $500,000/year toward ECMs. DOE has a current contract with Johnson Controls Inc. (JCI) for an ORNL ESPC project. The delivery order was July 31, 2008, with a term of 24 years and 7 months. It includes ECMs consisting of steam system decentralization, building management system improvements, advanced meter installations, energy-efficient lighting upgrades, and domestic water conservation.	ORNL's ECMs need to be evaluated to determine which are life cycle cost-effective, and if found to be so, fund and begin installation to the maximum level of funding available. ORNL plans on expanding the auditing process and integrating this process with the facility condition assessments (FCAs). ORNL will then continue to investigate the best potential funding pathway strategies as the life cycle cost-effective	**Medium**

DOE goal	Current performance status	Planned actions& contribution	Overall risk of non-attainment
		ECM list grows moving forward.	
Electronic stewardship			
Electronics stewardship from acquisition, operations, to end of life.	ORNL maintained 100% compliance in the acquisitions of environmentally certified products. ORNL actively maintained power management features on 100% of all eligible IT devices in the operations. Disposition of 100% of end-of-life electronics was preformed through government reuse programs and certified recyclers.	ORNL plans to maintain 100% compliance with all electronic stewardship goals and categories. There are no foreseen obstacles to the goal.	**Low**
Increase energy and water efficiency in high-performance computing and data centers.	FY 2022 PUE maintained a comprehensive efficiency rating of 1.10 on average.	ORNL will continue optimization of Frontier's control system, and development of Trim CDU capability at the rack systems.	**Low**
Operational resilience			
Implement climate adaptation and resilience measures.	In response to EO 14008 and DOE directives, ORNL submitted the VARP in September 2022 along with a portfolio of actionable resiliency solutions.	Updates of the implementation status of ORNL's solutions will be reported annually to SPD, starting in the fall of 2023.	**Low**
Multiple categories			
Reduce Scope 1 & 2 GHG emissions.	FY 2022 Scope 1 & 2 GHG inventory is 212,929 $MTCO_2e$ (net after RECs), an annual reduction of approximately 6.2%. Currently, purchased electricity (Scope 2) makes up 71% of ORNL GHG emissions. Regional EPA eGRID improvements bolstered Scope 2 reductions.	Mission growth, as described in several sections in this report, will limit the ability to realize lower emissions in the next 5 years. However, forward-looking DOE priorities such as those combined for net-zero carbon initiatives will reverse the trend of higher emission.	**High**
Reduce Scope 3 GHG emissions.	Current Scope 3 GHG inventory is 23,527 $MTCO_2e$, a 39.5% increase from FY 2021. Scope 3 activities at ORNL include distribution losses from purchased electricity, and increased employee commuting and business travel.	Employee commuting and business travel categories are returning to pre–COVID-19 pandemic levels, which will likely reverse progress in Scope 3 reductions as experienced in FY 2020 and FY 2021.	**High**

3. GREENHOUSE GAS (GHG) PERFORMANCE

3.1 GHG EMISSIONS IN METRIC TONS OF CARBON DIOXIDE CO_2 EQUIVALENCY ($MTCO_2E$)

3.1.1 Performance Status

The sources of GHG emissions at ORNL and the inventory for FY 2022 are detailed in Table 1. After 2 years of curtailed emissions owing to COVID-19 pandemic protocols, GHG emissions are expected to increase in the next 2 years. The science mission at ORNL is growing, and because federal accounting guidance allows no GHG emissions exceptions or exclusions, regardless of mission, emissions are expected to increase in the near term. Federal priorities should work together to provide significant reductions in GHG emissions by 2030, per EO 14008, EO 14057, and other federal programs and initiatives.

Table 1. Sources of GHG emissions at ORNL in FY 2022

Source of GHG emissions	FY 2022 inventory ($MTCO_2e$)	Percentage of total (%)
Purchased electricity (net after renewable energy credits)	168,270	71%
Natural gas, facilities	34,981	15%
Employee commuting	13,948	6%
Transmission & distribution losses	8,939	4%
Fugitive gases and refrigerants	8,378	4%
Fleet fuels	780	Less than 1%
Business air travel	555	Less than 1%
Fuel oil, facilities	294	Less than 1%
Non-fleet vehicles and equipment fuels	214	Less than 1%
Business ground travel	85	Less than 1%
Misc. minor sources (wastewater)	12	Less than 1%
ORNL Total GHG emission sources	**236,456**	**100%**

3.1.2 Plans and Projected Performance

By far, the most significant component of GHG emissions is the production and delivery factors associated with electrical power production, netting 71% of ORNL emissions in FY 2022. As net-zero strategies are positioned by the power plants, more efficient and cleaner energy sources will be used for electricity and as correlated emissions are updated, favorable impacts will develop. In January 2022, a new set of electricity grid factors was released by the US Environmental Protection Agency (EPA; https://www.epa.gov/egrid).

Over the past 15 years, GHG emission factors from electricity have shown slow but steady improvements, but the rate of progress is expected to accelerate as net-zero strategies are deployed nationwide by the producers of CFE. In the coming year, ORNL will explore the possibility of reporting carbon sequestration that occurs on the Oak Ridge Reservation's 25,000 acres of unimproved land. Historically 40% of the reservation, or 10,000 acres, is attributable to ORNL.

4. ENERGY MANAGEMENT

4.1 ENERGY MANAGEMENT PROGRAM OVERVIEW

The ORNL Energy Management Program begins with comprehensive understanding through ongoing monitoring and assessments of all energy and water consumption. The site utility services include electrical power, natural gas, fuel oil, steam, chilled water, and potable/process water to support ORNL's mission and research programs. Electrical services include basic power needs as well as chilled water service and direct cooling applications. Steam and hot water are generated on-site from a combination of natural gas and fuel oil. Natural gas is also used in direct heating applications and research activities. Potable water use supports mission-critical process applications as well as domestic water use, including restrooms and drinking water. ORNL's utility consumption and costs reflect the ORNL main campus, the Spallation Neutron Source (SNS) site, various research and support facilities throughout the property, and leased spaces, primarily the National Transportation Research Center at the Hardin Valley Campus. The continued knowledge gained from the analysis of past and current energy consumption will better position ORNL to develop plans for improved energy efficiency and GHG reduction in facility operations.

The ORNL Facilities Management Division (FMD) was successful in the attainment of DOE's 50001 Ready recertification in FY 2019, FY 2020, and FY 2021. FMD first received certification in FY 2019, and at the time of initial certification, ORNL was the third federal location and only the second national laboratory to receive the certification. The certification covers over 2.5 million square feet in 65 FMD buildings that are equipped with advanced metering. FMD's Energy Efficiency and Sustainability (EE&S) program led the certification effort, but contributions and support from many other divisions were necessary for the achievement of the project goals. DOE 50001 Ready has provided a structure and documentation strategy that identifies areas for growth while also tracking growth each year as the (EE&S) program progresses.

Although FY 2022 was a year of major change, ORNL focused on becoming familiar with the ambitious goals via EOs issued by this administration and new laws such as EAct 20. DOE 50001 Ready certification was not pursued in FY 2022, but a majority of the documentation was updated to position ORNL for recertification in future years.

DOE's Better Building's website provides more details outlined in the ORNL FMD certification case study, ORNL's DOE 50001 Ready Case Study.

4.1.1 Utility Consumption

Electricity, the largest energy commodity for ORNL, currently accounts for approximately 75% of ORNL's total energy consumption (Figure 2). Electrical services dominate ORNL's energy, primarily because of critical operations at High-Energy Mission-Specific Facilities (HEMSFs). Electricity accounts for 85% of the utility provider commodity budget at ORNL (Table 2).

Heating energy makes up the remaining 25% of fuels at ORNL. Natural gas is the primary fuel used for steam generation at the ORNL Steam Plant and the Melton Valley Steam Plant, and for hot water generation at the Central Utilities Building supporting SNS. Natural gas is also used in direct natural gas heating and research applications. Fuel oil, which is used for steam generation during curtailment and maintenance periods, as well as for heating at the Energy System Test Complex, accounts for less than 1% of the total energy consumed.

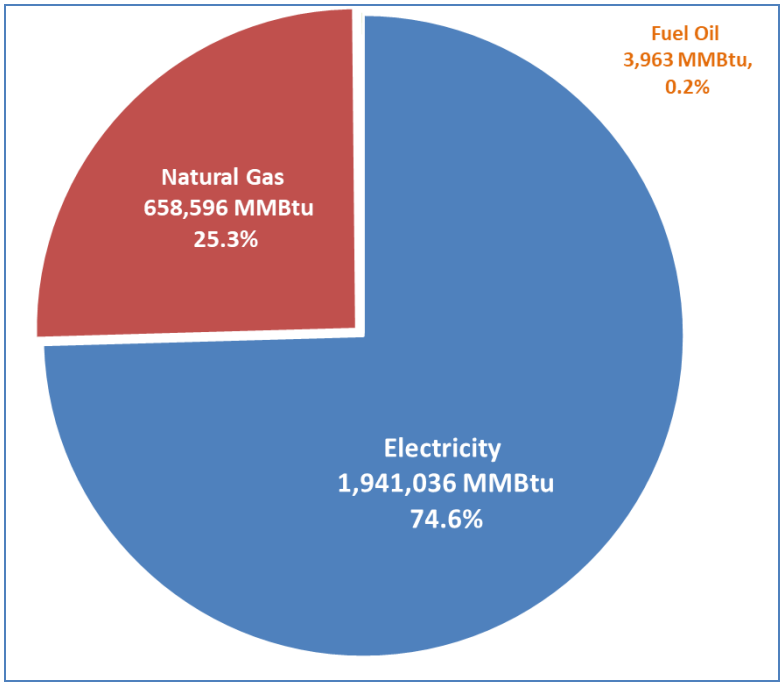


Figure 2. FY 2022 total utility consumption breakdown.

Table 2. ORNL FY 2022 utility consumption and cost

Utility	Consumption	Cost (1,000)
Electricity	569,783 MWh	$37,721
Natural gas	641,906 MCF	$5,409
Fuel oil	29 kgal	$83
Potable water	613.410 Mgal	$1,255

4.2 PROGRAM INFORMATION FOR ORNL HEMSFS

ORNL's unique research mission results in energy efficiency challenges not seen in conventional office and laboratory buildings. DOE and SC have designated a unique facility category for these exceptional operations, defined as HEMSFs. ORNL currently designates and tracks four unique facility/research systems as HEMSFs. The following contains brief program information for ORNL HEMSFs and is offered to better document this challenge in terms of energy and water performance improvement efforts.

High Flux Isotope Reactor (HFIR)

The neutron scattering research facilities at the High Flux Isotope Reactor (HFIR) allow scientists to study the molecular and magnetic structures and behavior of a variety of materials, including high-temperature superconductors, polymers, metals, and biological samples (Figure 3). These studies are leading to scientific and technical advances in a wide range of fields, such as physics, chemistry, materials science, engineering, and biology. The reactor is also used for isotope production, materials irradiation, and neutron activation analysis.

Figure 3. ORNL's HFIR.

Computational Sciences Building

Figure 4. ORNL's Computational Sciences Building.

The HPC mission includes the Computational Sciences Building (Figure 4), part of the Oak Ridge Leadership Computing Facility, giving the world's most advanced computational researchers an opportunity to tackle problems that would be unthinkable on other systems.

To date, the Oak Ridge Leadership Computing Facility has produced four supercomputers, each bearing the title "world's fastest computer" in its time. In May 2022, Frontier came online as the first exascale machine in the world. Exascale is the next level of computing performance. By solving calculations more than five times faster than today's top supercomputers— exceeding a quintillion, or a billion billion, calculations per second—exascale systems will enable scientists to develop critically needed technologies for energy, medicine, materials, and more. As supercomputing strategy continues to evolve, the design features championed at ORNL will ensure that DOE remains positioned at the forefront of HPC on the international stage.

Spallation Neutron Source (SNS)

Figure 5. ORNL's SNS.

SNS is an accelerator-based neutron source that provides the most intense pulsed-neutron beams in the world for scientific research and industrial development (Figure 5). The beams deliver short pulses of protons—60 times a second—to a target system where neutrons are produced through a process called *spallation*. SNS gives researchers more detailed snapshots of smaller samples of physical and biological materials than ever before possible. The diverse applications of neutron scattering research are providing opportunities for exploration into the structure and dynamics of materials in practically every scientific and technical field. Each year, more than 1,000 scientists from around the world compete for valuable research time at the SNS facility. SNS will expand with a Second Target Station in the coming years.

Center for Nanophase Materials Sciences (CNMS)

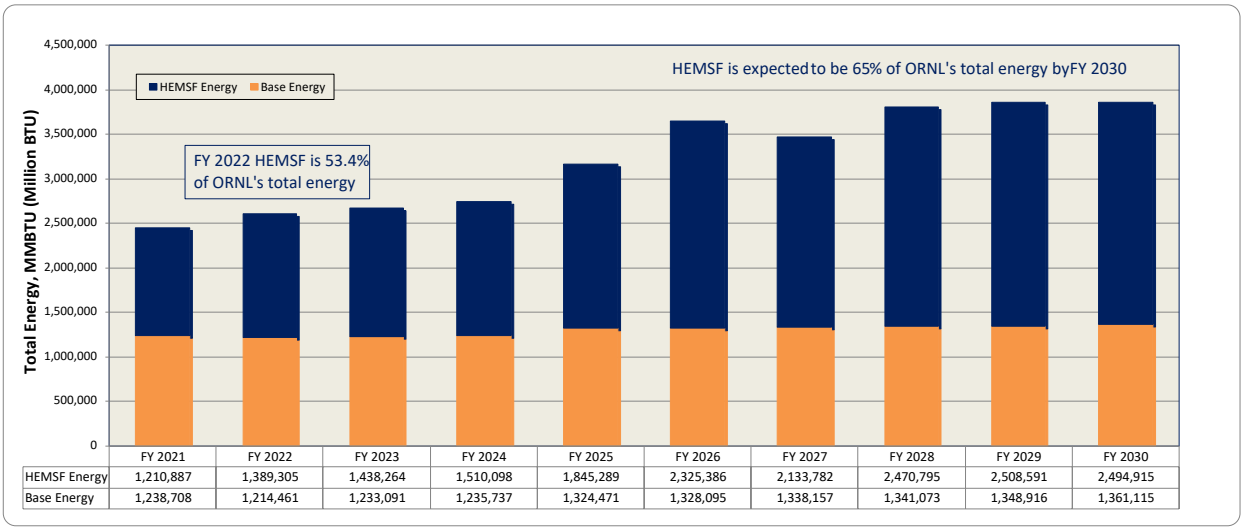
The Center for Nanophase Materials Sciences (CNMS) is one of five DOE Nanoscale Science Research Centers (Figure 6). The centers provide leading-edge tools and scientific expertise for synthesis, characterization, and computation for interdisciplinary research at the nanoscale. Providing its own unique capabilities, CNMS enables scientists worldwide to "see," make, control, and understand nanoscale matter. Nanoscience aims to understand advantageous yet sometimes strange physical and chemical behaviors that arise in structures 1 to 100 nanometers (nm) wide that do not occur in larger structures. The CNMS program integrates nanoscale science with neutron science; synthesis science; and theory, modeling, and

Figure 6. ORNL's CNMS.

simulation. The facility is equipped with a wide range of specialized tools for synthesis, characterization, and fabrication of nanoscale materials and assemblies, including the integration of hard and soft materials.

4.3 ORNL HEMSF ENERGY USE AND PROJECTIONS

The current and projected values for total energy consumption, in millions of British thermal units (Btu), by all sources at ORNL are shown in Figure 7 in comparison with the energy consumed by the HEMSF systems. HEMSF energy consumption accounted for approximately 53% of ORNL's total energy use in FY 2022. It is expected to grow to 65% of total energy use by FY 2030. As shown previously in Figure 2, electricity is the dominant utility at ORNL (at 75%) for all of ORNL, both at the HEMSF and the base site (or overall campus).



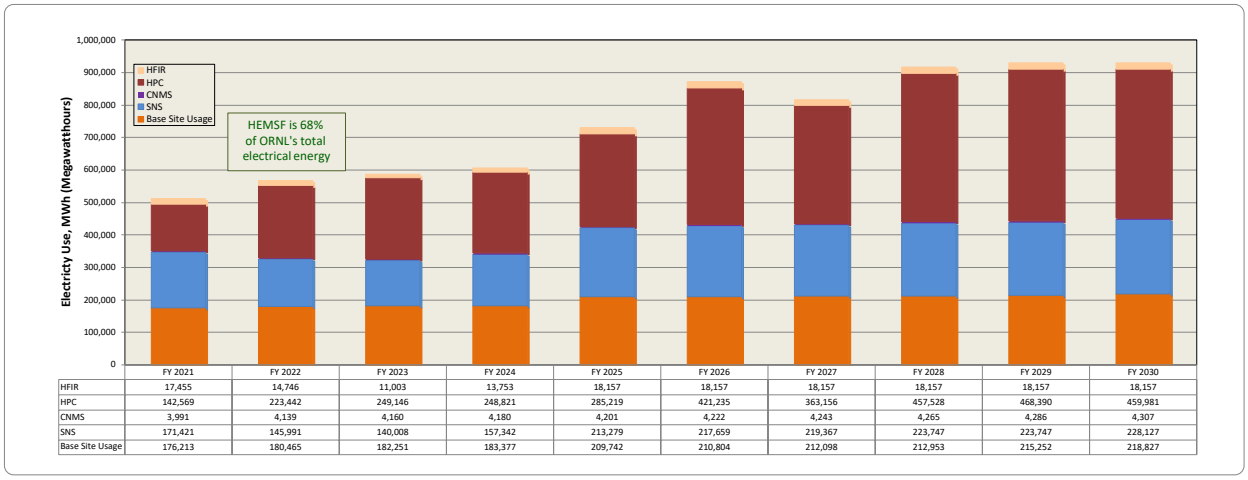
	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
HEMSF Energy	1,210,887	1,389,305	1,438,264	1,510,098	1,845,289	2,325,386	2,133,782	2,470,795	2,508,591	2,494,915
Base Energy	1,238,708	1,214,461	1,233,091	1,235,737	1,324,471	1,328,095	1,338,157	1,341,073	1,348,916	1,361,115

Figure 7. Total energy use at ORNL vs. the energy use for HEMSFs.

The top section of the bar graph includes all HEMSFs. Other ORNL energy is shown on the bottom section of the bar graph and is identified as Base Energy consumption. For all comparisons, Base Energy includes electricity and other fuels used for basic facility operations and not consumed at HEMSF systems.

The HEMSF electrical energy use and projection bar graph in Figure 8 is provided to demonstrate the importance of electrical energy at ORNL. Electricity consumption is the largest component of HEMSF energy. Around 68% of all ORNL electricity is consumed at these research facilities. The electrical consumption is expected to decrease slightly as HFIR operations are projected to run fewer cycles in FY 2023. Likewise, SNS operations are expected to be limited in FY 2023 and FY 2024 because of the implementation of the Proton Power Upgrade project. As the mission continues, HEMSF electrical consumption is projected to grow to nearly 77% by FY 2030 based on projections for HPC expansion and infrastructure improvements for SNS's Second Target Station.

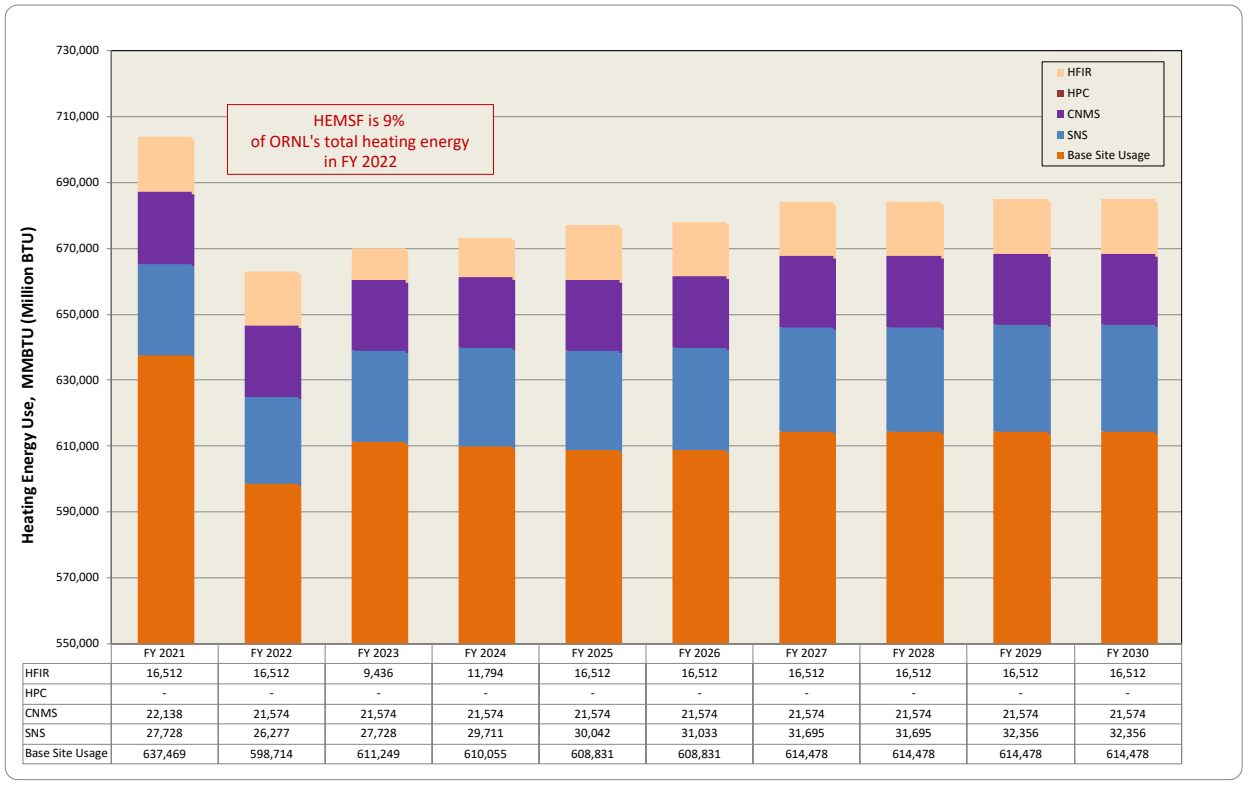
The bar graph in Figure 8 shows the electricity use and projections for each of the four ORNL HEMSFs. All other electricity consumption is also shown on the bar graph as Base Site Usage.



	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
HFIR	17,455	14,746	11,003	13,753	18,157	18,157	18,157	18,157	18,157	18,157
HPC	142,569	223,442	249,146	248,821	285,219	421,235	363,156	457,528	468,390	459,981
CNMS	3,991	4,139	4,160	4,180	4,201	4,222	4,243	4,265	4,286	4,307
SNS	171,421	145,991	140,008	157,342	213,279	217,659	219,367	223,747	223,747	228,127
Base Site Usage	176,213	180,465	182,251	183,377	209,742	210,804	212,098	212,953	215,252	218,827

Figure 8. Electricity consumption of the four identified HEMSFs at ORNL.

Thermal energy consumption is also expected to increase with ORNL mission growth as HEMSF research needs increase (Figure 9); however, electricity will remain the dominant energy source. All other heating energy values are shown on the bar graph as Base Site Usage.



	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
HFIR	16,512	16,512	9,436	11,794	16,512	16,512	16,512	16,512	16,512	16,512
HPC	-	-	-	-	-	-	-	-	-	-
CNMS	22,138	21,574	21,574	21,574	21,574	21,574	21,574	21,574	21,574	21,574
SNS	27,728	26,277	27,728	29,711	30,042	31,033	31,695	31,695	32,356	32,356
Base Site Usage	637,469	598,714	611,249	610,055	608,831	608,831	614,478	614,478	614,478	614,478

Figure 9. Projections of thermal energy consumption for the HEMSFs systems at ORNL.

4.4 ORNL GOAL ENERGY USE INTENSITY (EUI) AND EXCLUDED ENERGY USE AND PROJECTIONS

4.4.1 Performance Status

Based on FY 2022 data, energy use in the buildings category at ORNL is 1,025 billion Btu, not including ORNL's excluded facilities as defined by the Energy Policy Act of 1992. Given an area of 4,376,221 GSF of energy-consuming buildings, trailers, and other structures and facilities identified in the Facilities Information Management System (FIMS), the FY 2022 calculated energy use intensity (EUI) is 234,194 Btu/GSF. This results in a cumulative reduction of 35.6% since FY 2003 and a decrease of 2.81% from FY 2021 (Figure 10).

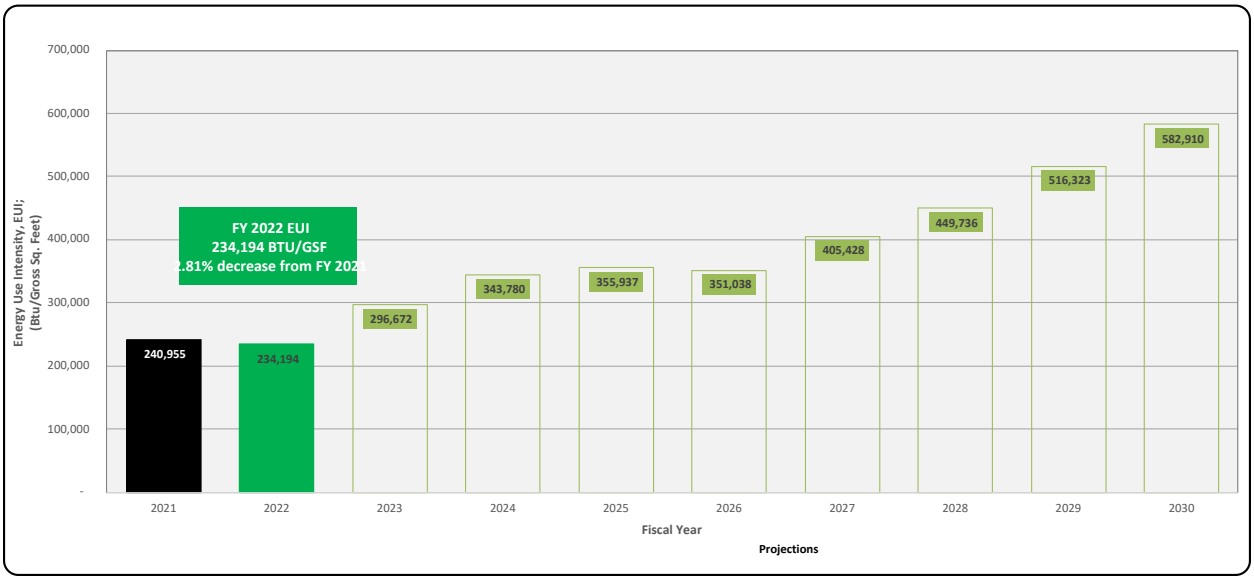


Figure 10. Historical, current (FY 2022), and projected EUI at ORNL.

ORNL's electrical consumption is used primarily by mission-critical buildings and systems. Approximately 76% of the total electrical load is formally assigned to the Excluded category, as is 16% of the thermal energy (natural gas and fuel oil). These mission-critical systems are not subject to conventional energy conservation methodologies.

The Excluded category energy and fuel projections are expected to increase as ORNL's HPC and SNS target station missions grow. Additional maintenance scheduled for HFIR in FY 2022 and FY 2023 is also reflected in the electrical projections. In FY 2023 and FY 2024, SNS will have limited operations because of the Proton Power Upgrade project.

In FY 2020, SPD modified performance parameters to exclude leased facilities from the Goal Subject category because of terms in the lease contracts that do not accurately reflect the energy consuming GSF. This methodology was maintained for FY 2022. The EUI is impacted when there is a reduction in facility area (square foot lease quantity). Building on FY 2021's improvement in identification of specific facility energy/fuel consumption, ORNL's energy consuming area (square feet) has been updated and increased, which helped improved EUI performance.

ORNL anticipates more buildings being constructed by FY 2025. These buildings are expected to be in the Goal Subject category, and they included the Craft Resources Support Facility (30,000 ft^2) in FY 2023 and the Translational Research Capability building (80,000 ft^2), expected completion in FY 2023.

Additional new construction and modification are being considered by SC for ORNL's Annual Laboratory Plan.

4.4.2 Plans and Projected Performance

ORNL's efforts toward energy intensity reduction have resulted in considerable progress by targeting readily applied ECMs in existing buildings. As these types of opportunities become less prevalent, ORNL will shift focus to a deeper level, leveraging the cooperation of data and operations staff to find new, innovative energy-savings potential. ORNL will also use DOE 50001 Ready's process for identifying buildings that are significant energy users as a strategy for ECM implementation.

ORNL is continuing to build a foundation of awareness to make energy efficiency increasingly part of daily operations. A goal has been established to make energy implications part of the consideration for specific ECMs in addition to being the daily operation, maintenance, and update of buildings and their systems. Energy managers cannot be a part of all decisions, so it is important that the decision-making process includes considerations of energy efficiency and life cycle cost.

ORNL will continue to leverage the power of building operations data from existing systems, including the Building Automation System (BAS) and metering systems. New sensors and meters will be added in strategic locations, and new capabilities will be built out in existing systems or layered on with new systems, as necessary. Focus will be placed on developing tools for operations staff to maintain building systems in a way that supports reliability, meets the needs of building occupants, and achieves energy efficiency.

The Utility Division will continue to evaluate utility systems for improving operations, improving reliability, and reducing maintenance costs. Future activities in planning include the following:

- Additional electrical service infrastructure and cooling tower optimization is underway to support the HPC mission and improve efficiency and reliability.

- Further chilled water system improvements are expected from two additional chiller rebuilds and utilization of reduced condenser water temperatures at Building 6018.

- Utilities will prioritize potential projects and support design of the Critical Infrastructure Modernization Project (CIMP) for improved operations, resiliency, and efficiency.

EO 14008 calls for federal agencies to take the lead in tackling the climate crisis, to engage in the formation of a net-zero economy and enhance operational resilience at federal facilities. The ORNL Carbon Reduction Team was chartered in FY 2021 to bring R&D scientists and operations SMEs to the same table and to align with SC as it amplifies net-zero as part of its business methods and in the budget planning process. Net-zero initiatives work in conjunction with other priorities to reach a number of objectives. Throughout ORNL, projects are evaluated on several sustainability priorities, including energy and water savings (and cost savings) from ECMs, net-zero initiatives, and enhanced operational resilience.

4.5 ENERGY MANAGEMENT: INITIATIVES, PROJECTS, STRATEGIES, AND PROCEDURES

4.5.1 Performance Status

To maintain steady progress toward EUI reductions, ORNL focuses on energy-efficient and sustainable design in new construction projects, as well as smart repurposing of existing facilities and a drive for continuous improvement in facility and utility operations. Efforts throughout ORNL that have an impact on energy consumption are described here.

Fault Detection and Diagnostics (FDD)

- EUI reduction in existing ORNL facilities is data-driven, and efforts are made to quantify and bring awareness to building energy performance so that operations staff can make informed decisions. ORNL pursues approaches to energy consumption awareness using data visualization and reporting. Building data analytics, including fault detection and diagnostics (FDD), have been added to ORNL's energy conservation tools. In FY 2021, ORNL piloted SkyFoundary's SkySpark FDD system in two buildings. In FY 2022, ORNL utilized awarded Science Laboratories Infrastructure (SLI) General Plant Project (GPP) funding to successfully add 13 buildings to SkySpark, bringing the total number of buildings to 15, with more than 1.5 million gross square footage covered and nearly 32,000 data points connected (Table 3). The additional 13 buildings were chosen with a focus on significant energy users. Many are also very aged and/or complex and thus stand to benefit greatly from commissioning with improved monitoring and analytics. Faults and key performance indicators are in place to identify opportunities for improved performance and energy savings. In FY 2023, ORNL will continue to reevaluate and optimize the established faults and key performance indicators for these buildings with input from facility operators.

- As personnel changes occur throughout the years, ORNL knows it is beneficial to regularly review the BAS setbacks that may have been added and removed because of operational changes or system needs. ORNL is working to identify and track all setbacks in place throughout the campus. With the SkySpark FDD system, ORNL hopes to use the controls monitoring capabilities to successfully implement and monitor more HVAC setbacks and identify any deviations away from such controls.

Table 3. ORNL Buildings with SkySpark FDD.

ID	Name	Year Built	Size (GSF)	Data Points
1505	Environmental Science Laboratory	1978	88,843	785
1520	Joint Institute for Biological Sciences	2007	35,543	1,409
2033	Measurements & Controls Facility	1990	31,286	844
4100	Chemical & Materials Sciences Building	2011	155,712	8,413
4501	Radiochemistry Laboratory	1951	75,738	360
4508	M&C Laboratory	1962	97,781	1,245
4515	High Temperature Materials Laboratory	1987	65,093	1,610
5100	Joint Institute for Computational Sciences	2003	51,451	2,737
5200	ORNL Conference Center	2004	1,265	1,265
5600	Computational Sciences Building	2003	98,348	2,945
5800	Engineering Technology Facility	2003	77,492	1,742
7130	Research Operations Support Center	2020	29,049	371
8630	Shull Wollan Center	2010	32,046	1,712
4500N	Central Research & Administration - North	1952	363,758	3,865
4500S	Central Research & Administration - South	1961	317,258	2,612
		Total	**1,573,341**	**31,915**

LED implementation and standardization of energy-efficient equipment through division policies

Although many LED upgrade projects were pursued as ECMs in FY 2022, significant efforts were also made within the facilities to upgrade to LEDs when old, more inefficient, lighting failed. These efforts were not captured as an ECM but rather as general maintenance. ORNL used the Esri ArcGIS system to track the LED upgrade information, such as energy savings, which is conducted for general maintenance. In FY 2022, the LED Tracking tool was established to track the details of LED upgrades throughout the ORNL Campus (including those associated with ECMs and those not associated with the previously listed ECMs). Information tracked in the LED Tracking tool using ArcGIS includes location, old lamp count, new lamp count, wattage difference, type of replacement (e.g., retrofit kits, instant fit bulbs, new fixtures), and occupancy sensor status (before and after upgrade). With this information, a simple energy savings of each light replaced at ORNL can be calculated. The data are sorted by year and per building, as shown in Figure 11. Figure 11 also shows the data input for FY 2022, but this application can show the entire LED data for all years since this effort began (FY 2018–FY 2022). This dashboard will help show the overall effort ORNL is making in its facilities that is not directly funded directly with ECM funding.

- In FY 2022, the FMD director implemented a new policy for 100% LED replacement of any lighting moving forward. This policy was communicated to the division and to all those that purchase lighting for the facilities.

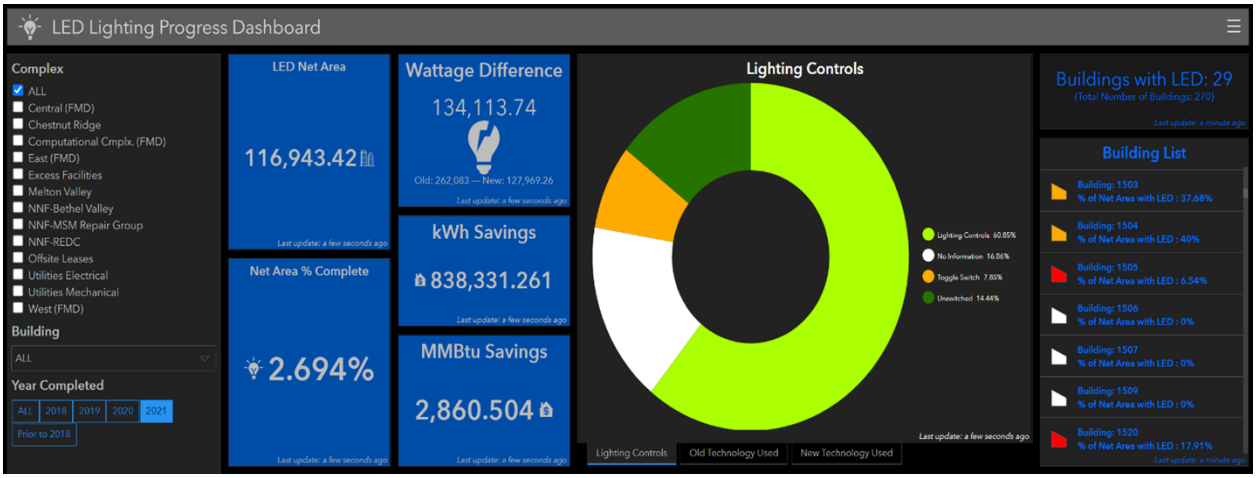


Figure 11. LED lighting upgrade tracking dashboard in Esri ArcGIS.

Excess facilities

- ORNL continues to modernize its campus by demolishing shutdown facilities that are underutilized or no longer needed to support the mission. ORNL's Excess Facilities Program (EFP) works with FMD and other building-owning organizations to mitigate energy waste after assets have been transitioned to excess. The EFP demolition plan is based on the availability of monetary and human resources, organizational and operational needs, and strategic modernization plans for the campus. On a case-by-case basis, after a facility is transitioned from Operating to Shutdown (excess) status, an analysis is performed to determine suitability for de-energized status. EFP typically demolishes these older, energy-inefficient facilities to make way for newer, more efficient buildings that better serve ORNL's mission.

    - ORNL demolished 15 facilities in FY 2022, including Buildings 7067, 7077C, 7103, 7605A, 7615, 7849, 7867, 7964C, 7981B, 7981C, 8940, XF1304, XG1410, XG1415, and XG1416. In FY 2022, these buildings accounted for 5,811 GSF, which is now removed from ORNL's energy consumption.

    - EFP isolated utilities to one facility in FY 2022: Building 5505 (23,191 GSF), with an estimated 165 MMBtu of energy removed from ORNL operations.

    - EFP also isolated utilities as a precursor activity to the demolition of 4 laboratories in Building 4500N and 15 laboratories/rooms in Building 4500S. As part of the renovation of these spaces, it is EFP's policy to install LED lighting as these laboratories/rooms are rebuilt.

    The combination of the two types of adjustments to facility square footage associated with EFP actions totaled 29,002 GSF (not including the laboratory/room renovations in Buildings 4500N and 4500S), which is now removed from the denominator of the EUI equation.

Space management

- ORNL's Space Management program is responsible for proper space utilization, such as space renovations and asset relocation actions for ORNL personnel throughout the campus. Space Management incorporates energy-efficient technologies and practices into their space renovations with the help of FMD. Specifically, LED upgrades are installed for space renovations that require new lighting. In FY 2020, Space Management implemented a new space management software. The

new ORNL software is an integrated work management system that provides strategic planning, space management, move management, and enhanced reporting capabilities. In FY 2021, the new software expanded ORNL's ability to store space-related data for all facility spaces (including occupancy and floorplans), develop strategic space planning scenarios, and create customized reports for customers. During the pandemic, the software has been a valuable tool that has allowed the Space Management team to assist ORNL directorates with space planning in accordance with health and safety guidelines. Space Management is also working on providing an updated list of all square footages of applicable EUI facilities operated by UT-Battelle (including those within the X-AREA facility category). Working to improve square footage reporting will ensure more accurate EUI reporting.

Utility improvements

- Improvements in utility services have reduced the costs of energy, fuel, water, and maintenance and have increased reliability in the delivery of steam, chilled water, and potable water. Utilities personnel were crucial in the VARP in FY 2022, and some of their involvement is outlined here. FY 2022 projects include the following:

- Electric utilities
    - Completed relay replacement at Building 0976 (improved reliability)
        - Completed wood pole condition assessment (improving reliability)
        - Completed CIMP CD-1 documents (planning for reliability and efficiency improvements)
        - Started medium-voltage design standard (increase in efficiency and cost savings)
        - Started a strategic spare transformer inventory due to long lead times in the industry
        - Completed 0901Transformer Storage Pad construction and closeout with release back to utilities. The pad enhanced transformer storage, protection, and accessibility by operations and uses an existing underutilized area in the switchyard without increasing the campus footprint

- Mechanical utilities
    - Completed Phase 5 and 6 of the ORNL Area Steam Pits Upgrade Project using the HUB zone approach facilitated by Procurement. To date, approximately 50% (~30 pits) of the ORNL campus steam pits have been completed and upgraded to OSHA safety requirements for access ladders, which also meet the ORNL ladder inspection checklist for fabrication safety and user access. The new aluminum grating provided for the pits reduces environmental impact and waste/scrap from a long-term perspective since it is noncorroding and will not rust. The old grating/steel/ladders were recycled and provided several thousand pounds of recovered scrap metal that did not go to landfills.
    - A design member of ORNL's Utilities Division personnel maintained professional credentials for the Leadership in Energy and Environmental Design (LEED) AP BD+C accreditation through continuing education courses pertinent to the sustainability disciplines.
    - Rebuilt Chiller Plant (Building 4509) Trane Chiller #4 and extended life expectancy of a 26-year-old chiller, hopefully for another 15 years, including 30% gain on efficiency. Task also included replacing leaking valves, which enables having maintenance outages without affecting many customers.
    - Rebuilt Chiller Plant (Building 4509) Trane Chiller #6 and extended life expectancy of this 25-year-old chiller, hopefully for another 15 years, including 30% gain on efficiency.
    - Commissioned Frontier as the world's fastest exascale computer. The computer is cooled by tower water, using high-temperature water, which not only makes it the fastest computer, but

also the most efficient computer, providing more flops per watt than any other computer in the world.
    - Cleaned condenser tubes in eight chillers every year to reduce approach temperatures and improve operating efficiency. Eddy-current testing was performed on each condenser and four chiller evaporators to verify tube integrity.
    - Repaired leaks in three chillers to maintain stratospheric ozone compliance. All chillers are leak checked annually.

4.5.2 Plans and Projected Performance

Standardization of energy-efficient equipment through campus policies

- Similar to the LED policy, FMD is considering other energy efficient policies moving forward, such as standardizing energy-efficient packaged terminal air conditioners. FMD will assess how the LED policy implementation goes and determine if ORNL wants to take further steps to try to institutionalize certain energy efficient equipment for the energy benefits as well as the general knowledge of maintenance across the division that comes with standardizing equipment.

Electrification

- ORNL will continue to discuss options and strategies for electrification as the lab moves forward with its CFE and net-zero discussion. ORNL will continue to include electrification in discussion for its net-zero assessment.

Refrigerant HVAC systems

- ORNL will continue to pair electrification and refrigerant investigation together. When looking for ECMs, ORNL will look for HVAC systems that still use older, more GHG-emitting refrigerants and try to upscale to new systems that can use refrigerants that emit less GHG emissions.

Future utilities projects

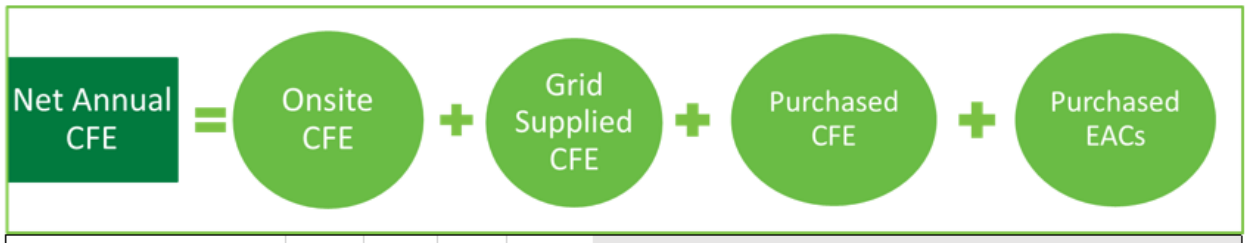
- Rebuild Building 5600 Chiller #5
- Continue with annual chiller tube cleaning and eddy-current testing
- Develop schedule to clean cooling towers and have begun to increase maintenance staff to perform this task since the number of towers has increased by 60% since FY 2021
- Work with researchers to incorporate carbon capture technology into operating cooling towers
- Commission new building (Translational Research Capability, Building 3700) magnetic drive chillers, which run on low-temperature condenser water to provide high chiller efficiencies. This building system also includes a heat pump chiller that rejects heat to building heating system

4.6 CARBON FREE ELECTRICITY (CFE)

4.6.1 Performance Status

Per the defined methods for calculated percentage of CFE shown in Figure 12, ORNL has a 43.8% CFE. The 43.8% CFE is largely due to the grid supplied CFE from ORNL's supplied electricity region, or

eGRID Subregion SRTV (SERC Tennessee Valley). Figure 12 shows the specific numbers used to calculate ORNL's percentage of CFE. Less than 1% of the current percentage of CFE comes from onsite generation.



					FY 2021 Electricity (MWh)						
Site Name	Main Zip	eGrid Subregion	% CFE	Net Annual CFE	Purchased CFE	Onsite CFE	Purchased EACs	Grid-Supplied CFE	Grid-Supplied	Conventional Hydro	Purchased CFE w/o limit
Oak Ridge National Laboratory	37831	SRTV	43.8%	224,041.35	-	86.68	-	223,954.67	511,649.52	-	-

Figure 12. ORNL CFE calculation.

The SRTV includes the Tennessee Valley Authority (TVA), which is ORNL's direct electricity provider. It is estimated that TVA's percentage of CFE is currently 30% higher than the eGRID subregion's percentage of CFE production with an approximate 57% CFE for TVA. Figure 13 outlines the net annual CFE calculation from 2005, with projections into future years.

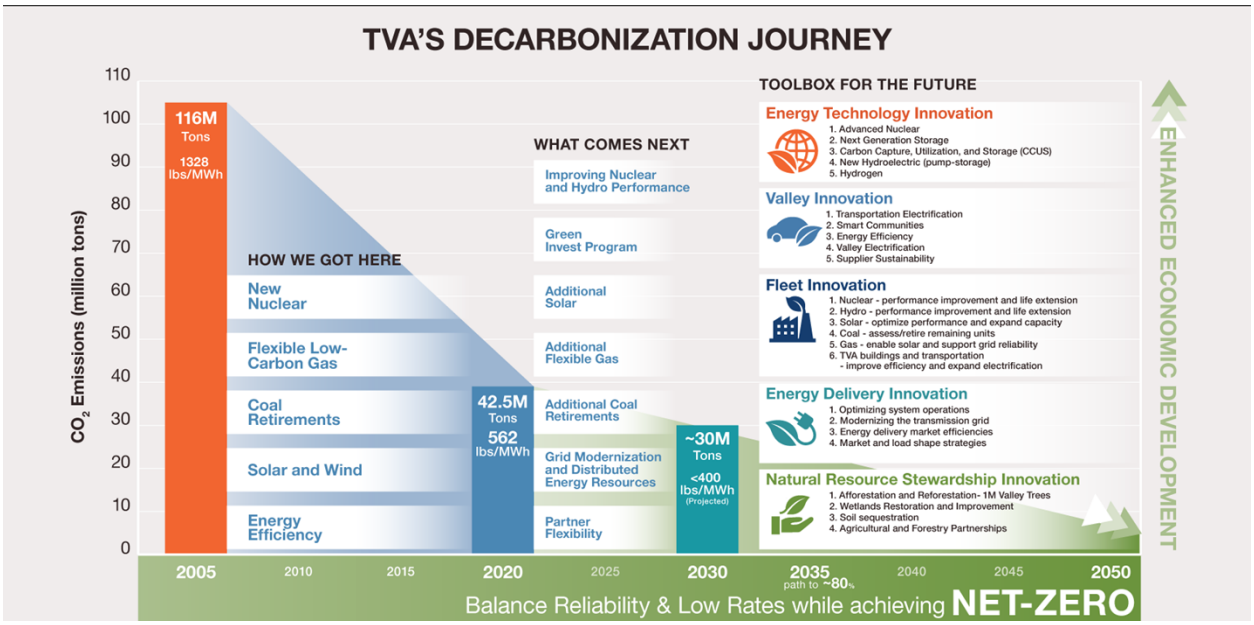


Figure 13. TVA's CFE and net-zero projections.

4.6.2 Plans and Projected Performance

In September 2022, ORNL submitted the CFE Implementation Plan to SC which was intended for sites to provide projections of percentage of CFE toward goals of achieving 100% CFE by 2030, including 50% on a 24/7 basis established by EO 14057. For this request, ORNL provided annual projections or targets toward percentage of CFE through FY 2030, as listed in the Table 4.

Table 4. ORNL's baseline CFE and annual CFE performance targets

Fiscal Year	Program office baseline and annual CFE performance target (%)
2022 (baseline)	44
2023	55
2024	60
2025	62
2026	64
2027	66
2028	68
2029	70
2030	100

ORNL projects 100% CFE by FY 2030 to meet the federal goal. However, some caveats were identified before ORNL can make this 100% CFE goal a reality.

1. In 2023, ORNL's targets align with TVA's percentage of approximately 55% CFE. This assumes ORNL will use TVA's percentage of CFE instead of the eGRID SRTV subregion's percentage since ORNL's electricity is provided directly from TVA.

2. Most of ORNL's annual CFE target increase relies upon TVA's strong commitment toward CFE increases through FY 2030 (Figure 13). TVA has projected that it will reach approximately 70% CFE by 2030. Since ORNL is a direct feed from TVA, the lab forecasts 70% CFE by FY 2029.

3. The large jump between FY 2029 and FY 2030 is possible due to anticipated clean energy projects/applications, such as an anticipated solar project that is being investigated. ORNL will also consider energy attribute certificate (EAC) purchases if supply is available in the coming years, and specifically if they are available between FY 2029 and FY 2030. The purchased EAC strategy to meet CFE goals will be accomplished on an as-needed basis and reevaluated annually. Due to the risk of the developing energy attribute markets, there is a supply chain risk concerning EAC supply availability that cannot be foreseen. TVA will likely have established some EAC availability as we approach FY 2030. Due to the many unknowns, there is a risk that ORNL will not be able to purchase enough EACs to supplement annual targets.

The action items between FY 2029 and FY 2030 depend on further investigation, identification of the most effective strategy, verified project efficiencies, leadership approval, and capital funding. ORNL will continuously investigate changing technologies and aim for capital projects with the best probabilities of reaching and maintaining energy efficient performance over time. ORNL must balance progress toward 100% CFE for existing electricity consumption as well as predicted electricity consumption growth due to mission needs. Electricity is expected to increase due to the SNS Second Target Station and the next High-Performance Supercomputer launch in the coming years.

As more information and clarification is provided by DOE, ORNL will seek to identify 24/7 hourly load measurement options/capabilities in FY 2023 and FY 2024. On-site deployment of necessary metering, if appropriate, could be completed in FY 2024 through FY 2025. ORNL has a robust metering network with distribution meters (more elaboration on this is in the Energy Management: Facility Metering section) that could possibly support this effort within the lab's current capabilities, but further analysis will be needed to confirm if the metering network system meets the 24/7 data requirement.

ORNL will also investigate LED upgrades and HVAC efficiency improvement projects on a larger scale than previously executed. Applying electrification strategies, rightsizing facility equipment, and replacing older equipment are possible upgrades that can be identified in the facility condition assessments (FCAs). The annual mission readiness funding calls as part of the annual lab plan process is one possible avenue that ORNL is considering for large collective funding request for some of these projects.

4.7 ENERGY MANAGEMENT: ENERGY INDEPENDENCE AND SECURITY ACT (EISA) SECTION 432 BENCHMARKING AND EVALUATIONS

4.7.1 Performance Status

In FY 2022, ORNL started the second year of the 4-year energy audit cycle by conducting 22 building audits throughout the year to cover a quarter of the buildings that are qualified for audit inclusion. Most audits were done internally by using ORNL's Central Energy Data System (CEDS) data for energy benchmarking and by interviewing facility operations staff. For each facility audit, a report was drafted outlining the significant energy users, recent or impending operational changes, and potential ECMs for the facilities identified by facility personnel. Throughout the year, ORNL leveraged technology in the form of meter data analytics and BAS data for audits. Because of the COVID-19 pandemic, a majority of the audits scheduled to be conducted at the beginning of the year were conducted remotely with the facility operation staff to maintain proper social distancing.

Energy Independence and Security Act of 2007 (EISA) benchmarking of buildings is performed by using ORNL's Resource Advisor (RA) system, addressed in the Energy Management: Facility Metering section, to configure building utility meters to automatically report building utility consumption to the ENERGY STAR Portfolio Manager. Once the reporting connection is set up between the two systems, the process does not need any more effort for reporting with the exception of ensuring data quality and proper configuration within RA and the ENERGY STAR Portfolio Manager.

ORNL uses an internal high-level project tracking system, RESolution, to track all ECMs identified via the audit process or communication with facility engineers. RESolution is used to track the major project core details such as time, budget, and scope. ORNL's EE&S program tracks the progress of the ECMs according to these project core details. As part of the scope, the EE&S program includes measurement and verification (M&V) when possible. If it is a more intricate project, it may require a walk down or analysis of the controls, but for simple projects such as LEDs, the installation of LEDs is confirmed to verify the details used in the calculation of the life cycle cost effectiveness prior to project start. When possible, processes will also be developed to embed M&V into the maintenance and operations workflow.

ORNL's M&V process for implemented ECMs aims to balance the rigor, time, and cost of M&V with the scope, scale, and data availability associated with each project. Advanced utility meter data will also be used when the meter data are available, and the projects are impactful enough to be seen in the building-level utility metering. M&V measures for the ORNL energy savings performance contract (ESPC) are discussed in the Investments: Energy Savings Performance Contract section.

4.7.2 Plans and Projected Performance

In FY 2023, ORNL will start the third year of the 4-year energy audit cycle. This will be the first year that all ECMs that are life cycle cost-effective moving forward must be funded and implemented per EAct 20. Moving forward, ORNL plans to incorporate a more documented formalized energy auditing process. This will also align with efforts to document and formalize the process per DOE 50001 Ready to improve and promote progress. To assist with this process, ORNL Facilities and Operations (F&O) management hired a new engineer for the EE&S program to support EISA audits and EAct 20 process (also discussed

in the Investments: Energy Act of 2020 section). This engineer's primary focus will be on optimizing, documenting, and institutionalizing the auditing process, along with ECM identification, life cycle cost analysis, and reporting.

To further institutionalize the auditing process, the EE&S program will provide facility engineers with a list of information that they must be prepared to discuss before the audit. Thorough walk downs of the facilities may be necessary moving forward, especially in mechanical and electrical rooms to identify ECMs and calculate life cycle cost effectiveness. The EE&S program will work to establish a consistent auditing structure to ascertain the following available information before and during all building audits:

- Meter data
- BAS data
- FDD data
- Drawings needed for discussion
- LED tracked information (to baseline and update information)
- Old audits and commissioning reports
- Old benchmarking data (for the prior year and the prior year audited on the 4-year cycle)
- FCA information

ORNL complies with the 5-year FCA cycle to identify and document maintenance that is needed within designated facilities throughout the ORNL campus. During FCAs, various SMEs are contacted to perform the FCA for each respective building. Meeting with the different individuals creates a bridge of knowledge with respect to equipment repairs, repair costs, and energy improvements. The knowledge transfer and documentation of these FCAs provide those responsible with helpful resources and necessary information for identifying and prioritizing maintenance issues, including some that may have energy efficiency impacts on buildings.

ORNL's FCA program has a custom system programmed for tracking assessments. This program tracks the date and assessment details, allows for upload of information to create a formal assessment report, and tracks actionable deferred maintenance. ORNL's EE&S program will work with the programmers moving forward to integrate energy and water auditing into this system. This system could be set up to upload the EISA file that ORNL must submit each year. ORNL will also work with programmers to incorporate an ECM tracking system for all identified ECMs. Once established, the programmers could incorporate a collaborative screen between the two reporting needs, FCAs and EISA audits, to show all the needed projects within a single building. A combined system of actionable projects that could accomplish two designated requirements could allow for improved decision-making data for funding moving forward. ORNL will also include general and deferred maintenance as a factor to consider when prioritizing ECMs each year, along with consideration for safety and environmental benefits.

In FY 2018, the application of building energy models to the energy auditing process began through collaboration with ORNL's Energy and Transportation Science Division research staff. As part of a previously funded Laboratory Directed Research and Development project Urban-MET (FY 2016–FY 2017), ORNL staff applied AutoBEM technologies and manually collected data (e.g., laser scans for measurement of window-to-wall ratio of every building façade) of 31 buildings on the ORNL campus. DOE has invested $85 million since 1995 in the development of EnergyPlus and OpenStudio, which simulates thermodynamics and energy consumption of buildings and provides tools to rank individual ECMs (e.g., add insulation, change HVAC control) by cost effectiveness. The Urban-MET project created EnergyPlus and OpenStudio models of ORNL buildings, resulting in a virtual ORNL campus that can be simulated.

FY 2018 efforts focused on modeling 5 of the original 31 buildings, and FY 2019 efforts focused on modeling 4 new buildings. The models were calibrated to industry standards with real advanced meter data and quantified the impact of ECMs. The intent was to make these models so that they would cover the EISA requirements while also calibrating for various ECM proposed, potentially with the ability to calculate life cycle cost effectiveness. Because of the new EAct 20 requirements and the help of a dedicated engineer, the EE&S program is considering reapproaching these types of efforts in the future.

4.8 ENERGY MANAGEMENT: FACILITY METERING

4.8.1 Performance Status

During the past few years, efforts have been made to document all facility metering into ORNL's work management and enterprise asset management system, Infor EAM. With the recent deployment of Esri ArcGIS across many operational areas at ORNL, the capability to join asset information with utility distribution system information has provided the means to create a master meter report/plan, to determine where metering is lacking, and to prioritize resources toward additional metering. The metering plan is a comprehensive document that charts a course for ORNL's continued advanced metering deployment, which is consistent with the November 2014 DOE *Update to the Federal Building Metering Guidance* and with current DOE directives focused on advanced utility metering where cost-effective and appropriate. In using ArcGIS, the metering plan and meter implementation process becomes institutionalized in ORNL's systems so that once a meter is added as an asset, it can be tracked and reported in the meter network (Figure 14).

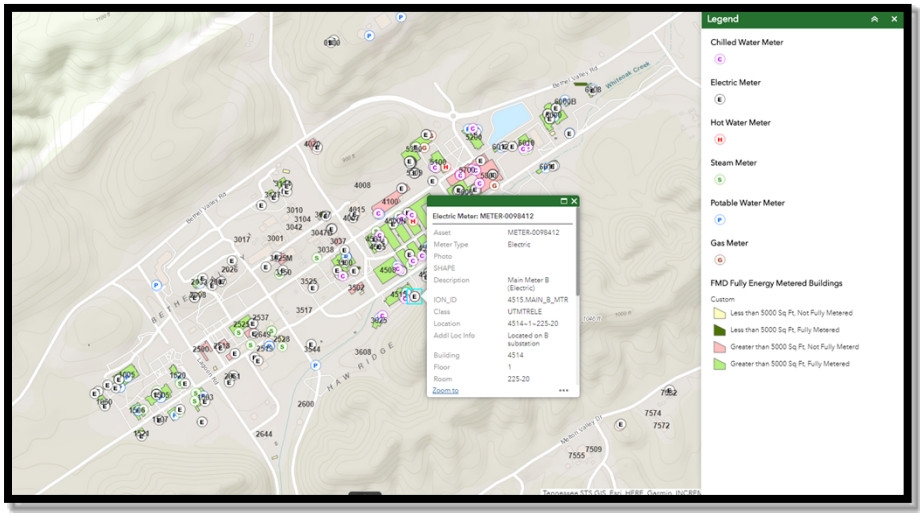


Figure 14. ArcGIS map of the meter network across ORNL. An electric meter was selected to show the information tracked for each meter.

The total number of facility and distribution meters, the connection points to facilities, the number of facilities that are fully or partially metered, and where these meters are located are now tracked and interconnected between Infor EAM and ArcGIS (Figure 15). All mechanical meters are integrated into this process for inclusion in the meter plan report and efforts are ongoing to integrate electrical metering into this process.

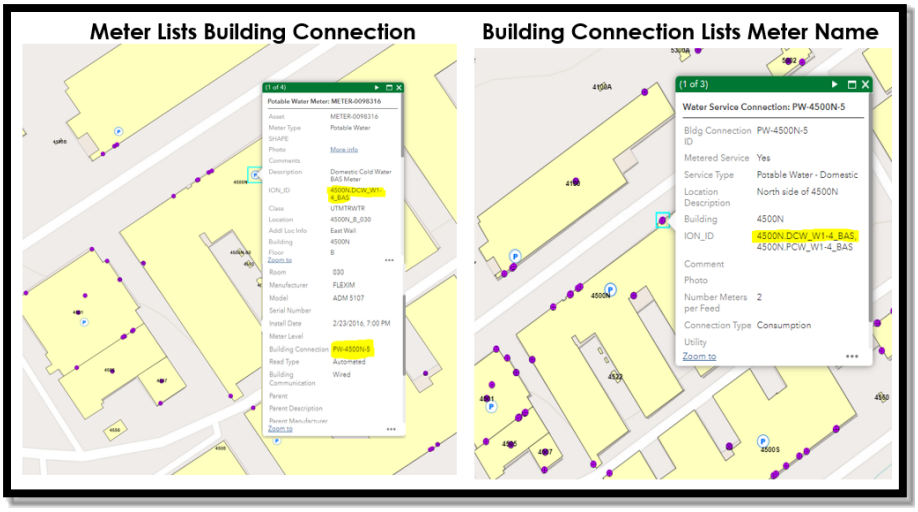


Figure 15. ArcGIS map showing meters connected to utility building connection feeds. Once a meter is linked to connection points (purple dots), a meter plan (as well as meter gap analysis) can be developed.

In FY 2022, ORNL added 75 new advanced utility meters (including computational metering and electrical utility distribution metering), migrated 7 new data streams from other systems across the lab, and replaced 6 meters. ORNL meter installations include electrical, steam/hot water, natural gas, chilled water, and potable water. The meters were connected to ORNL's CEDS, which is a network of systems used for data archiving and analysis. CEDS serves to securely collect, archive, and display advanced utility meter data from the network of utility meters installed throughout the laboratory. CEDS logs multiple parameters from each meter on a standard 15 minute interval. This system also enables meter data trend analysis, report generation, and energy awareness dashboard deployment, as well as data export for use in other analyses.

RA, the newest tool in CEDS, was deployed in FY 2017. Since its deployment, RA's advanced configuration capabilities are used to easily calculate and quickly display total building energy consumption using data from the advanced utility meters. RA provides comprehensive dashboard and energy-analysis capabilities that align with ORNL's continued maturation in energy data utilization. RA also directly feeds metered energy data into ENERGY STAR for benchmarking.

The meter network and CEDS were crucial assets in achieving the DOE 50001 Ready certification for 65 FMD buildings in FY 2019 and recertification in FY 2020 and FY 2021. The documentation of the meter plan, the use of the energy systems collecting and reporting energy data, RA's configuration capabilities, and the meter alerts helped ORNL with DOE 50001 Ready tasks such as energy analysis, monitoring and measurement, and corrective actions. As ORNL's network of advanced utility meters continues to grow, the DOE 50001 Ready platform complements the system by creating a systematic program for using the energy data and documenting the energy program. The continued development of the CEDS network, combined with the DOE 50001 Ready standards, will help provide management decision tools to attain energy and water efficiency goals and cost savings.

Meters are also used in the following ways:

- ORNL uses its robust meter network to establish a process for continuous energy monitoring using a meter alert capability within the CEDS. Alerts are placed on real-time readings for mechanical utility meters, including steam, chilled water, natural gas, and potable water for all buildings that have mechanical meters. Alert parameters are determined by reviewing meter trend history and analyzing

as many months or prior years as possible to obtain an accurate representative trend for each building utility baseline use. Meter alerts have been used to identify and prevent unnecessary waste.

- Metering at service entrances to ORNL are used to validate services for utility provider payments (electricity, natural gas, and water).

- The service-level meters are used along with building-level metering to distribute utility service costs among programs at ORNL for cost recovery.

- Meters are used for tracking the use of energy/fuel/water for various data reporting requirements and to help identify problems and potential conservation opportunities.

- Metering is used in the review of the M&V report for the ESPC with Johnson Controls Inc. (JCI).

- Metering assists with measurements of on-site electrical generation at the solar arrays.

As with any project of this scale, continued meter deployment will not be without barriers. These barriers may include installation funding limitations, alternative prioritizations of the installation labor force, utility outages or service interruptions required to accommodate installations, and other technical challenges.

4.8.2 Plans and Projected Performance

All buildings should have been fully metered by FY 2022 per EAct 20. ORNL is not 100% metered (energy and water) for all buildings greater than 5,000 ft^2 (per the 2014 metering guidance). ORNL will continue to add metering each year to SC-owned buildings that are 5,000 ft^2 or greater to move toward the defined goal, unless new metering guidance specifies differently.

The asset management and geographic information system mapping of the utility services and the associated advanced utility meters will continue to be documented, maintained, and expanded upon into the future. The institutionalized meter plan report will be a valuable asset that will help maintain and document the meter network into the future. Specific focus will be on implementing the electric metering network into the report. ORNL will continue to use the metering plan for guidance in installing additional advanced utility meters, where cost-effective and appropriate, on all utilities. All utility meters will be connected to ORNL's CEDS for data analysis and archiving.

RA can be used to expand energy awareness with more robust dashboards and analyses for facility managers, facility engineers, and eventually the greater laboratory population. RA is currently being developed to track energy reporting throughout the year using meter data and allocation data, when building-level meters are not available, for improved reporting and tracking of EUI throughout the year. Additional metering will expand building-level EUI and water use intensity (WUI) tracking for potential project opportunities and reporting metrics, as well as to enhance cost recovery efforts.

ORNL will continue learning more about the 24/7 CFE requirements and determining if there are metering needs necessary to meet the CFE goals. ORNL is well positioned with electricity metering to support this effort, but further investigation of the goal and further understanding of the metering needs or gaps will be required.

4.9 ENERGY MANAGEMENT: NON-FLEET VEHICLES AND EQUIPMENT

4.9.1 Performance Status

At only a fraction of 1% of all facility energy, non-fleet fuels (for facility vehicles and equipment) are a comparatively minor source of energy usage and emissions at ORNL. ORNL remains in compliance with reporting and tracking the use of these fuels (diesel, biodiesel, gasoline, and oils) for DOE SSP reporting and performance.

For FY 2022, the generators, landscaping equipment, and heavy machinery reduced their combined fuel consumption by approximately 5% from FY 2021.

During FY 2022, fleet management added several pieces of non-fleet vehicles and equipment to meet the growing demand for projects requiring heavy equipment. The equipment was an improvement in capability and sustainability, with all heavy equipment meeting Tier 4 emission requirements. In addition to improved emission systems and fuel economy, most equipment can operate using biodiesel and is equipped with idle reduction technology. Additionally, ORNL added multiple lifting devices, including pallet jacks and forklifts. The fleet office found all lifts with an electric option as opposed to traditional fuel operations.

4.9.2 Plans and Projected Performance

ORNL will continue to upgrade equipment with more energy-efficient options.

Sustainable ORNL and the Fleet Management team will continue to look for opportunities to upgrade existing non-fleet vehicles.

ORNL is investigating alternate fuel options for generators.

4.10 ENERGY MANAGEMENT: EUI FACILITY IDENTIFICATION

Figure 16 identifies 37 EUI values for buildings in the Goal Subject category that are greater than 5,000 GSF with an EUI of 234,000 Btu/GSF or greater. The FY 2022 EUI of 234,193 Btu/GSF is also identified on the chart. Buildings in excess of the current EUI will be the focus of energy conservation activities in the future because improvements in EUI are necessary to meet several of the DOE energy management and sustainability objectives. As is expected, buildings with the greatest EUI are associated with HEMSF research systems (Excluded category) but are not included in this figure.

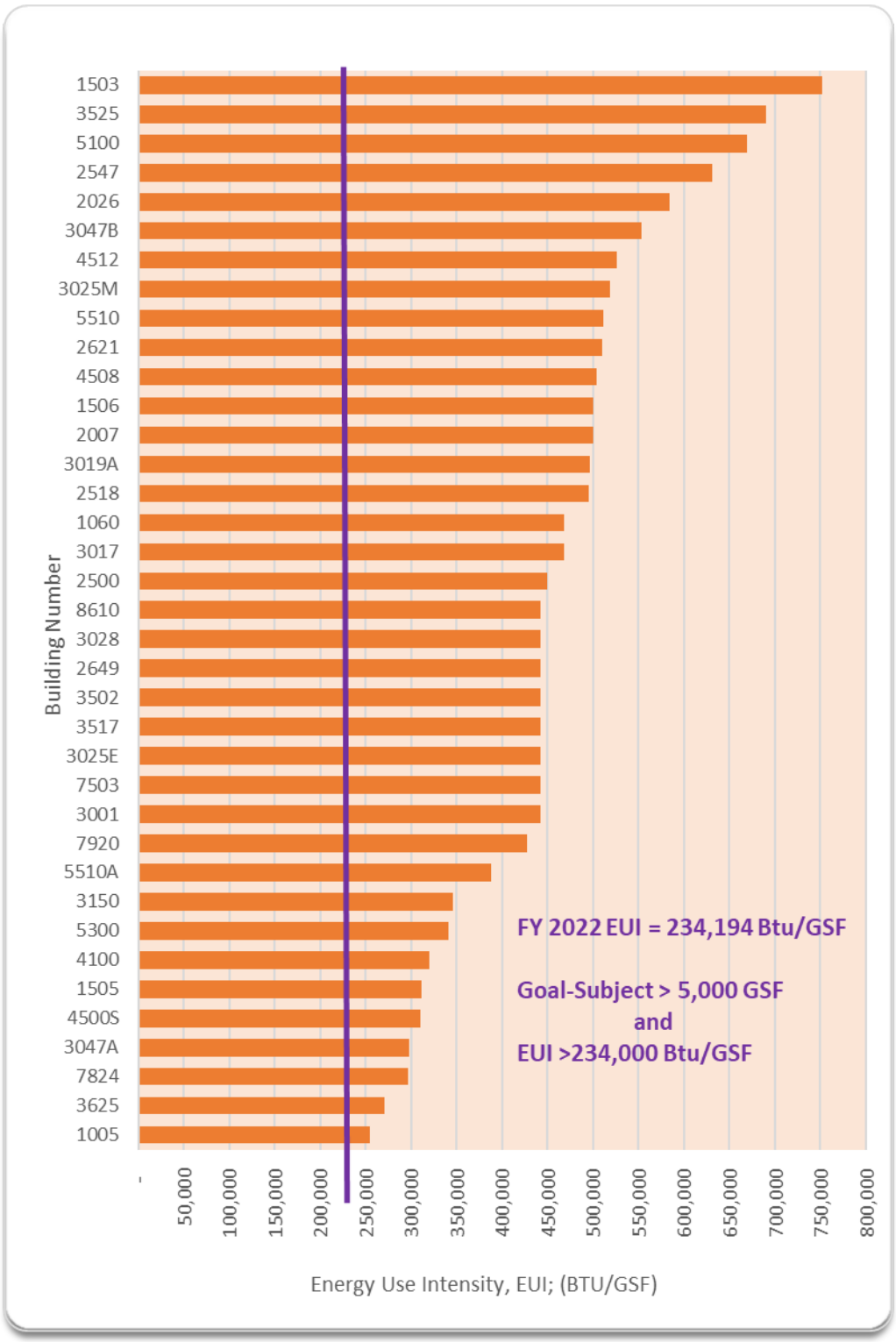


Figure 16. FY 2022 EUI by building at ORNL.

5. WATER MANAGEMENT

5.1 WATER MANAGEMENT: WATER USE INTENSITY (WUI)

5.1.1 Performance Status

ORNL procures potable water from the city of Oak Ridge for domestic use (e.g., handwashing, flushing), cooling (e.g., cooling towers, chillers), heating (e.g., steam generation, hot water generation), limited landscape irrigation, laboratories, and special research processes. ORNL does not utilize gray water or industrial, landscape, and agricultural (ILA) water.

ORNL has long been aware of the benefits of effective water management, having already experienced a 65.7% reduction in water use compared with its highest level of water use experienced in FY 1985. A firmly established, aggressive plan continues to be deployed. Numerous strategies are engaged to reduce water consumption, which includes repairing leaks, replacing old lines in the site water distribution system, and eliminating once-through cooling (OTC) where possible. The FY 2022 water consumption decreased by 1.7% from FY 2021, partially because of slight reductions in operations at HFIR and SNS, while being offset by Summit and boiler makeup increase. ORNL's water consumption still realized a 30.0% reduction in annual total water use since the FY 2007 baseline (Figure 17). Water consumption is expected to increase slightly in FY 2023 and FY 2024 because of limited SNS operations to support the Proton Power Upgrade while being offset by a growing HPC mission. As SNS returns to normal operations and with an increased HPC mission, ORNL's water consumption is projected to increase by 9.5% by FY 2030.

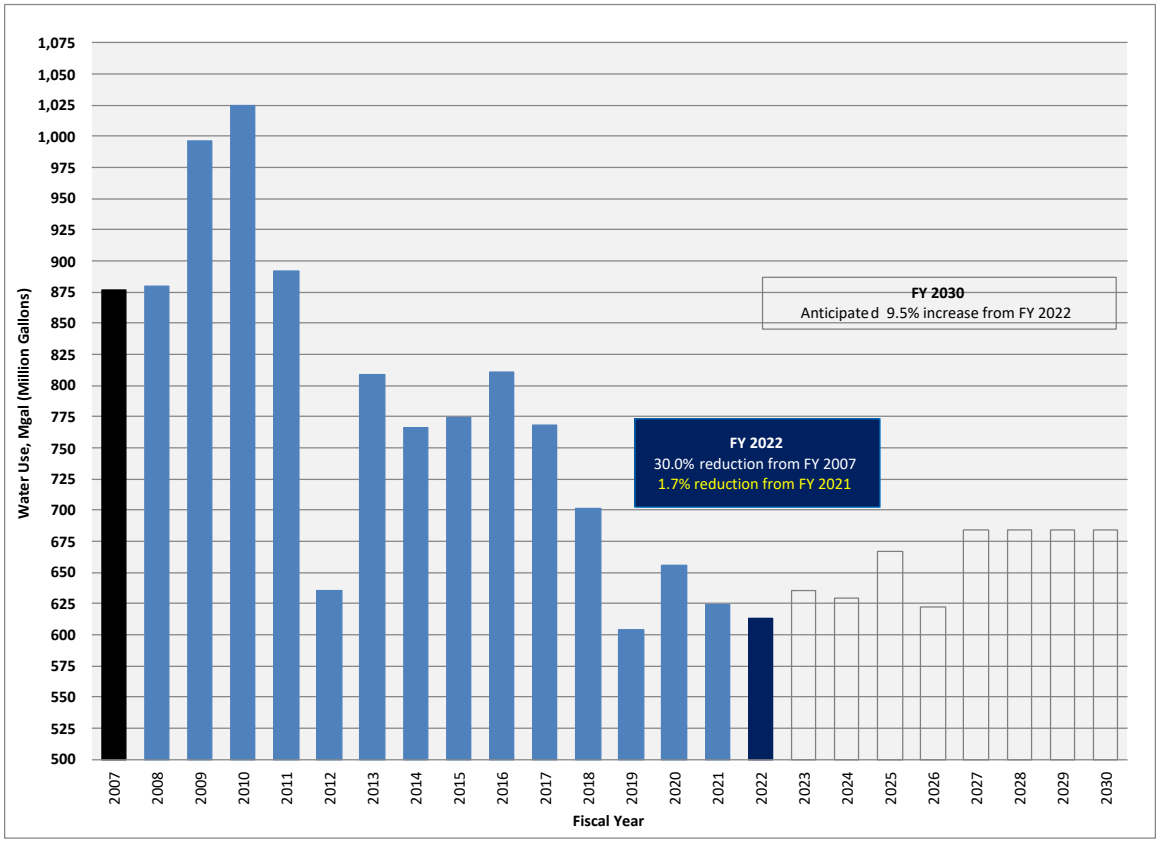


Figure 17. Historical, current (FY 2022), and projected water use at ORNL.

The FY 2022 water consumption yields a WUI value of 137.6 G/GSF, which is an increase of 1.7% from FY 2021 (Figure 18), missing the desired 0.5% annual reduction goal. Continued improvements in the identification of water-consuming facilities yielded a 3% reduction in GSF, contributing to the increased WUI.

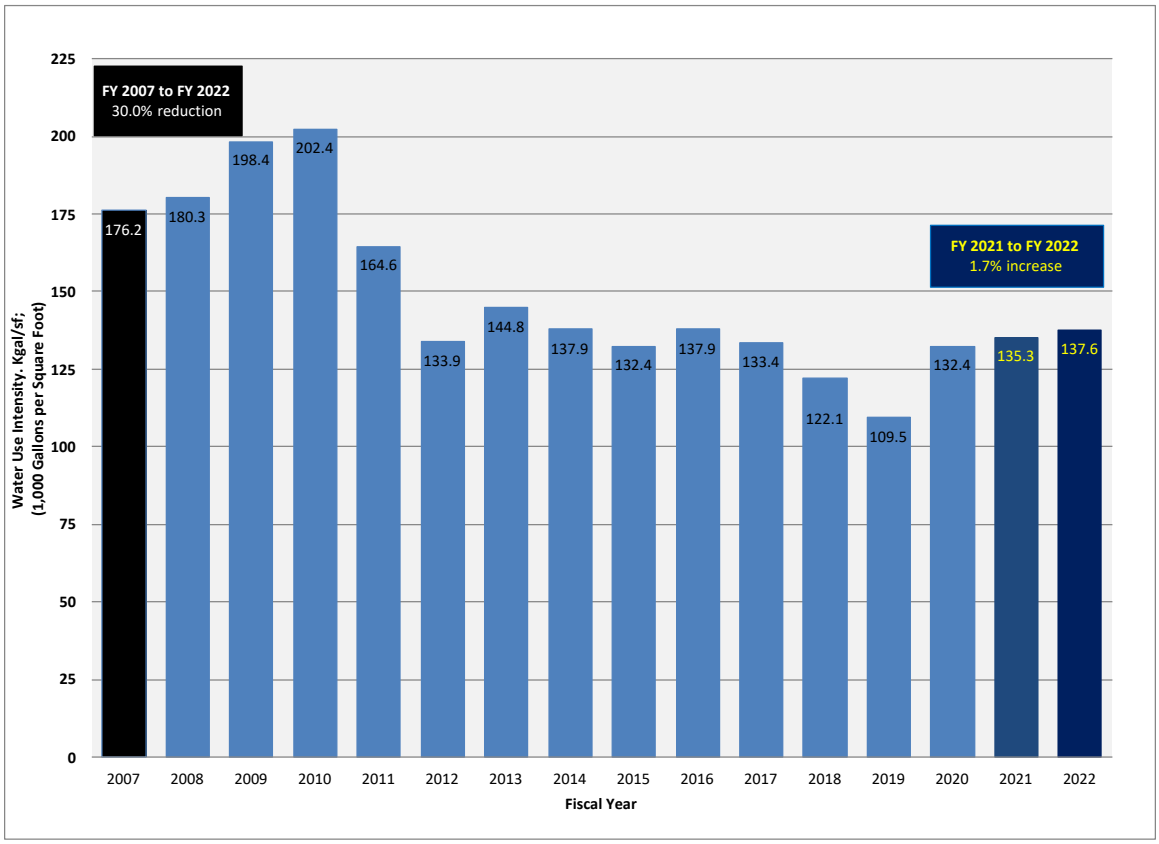


Figure 18. Baseline (FY 2007) to current (FY 2022) WUI at ORNL.

ORNL's end use water consumption

Typical site services such as chilled water and steam/heating production share water use across the facilities that receive those services (Figure 19). Base water use (58% of total water use) is considered more typical in conventional offices and standard laboratories for traditional handwashing/flushing and some research-related water use. The base water is a prime target for energy conservation opportunities. OTC processes have been significantly reduced at ORNL.

Although the WUI does not permit excluding water consumption for high-intensity processes, ORNL's end use water consumption shows that 24% of the water consumption is dedicated to research and process activities. This includes dedicated water for cooling tower makeup for HPC (such as Summit and Frontier), SNS processes, and HFIR.

These research/process users and utility service providers have a combined dedicated WUI of 160 G/GSF, serving approximately 940,897 GSF. This WUI for special processes is significantly higher than ORNL's integrated WUI of 137.6 G/GSF. Because of the mission-specific nature of the process water consumption and the dedicated service areas, a logical consideration should be made for the exclusion of these intensive areas. If the exclusion procedures are applied to mission-specific water use, ORNL's WUI

would drop to approximately 128,596 G/GSF as a comparison, which would be a more reasonable metric for targeting water reduction opportunities.

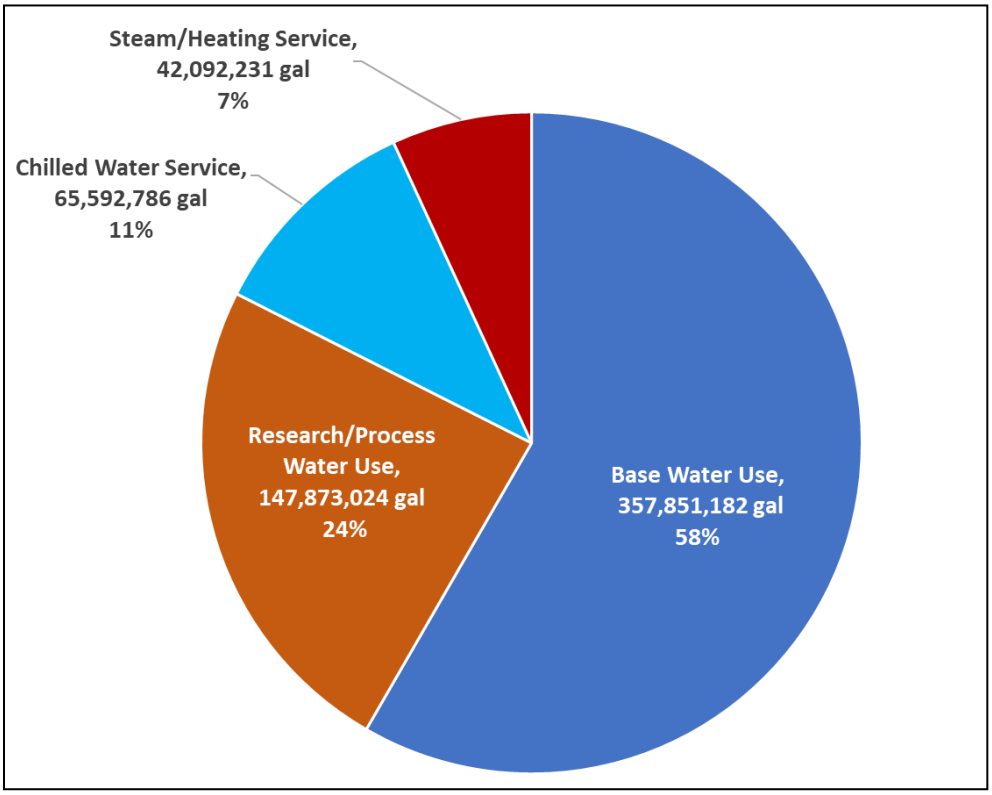


Figure 19. ORNL's detailed end use water consumption for FY 2022.

Water management ECMs and initiatives in FY 2022

- In the past few years, ORNL has reduced OTC processes throughout the campus. Mechanical utilities have been working on water consumption reduction through utilities repairs/upgrades. On occasion, ORNL engineering groups review the feasibility of alternative water options. If there is a potential option for alternative water to be cost-effective in new construction, it can be included as one of the noncore Guiding Principles (GPs). However, factors such as cost and complexity of water treatment for some of these alternatives make them difficult to implement. ORNL will continue to explore alternative water sources when cost-effective and feasible, but in the meantime, ORNL is focused on overall water consumption reduction when possible.

- Environmental compliance specialists have agreed to inform the EE&S program when/if there is a request for water use variances to see if these needs can be engineered to avoid OTC when possible.

- Efforts to maintain WUI-improving measures were initiated in FY 2008 upon the award of an ESPC. Year 10 contract performance indicates a water savings of 169 Mgal per year.

- To gain a better understanding of water use at ORNL, a water-metering plan is being implemented. Many of ORNL's most significant water-consuming facilities and utility processes, such as cooling tower makeup water, have been updated with advanced meters that are connected to CEDS and are collecting interval data. These data are used to understand water end uses, consumption patterns, and potential opportunities for WUI reduction. In FY 2022, ORNL installed 14 new water meters,

migrated 7 water meter data sources to CEDS, and replaced 3 water meters. This metering count is also included in the Energy Management: Facility Metering section to provide the number of total metering conducted at ORNL in FY 2022.

- The aggressive campaign to repair leaks and to replace failed components in the vintage water distribution system continued in FY 2022.

- A new Echologics™ leak detection and pipe monitoring system was installed on the main ORNL water feed to help identify a water break or interruption of any kind to help initiate a fast response time for repairs.

- Retouring of the water feed in the Building 7600 area eliminated the need for flushing water to maintain proper water turnover and improved water quality.

- A new water meter was installed in the Building 7000 area to help track water consumption in this area and monitor for leaks.

- An automatic boiler blowdown system was installed at the steam plant to optimize the blowdown flow to around 2%, reducing the amount of blowdown from the manual operations. This automation results in water savings to maintain the boiler water level and fuel savings to produce steam.

Stormwater management

Section 438 of EISA of 2007 stipulates that any development or redevelopment project involving a federal facility with a footprint that exceeds 5,000 ft^2 shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow.

F&O's Laboratory Modernization Division, through the division's environmental compliance representative, evaluates any development or redevelopment project that exceeds the net 5,000 ft^2 footprint of new impervious area. ORNL's approach to addressing EISA-438 requirements for storm water management was revised. Because of the soil types (low permeability) and karst geology, conditions exist at ORNL that would allow for claiming technical infeasibility, as described in technical guidance from EPA section 2009b. Clay soils have low infiltrative capacities, and the introduction of more water to the subsurface in a karst geology can accelerate the formation of sinkholes. As a result of these two geological conditions at ORNL, the use of subsurface infiltration to address EISA-438 is only being pursued on a limited basis. Instead, mitigation strategies (e.g., for streams and their associated buffer zones, installation of water quality systems and devices to improve water quality, and strategies that would allow for additional evapotranspiration) are being pursued. Implementing this revised approach to EISA-438 compliance, as opposed to claiming technical infeasibility, demonstrates ORNL's commitment to environmental stewardship. If projects take place in existing contaminated areas or where an area approach is not feasible, technical infeasibility is claimed to prevent potential movement of contamination within soil or groundwater.

When possible, this environmental stewardship approach is implemented on an area basis at ORNL. Addressing EISA-438 on an area basis, instead of a project-by-project basis, allows for the following:

- Storm water runoff from adjacent areas can be diverted around developed areas to keep water quality high.

- Water quality structures/devices can be installed to handle runoff from developed areas, thus reducing the number of water quality structures/devices to be installed and maintained.

- Individual projects are not burdened with the costs associated with addressing EISA-438 requirements.

In FY 2022, no EISA-438 projects were completed.

The ORNL Utilities Division provided a conditions statement for current stormwater systems in use on the campus. The stormwater collection system consists of drainage ditches, catch basins, manholes, and collection pipes that convey stormwater, condensate, and cooling water flows to the receiving streams. White Oak Creek traverses the ORNL site and ultimately receives all the discharges from ORNL, as well as normal flows from the four tributaries that feed it. Rainfall, snowmelt, and other authorized flows are directed to the gravity-drainage system that conveys the water from buildings, parking lots, streets, and roofs to specific outfalls. The collection system itself was installed in an unplanned manner over the years as ORNL developed and matured, which has resulted in the existence of 155 NPDES-permitted stormwater outfalls discharging into the receiving streams. To comply with current stormwater regulations and ORNL's NPDES permit, each of these outfalls must be periodically sampled and characterized to determine the makeup of the discharge stream and to ensure that it complies with permit requirements. The condition and performance of the stormwater collection system is very good. Under all but the worst of conditions, the system removes storm flows from the laboratory grounds without flooding or other damage.

5.1.2 Plans and Projected Performance

ORNL is working with a third party to perform a site-wide utility infrastructure assessment. The assessments anticipated upgrades to the water distribution system will be identified for water efficiency, maintenance reductions, and reliability improvements.

Current performance and future projections indicate that ORNL's WUI is subject to rise because of increased demands for cooling tower makeup water to support the growth of HPC systems. Therefore, ORNL must aggressively pursue additional water-savings opportunities to offset mission-specific demands to continue to reduce overall water consumption. With continued modernization activities that include elimination of old facilities and the addition of new facilities, ORNL must consider more water-efficient systems and maintain a focus on water management best practices to meet future WUI reduction goals:

- Planned growth to support ORNL's HPC mission is projected to result in additional water consumption for cooling towers. While the HPC mission growth continues, current plans indicate the water use is expected to peak in FY 2030 at 176 Mgal per year.

- Building-specific locations and other strategic points across the site's water distribution system will continue to be evaluated for the installation of advanced metering in accordance with EAct 20. A thorough analysis of accumulated water meter interval data will be a priority in the pursuit of reducing consumption. ORNL is putting a large emphasis on building-level water metering in the next few years because of the EAct 20 metering requirement that now includes water metering. Compared with other energy utilities at ORNL, water metering will need to be a focus to catch up to 100% metered. Water metering will be a priority for ORNL EE&S metering efforts going forward.

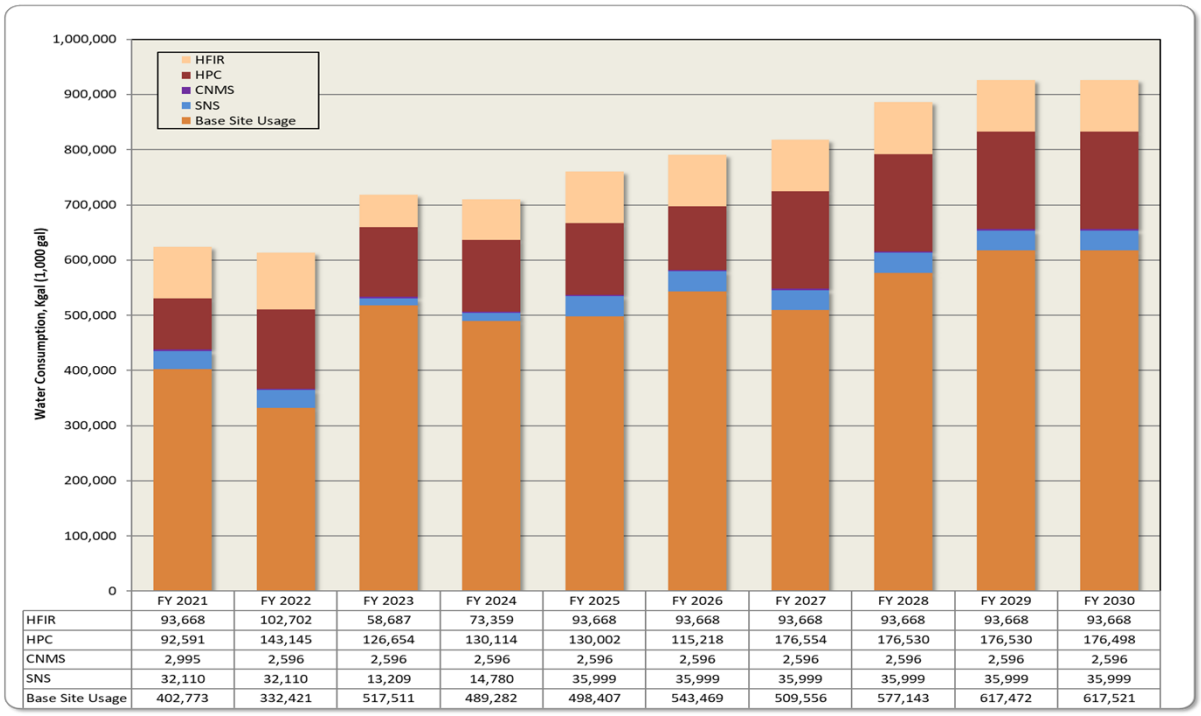
- Distribution meters for various areas throughout the campus were obtained in FY 2021 with the intent to install in the near term using a cost-effective approach. Some distribution meters were installed in FY 2022, and more will be installed in the coming years.

- Distribution and building-level water meters, facility audits, site-wide water crosstie connection survey, and ArcGIS water distribution maps help ORNL further understand the on-site water usage, which will aid in identifying new water conservation opportunities.

- ORNL will continue to identify and repair leaks and replacement component failures in the vintage water distribution system.

5.2 WATER MANAGEMENT: WATER CONSUMPTION AND HEMSF RESEARCH

ORNL's HEMSF systems consumed 46% of ORNL's water use in FY 2022 and are expected to remain around 33% by FY 2030. HPC activities were responsible for 23% of ORNL's water consumption in FY 2022; that amount is expected to increase by 19% in FY 2030 (Figure 20).



	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
HFIR	93,668	102,702	58,687	73,359	93,668	93,668	93,668	93,668	93,668	93,668
HPC	92,591	143,145	126,654	130,114	130,002	115,218	176,554	176,530	176,530	176,498
CNMS	2,995	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596	2,596
SNS	32,110	32,110	13,209	14,780	35,999	35,999	35,999	35,999	35,999	35,999
Base Site Usage	402,773	332,421	517,511	489,282	498,407	543,469	509,556	577,143	617,472	617,521

Figure 20. Current (FY 2022) and projected HEMSF water consumption at ORNL.

5.3 WATER MANAGEMENT: WUI FACILITY IDENTIFICATION

ORNL's mission requires the use of water for processes and cooling services. The 25 facilities identified in Figure 21 had the highest WUI at ORNL in FY 2022, several of which are associated with chilled water and steam production. As with energy, ORNL's water consumption is directly tied to mission-critical research growth and is expected to increase in the next 10 years.

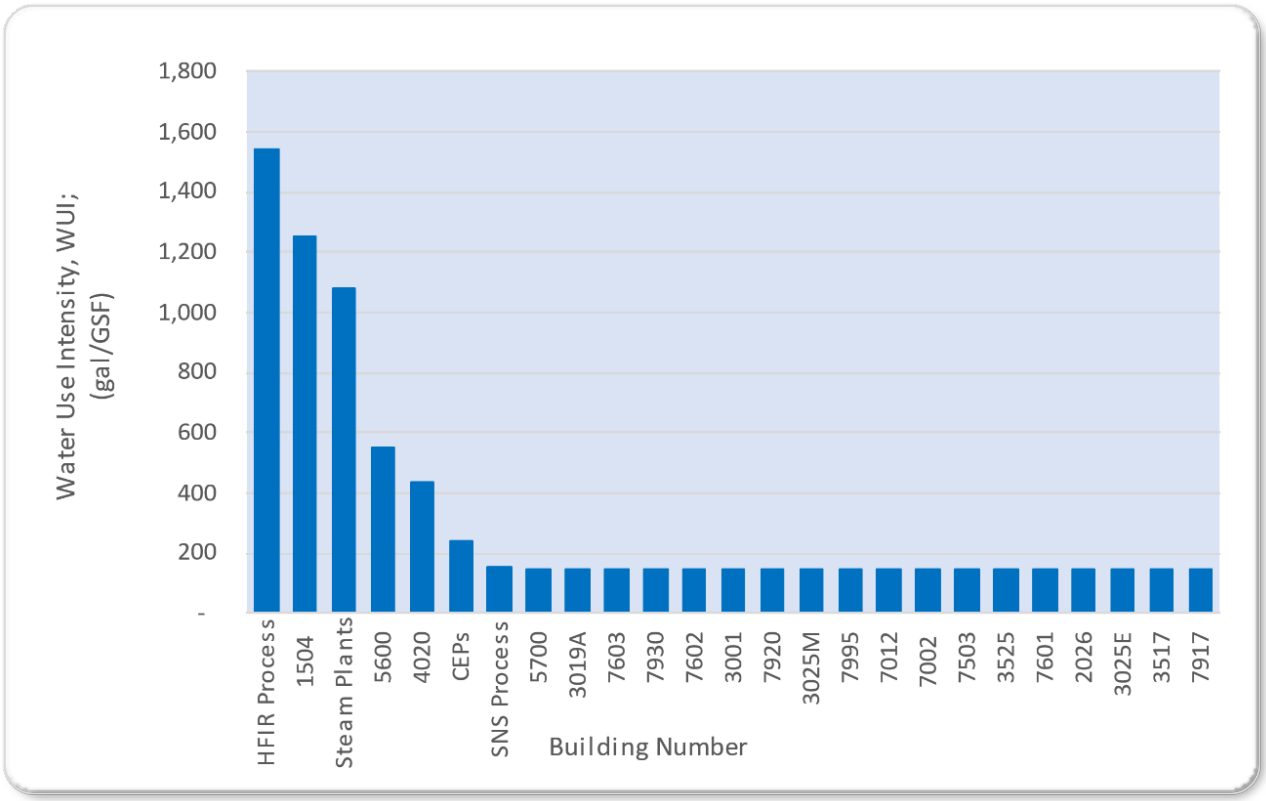


Figure 21. ORNL facilities with the highest WUI in FY 2022.

Thirteen facilities are responsible for 80% of ORNL's total water consumption. Again, chilled water and steam production are the largest consumers of water, as are HFIR and SNS (Figure 22).

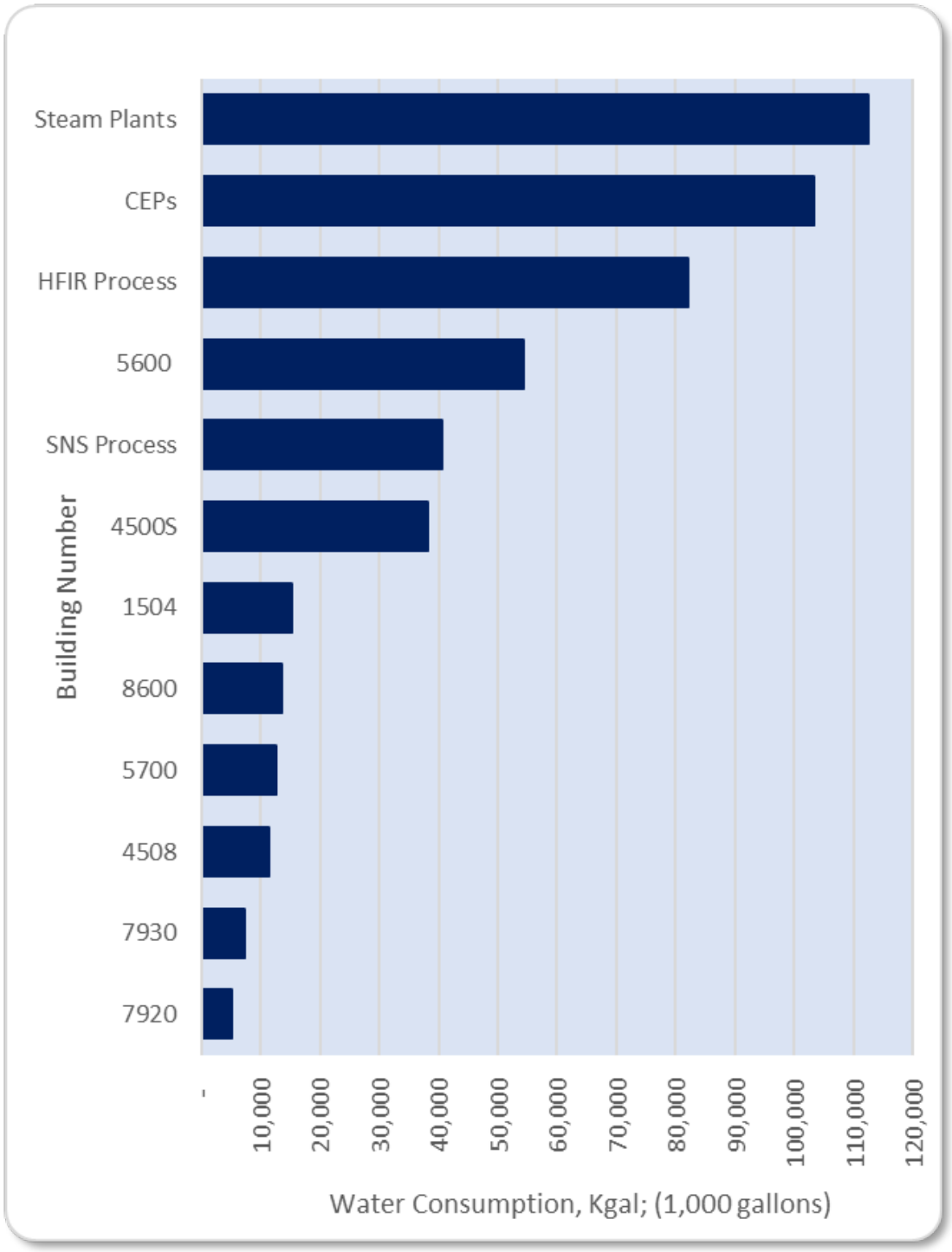


Figure 22. Water usage in the 13 facilities that consumed 80% of water at ORNL in FY 2022.

6. WASTE MANAGEMENT

6.1 WASTE MANAGEMENT: MUNICIPAL SOLID WASTE AND CONSTRUCTION & DEMOLITION WASTE

6.1.1 Performance Status

ORNL's pollution prevention (P2) vision, approach, program, and plan embody the commitment of ORNL management and staff to embrace sustainability, including reducing waste generation and toxicity. Accomplishing successful, sustainable results requires the merger of administrative and cultural changes with innovative technologies and procedures. Specifically, within waste management, the generation of waste and pollutants is minimized first through source reduction and then by reuse and recycling if a waste stream cannot be eliminated.

A primary pollution prevention focus has been to reduce and divert the amount of material intended for the landfill with efforts including the following:

- Development and use of planning and contract language requiring construction contractors to recycle as much construction debris as possible and to report the recycled amounts for all construction activities including new construction, modernization, and renovations

- Extensive use of training, awareness, presentations, and outreach, as well as placement of recycling containers throughout ORNL to encourage source reduction and recycling

- Identification and implementation of pollution prevention practices through project planning, operational assessments, trash can and dumpster monitoring, and National Environmental Policy Act reviews

- Maximized recycle/reuse for both municipal solid waste (MSW) and construction and demolition (C&D) waste, including recycling of scrap metal, wood, broken furniture, equipment, tires, paper, cardboard, toner cartridges, asphalt, and drums

The quantities of landfilled waste and diverted waste are highly dependent on ORNL's continued significant mission growth and associated on-site research and support activities, as well as the types of projects funded. Also, specific efforts to characterize wastes from deactivation and decommissioning (D&D) activities prevent costly disposal as low-level radioactive waste and reduce costs by managing the waste as C&D waste instead. The presence of certain regulated materials, such as asbestos and lead, prevents the recycling of some demolition waste and thus can have a negative impact on C&D diversion rates. Although these situations cause landfilled and diverted waste values to fluctuate, ORNL has emphasized source reduction efforts across the laboratory, such as the use of paperless systems, as its preferred pollution prevention technique. Even with mission growth, source reduction efforts and other strategies, such as diversion, have contributed to the overall downward trend observed in the combined total volumes of MSW and C&D.

Because ORNL MSW and C&D waste are both dispositioned in DOE landfills located on the Oak Ridge Reservation (ORR), no waste hauling contracts exist. However, the DOE contractor operating the ORR landfills does provide quarterly waste load data, including noting if a load of dirt or other construction-related waste is used in place of virgin material as either landfill cover or to create temporary roads withing the landfill. Also, the DOE contractor that operates the ORR landfills reports the landfill-associated GHG emissions in its SSP; however, ORNL maximizes source reduction and recycling of

materials to avoid waste generation, which subsequently directly and indirectly reduces Scope 1 and 3 emissions.

In FY 2022, ORNL's diversion rate for MSW reached 52.8%. The realized C&D diversion rate for waste materials and D&D debris was 70.8%, higher than previous performance. Contributing factors impacting this variability include the quantity and type of materials generated from the removal of decades-old materials during renovations and demolitions. Classification of certain materials, such as asbestos and lead, eliminate recycling as an option, but they can be isolated and encased for landfill disposal.

As part of its source reduction efforts, ORNL increases the use of acceptable nontoxic or less-toxic alternative chemicals and processes while minimizing the acquisition of hazardous chemicals and materials through material substitution, operational assessments, and inventory management.

When source reduction is not feasible, ORNL takes many steps to lessen the impact, including procurement of sustainable products such as biobased and recycle content, use limitation, and recycling, which work together to reduce impacts. Examples include using foam handwash that limits the amount dispensed and using a biobased product; using paper towels in dispensers that limit single-use amounts and then filling the dispensers with the most favorable biobased and recycled content product available; and upgrading aging transformers with new models that use a biobased oil instead of a mineral-based one.

Advances in DOE research to support recycling

ORNL recycles plastic waste through off-site recycling services along with numerous other recycle streams. Moreover, ORNL recognizes the need to close the loop for recycled materials and supports these efforts whether procuring materials with postconsumer recycled content or performing research to support closing the loop for plastic recycling. Specifically, the Manufacturing Demonstration Facility at ORNL works with industry to replace material disposability with renewability through research focused on closing the loop on the modern material supply chain. Through research, some conducted at ORNL, today's advanced manufacturing composite waste become tomorrow's valuable raw materials. Researchers are investigating and deploying new processes that convert feedstocks used in advanced manufacturing processes into reusable materials. These efforts, including controlled pyrolysis research (Figure 23), continue to close the recycling loop for plastics. More information is provided at https://www.ornl.gov/composites-recycling.

Figure 23. Controlled pyrolysis: creating a robust scalable composite recycling technology. Source: ORNL.

6.1.2 Plans and Projected Performance

Although expected future mission and population growth could cause diverted waste and landfilled waste values to increase, the use of source reduction and recycling will allow ORNL to minimize the impact of the growth on landfilled waste. Furthermore, ORNL will continue to characterize D&D wastes to minimize the generation of low level-radioactive waste, which may increase the amount of landfilled C&D waste but will provide overall cost savings.

The ORNL pollution prevention program will need comprehensive guidance and potential funding sources from DOE to begin the project development planning process to meet net-zero waste generation and/or waste-to-energy systems.

Planned activities include the following:

- Identification and implementation of additional source reduction opportunities
- Identification of new waste streams to recycle followed by cost-effective implementation
- Use of employee engagement and awareness activities to increase source reduction and recycling conformity

7. FLEET MANAGEMENT

7.1 PERFORMANCE STATUS

ORNL has continued to increase the number of alternative fuel vehicles (AFV), hybrid, and plug-in hybrid electric vehicles (PHEV) when options are available. Currently, 82% of all ORNL fleet vehicles are AFV. Since FY 2020, ORNL has replaced 343 vehicles, of which 307, or 90%, have been alternative fuel, hybrid, or PHEVs.

The fleet managers continued coordination with vehicle custodians during FY 2022 acquisitions to ensure vehicle rightsizing while also meeting mission-critical needs. This effort also provides the fleet manager the opportunity to place custodians in more fuel-efficient vehicles such as AFVs and EVs when applicable.

The fleet office is coordinating with the ORNL Laboratory Modernization Division to locate optimal location for future vehicle charging stations and include them in future projects.

The fleet office will also be growing by one employee to support the electrification requirements into the future. The ORNL fleet management organization structure is shown in Figure 24.

ORNL uses internal operating procedures per all applicable Code of Federal Regulations that govern procurement, utilization, disposition, and mission support while working closely with federal oversight.

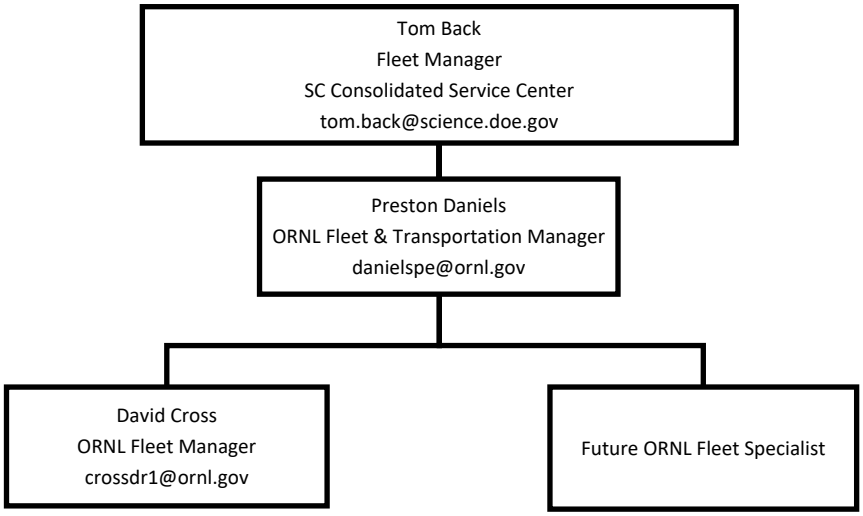


Figure 24. ORNL fleet management organizational structure.

Alternative fuel use and infrastructure

In accordance with DOE guidance, ORNL fleet management continues to stress the use of alternative fuels. The two alternative fuels available on-site are E-85 and B-10 biodiesel. Fleet management continues to examine available technologies to upgrade ORNL's on-site fueling station.

7.2 PLANS AND PROJECTED PERFORMANCE

ORNL plans to pursue the following tasks in its ongoing efforts to increase the fuel efficiency of its fleet:

- The ORNL Fleet Office will launch a passenger-carrying vehicle pooling program in FY 2023. By pooling ORNL's passenger-carrying fleet, ORNL seeks to do the following:

    - Optimize vehicle utilization
    - Expand vehicle options and accessibility for ORNL staff
    - Rightsize the ORNL fleet
    - Align Government Owned Vehicle parking spaces for future EV charging station deployment

- The expansion of projects at ORNL has led to an increase in fleet size since FY 2021. As the laboratory continues to explore options of teleworking and the launch of a passenger-carrying vehicle pool, the ORNL fleet size could be redistributed or reduced to meet current and future missions.

- Individual vehicle custodians are responsible for ensuring that vehicles are secured when not in use, with the keys removed. As ORNL moves toward the passenger-carrying vehicle pool, vehicle keys will be secured, and vehicle users will be tracked using technology associated with the pooling project.

- As ORNL deploys future EV supply equipment around the site, employees will receive training and communication on operations.

- ORNL will investigate the capabilities of the new telematics systems for further use of reporting and analysis functions.

- When no AFV/EV models are available as a replacement option, ORNL will select vehicles with the best possible fuel economy.

- ORNL will continue to invest in improved technology and updated management practices to reduce fuel consumption.

- ORNL will continue to investigate the feasibility of adding PHEV and EVs to the ORNL fleet in a greater number. This would require a study of electric plug-in capacity and the placement of charging stations. ORNL is awaiting additional DOE guidance/funding to further the ability to sustain these types of vehicles.

8. RENEWABLE ENERGY

8.1 PERFORMANCE STATUS

In FY 2022, ORNL purchased renewable energy credits (RECs) to supplement on-site renewable energy generation, representing 9.6% of the laboratory's electrical energy consumption shown in Figure 25. ORNL on-site renewable energy and REC purchases resulted in calculated renewable electricity usage of 54,502 MWh for the year. The result is a performance of 9.6%, exceeding DOE's 7.5% target as identified in the Energy Policy Act (EPAct) of 2005.

ORNL has identified multiple sources of renewable energy to offset the site's total electrical consumption of 568,783 MWh, including the following:

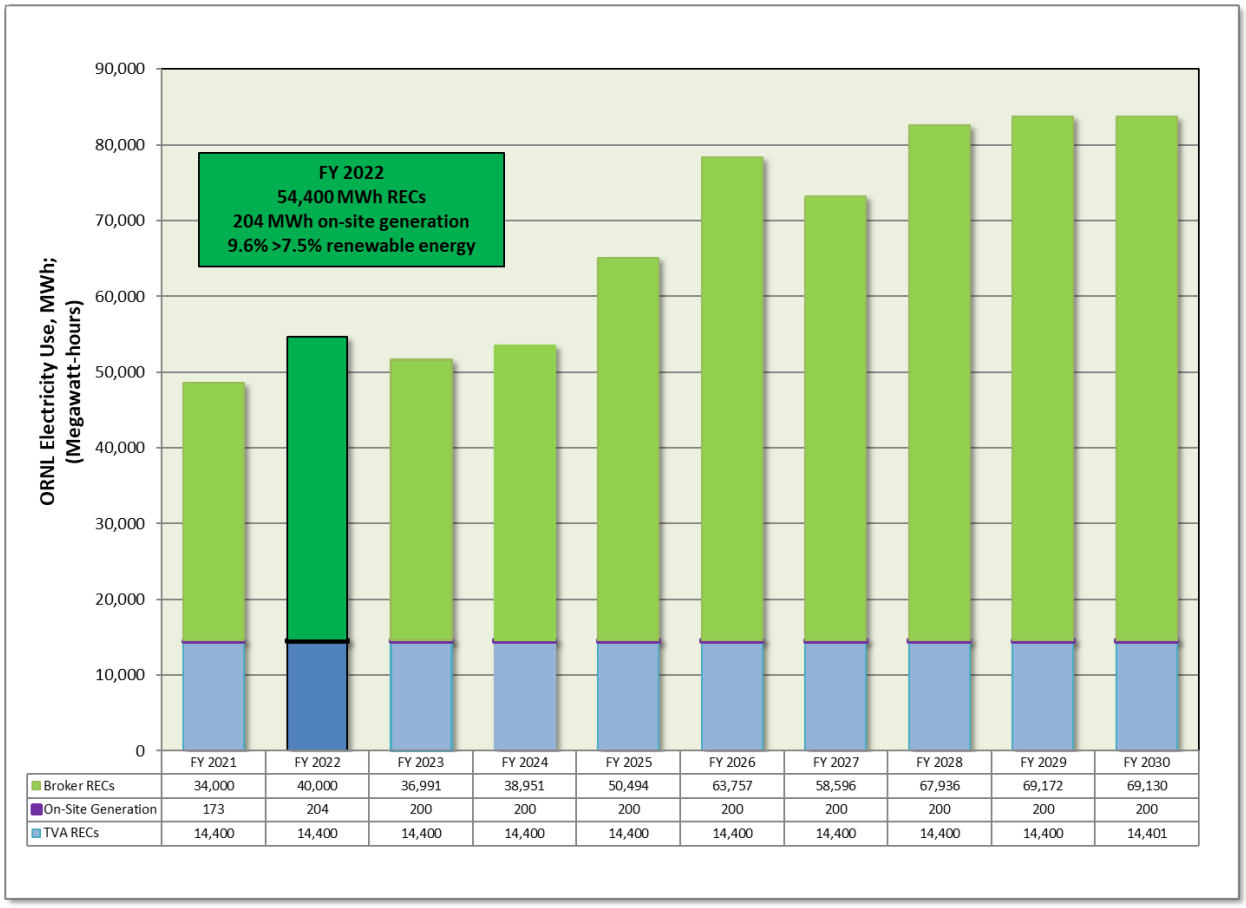
- The 102 MWh of electricity produced on-site by the five solar arrays accounted for 0.018% of ORNL electricity, which includes the double bonus allowed for on-site generation at federal facilities. Associated RECs are retained for use by the site.

- ORNL continued participation in TVA's Green Flex Program by purchasing 14,400 MWh of renewable energy in FY 2022.

- Via a competitive procurement, ORNL purchased 40,000 MWh of RECs from wind resources on the open market in FY 2022.

- ORNL's FY 2022 REC procurement activity included statements "Preference to Tribal Majority-Owned Business" in the request for proposal. Unfortunately, ORNL did not receive any bids for RECs generated on tribal lands.

- ORNL maintains an inventory of RECs that can be dedicated to specific buildings or projects to meet renewable energy goals for GP renewable energy criteria.



	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030
Broker RECs	34,000	40,000	36,991	38,951	50,494	63,757	58,596	67,936	69,172	69,130
On-Site Generation	173	204	200	200	200	200	200	200	200	200
TVA RECs	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,400	14,401

Figure 25. FY 2022 ORNL's REC purchase details and projections.

8.2 PLANS AND PROJECTED PERFORMANCE

For the near-term future, ORNL will continue with recent strategies to purchase sufficient RECs to meet the renewable energy goal until additional renewable and/or clean energy goals are identified. ORNL will continue to investigate on-site economically feasible renewable energy projects to minimize annual REC purchases. Strategies used to meet the renewable energy goals will also result in progress toward GHG emissions reduction. Specific plans include the following:

- Sustainable ORNL will take the lead in the continued investigation for a potential large-scale solar project at the main campus or a remote campus location. ORNL would like to encourage a project development plan that would combine/pair research opportunities, such as microgrid research, with large solar installations for renewable credit. ORNL will continue to evaluate project concepts that include financial benefits such as investment tax credits and research grant opportunities.

- Life cycle cost analysis and project payback are critical when investing public funds; sustainable solutions must include financial considerations. Until renewable projects are identified and implemented to meet on-site renewable objectives, RECs and EACs, when available, will be the primary cost-effective means to meet DOE goals. ORNL's primary strategy is to develop on-site capabilities, ideally incorporating research possibilities, before considering other options.

ORNL REC purchase strategy options will include the following:

- Looking into bundled RECs and EACs to count as credit for both CFE as well as EPAct of 2005
- Periodically monitoring the REC and EAC open-market and consider purchasing opportunities as they arise
- Monitoring changes in renewable goals and striving to purchase the quantity of RECs needed to meet or exceed renewable targets as they change while maintaining good stewardship of government funding
- Planning for multiple strategic purchases throughout the year based on energy consumption projections and REC pricing to best fit the identified annual targets
- Seeking options to engage in a multiyear purchasing agreement that will provide a more streamlined and flexible procurement process
- Considering increasing participation with TVA's Green Flex Program to purchase additional RECs through the utility if cost/benefit analysis is favorable
- Developing specific REC strategic purchasing guidance to help incorporate these strategies into a viable document to help determine the best value for the long term; guidance should encourage brokers to provide better tribal options, include dedication of RECs to specific buildings for LEED certification or Guiding Principles certification for consideration for premium REC cost from tribal land resources, and other goals
- Further evaluating opportunities to partner with the Defense Logistics Agency or the Western Area Power Administration to identify tribal RECs for purchase

9. SUSTAINABLE BUILDINGS

9.1 SUSTAINABLE BUILDINGS: GUIDING PRINCIPLES (GPS)

9.1.1 Performance Status

In FY 2021, ORNL's sustainable building inventory included a total of 21 buildings that are certified by either being grandfathered through LEED certification (gold or silver certified) or having attained 100% of the GPs listed in Table 5. Of the 21 sustainable buildings, 11 buildings were greater than 10,000 ft^2, and 10 buildings were greater than 5,000 ft^2. This met the historical GP target of 15% by building count for buildings greater than 10,000 ft^2 according to the *Guiding Principles for Federal Leadership in Sustainable Buildings* for DOE sustainable buildings.

Table 5. ORNL's sustainable buildings in FY 2021 with the goal of 10,000 ft^2 or greater

Property ID	Property Name	Ownership	Compliance Year	Gross /Rentable SqFt	Project GSF	Approach	Guiding Principle %	Guiding Principle Version	LEED Certification Level	LEED Project ID
1005	Ultra-Trace Forensic Science Center	DOE	2014	35,973	35,973	EB	100	2008 GP		
1059	Computational Biology and Bioinformatics	DOE	2010	6,998	6,998	EB	100	2008 GP	LEED Gold	10471002
1060	Environmental & Life Sciences Laboratory	DOE	2013	9,516	9,516	EB	100	2008 GP		
1061	Health Protection Services Facility	DOE	2012	6,999	6,999	EB	100	2008 GP		
1062	West Office Building	DOE	2011	6,998	6,998	EB	100	2008 GP		
1505	Environmental Science Laboratory	DOE	2013	88,843	88,843	EB	100	2008 GP		
1506	Controlled Env & Animal Bldg.	DOE	2013	16,785	16,785	EB	100	2008 GP		
1507	Life Sciences Data Analysis Bl	DOE	2011	6,996	6,996	EB	100	2008 GP		
1509	Safeguards and Security Tech. Center	DOE	2011	6,995	6,995	EB	100	2008 GP		
2661	Office of Technical Training	DOE	2011	6,995	6,995	EB	100	2008 GP		
3137	Surface Science Lab	DOE	2014	5,514	5,514	EB	100	2008 GP		
3625	Advance Microscopy Laboratory	DOE	2011	13,012	6,419	EB			LEED Silver	10507895
4007	Benefits Office Building	DOE	2012	6,995	6,995	EB	100	2008 GP		
4020	Maximum Energy Efficiency Research Lab	DOE	2013	19,709	19,709	NC			LEED Gold	1000010929
4100	Chemical and Materials Sciences Building	DOE	2012	155,712	155,712	NC			LEED Gold	10255188
4500N	Central Research & Administration North	DOE	2016	363,758	20,000	EB			LEED Silver	1000026829
5200	ORNL Conference Center	DOE	2004	53,943	53,943	NC			LEED Gold	10000604
6008	Joint Inst-Heavy Ion Research (JIHIR)	DOE	2012	7,489	7,489	EB	100	2008 GP		
6012	Computer Science Research Fac.	DOE	2013	12,569	12,569	EB	100	2008 GP		
7120	Receiving, Shipping, and Stores	DOE	2016	25,822	25,822	NC			LEED Gold	1000039572
7995	ORNL Melton Valley Maintenance Facility	DOE	2011	31,002	31,002	NC			LEED Gold	1000001560
8640	ORNL Guest House	DOE	2011	25,934	25,934	NC			LEED Gold	10161489
8930	Chestnut Ridge Maintenance Shop	DOE	2015	22,305	22,305	NC			LEED Gold	1000026156

One of the ways that ORNL achieved GP success in the past was through its long association with the US Green Building Council LEED certification program. Nine of the buildings listed in Table 5 were buildings that received LEED silver certification or better before the deadline of September 30, 2017, and could therefore be counted as GP-certified. This deadline was established in the 2016 GPs, which have since been replaced with the 2020 GPs. For the purposes of adjusted SSP reporting guidance, only 21 of the 23 buildings listed in the table qualify under current determinations. Line-item capital from SC was received to fund two major modernization projects in Building 4500N and Building 3625. Both projects received LEED silver certification, which is generally considered a high-level GP determination. However, since these projects covered only certain portions of the buildings' GSF (shown as Project GSF), the FIMS reporting system does not have a method to distinguish the specific project for inclusion in the GP count. Notably, Building 3137 is included in Table 5, but this building has been transferred from SC to the DOE Environmental Management program. Although it is still counted in the total since its certification, it provides limitation moving forward for upkeeping of the certifications.

In FY 2022, the square footage requirement for sustainable buildings was extended to buildings 25,000 ft^2 or greater. This significantly reduces ORNL's sustainable building potential inventory to approximately 40 applicable buildings. ORNL has seven buildings that are greater than 25,000 ft^2 that are currently GP–certified, as listed in Table 6. Therefore, with the new requirement parameters, ORNL still meets the historical GP target of 15% sustainable buildings by count. ORNL can also continue to count those as

GP-certified that are less than the 25,000 ft^2 or greater limits in Table 5 until they are removed once the reassessment requirements are not met. ORNL will focus on buildings that are 25,000 ft^2 or greater for GP certification and reassessment since approximately 40 buildings fall into the sustainable buildings category and will need to focus ORNL resources on those that fall within the requirements. In compliance with the most recently revised GPs, there were no contractor-owned leased facilities, as classified in the FIMS, included in the total and percentage calculation for the GPs target.

Table 6. ORNL's sustainable buildings in FY 2022 with the goal of 25,000 ft^2 or greater

Property ID	Property Name	Real Property Unique ID	Ownership	Compliance Year	Gross /Rentable SqFt	Project GSF	Approach	Guiding Principle %	Guiding Principle Version	LEED Certification Level Received	LEED Project ID
1005	Ultra-Trace Forensic Science Center	143038	DOE Owned (O)	2014	35973	35973	EB	100	2008 GP	None	
1505	Environmental Science Laboratory	97109	DOE Owned (O)	2013	88843	88843	EB	100	2008 GP	None	
4100	Chemical and Materials Sciences Building	209503	DOE Owned (O)	2012	155712	155712	NC			LEED Gold (CFR allowed)	10255188
5200	ORNL Conference Center	200845	DOE Owned (O)	2004	53943	53943	NC			LEED Gold (CFR allowed)	10000604
7120	Receiving, Shipping, and Stores	216227	DOE Owned (O)	2016	25822	25822	NC			LEED Gold (CFR allowed)	1000039572
7995	ORNL Melton Valley Maintenance Facility	208467	DOE Owned (O)	2011	31002	31002	NC			LEED Gold (CFR allowed)	1000001560
8640	ORNL Guest House	209001	DOE Owned (O)	2011	25934	25934	NC			LEED Gold (CFR allowed)	10161489

In FY 2021, ORNL began using ArcGIS to track and show the sustainable buildings throughout the campus (Figure 26). ORNL developed a map of the sustainable buildings along with some of the key statistics to help track and document the sustainable building reporting. This application also helps store the information based on FIMS updates so that it can be downloaded and reported for the SSP each year. ORNL has not updated this map yet to show the new 25,000 ft^2 requirements.

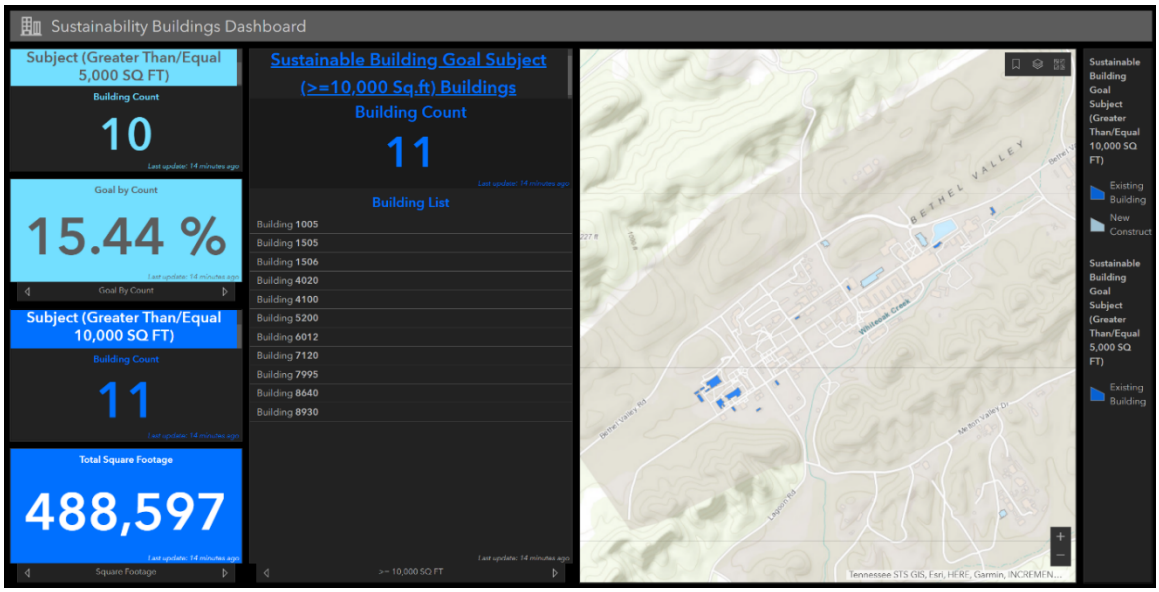


Figure 26. ArcGIS sustainable buildings dashboard for tracking GP compliance.

9.1.2 Plans and Projected Performance

Moving forward with GPs, existing building candidates will be identified based on existing metering infrastructure, FDD information/capability, known energy conservation opportunities, and the DOE

50001 Ready structure and documentation process whenever possible to make progress toward fulfilling GP criteria. Although still a work in progress, the DOE 50001 Ready "Energy Consideration in Design" task is being used to solely focus on GP tracking and implementation efforts. DOE 50001 Ready provides the necessary structure to help ORNL formalize a plan for institutional documentation that can be used for existing building GPs. By integrating this within the DOE 50001 Ready process, ORNL hopes to expedite the process for GP implementation. Action plans for achieving building-specific GPs will be developed and executed while laboratory-wide standards will be used when feasible to fulfill applicable GP policies and procedures across multiple facilities.

ORNL also hopes to address some of the necessary requirements of the GPs in the EISA audit process, which is also being integrated into the DOE 50001 Ready structure. Using the information collected for the audit, the impact made from the implemented ECMs, and the institutionalized documentation from DOE 50001 Ready, ORNL expects that the culmination of these efforts will provide a strong foundation to move toward GP certification for existing buildings.

As experience with the GPs grows, the focus of ORNL's GP efforts remains on certifying existing office buildings since they can be more readily identified and upgraded while also establishing a path for future certification in larger, more complex existing facilities such as laboratories and mixed-use buildings. Furthermore, as it becomes increasingly more challenging to apply 100% of the GPs to ORNL's most complex buildings, intensive effort and often capital investment will be required to make significant changes to reduce energy consumption. Additional time will also be required to measure performance and verify savings. Efforts will continue toward expanding the existing GP inventory when feasible.

The December 2020 updated *Guiding Principles for Sustainable Federal Buildings* requires that all buildings that have been certified as GP-compliant must be reassessed every 4 years. Although this new requirement is designed to demonstrate sustained savings and improvements over time, it will require much greater efforts and resources on the ORNL program. This will take away time and resources from certifying other existing building projects that would benefit ORNL by increasing the GP certification portfolio, which has always been an important DOE goal. Moving forward, ORNL plans to pursue reassessment of the seven GP-certified sustainable buildings by FY 2025 (recommended by SPD in the 2023 SSP guidance). Once all seven sustainable buildings are reassessed, ORNL plans to pursue new GP certification for existing buildings in FY 2026 and FY 2027.

9.2 SUSTAINABLE BUILDINGS: NEW BUILDING DESIGN

9.2.1 Performance Status

ORNL has been designing and constructing new buildings to achieve LEED certification since 2004. Beginning in 2010 and extending through 2016, ORNL established a goal to design and construct all-new buildings to achieve LEED gold certification per sustainable building DOE requirements. In 2017, the policy was modified to require all new construction to be compliant with the 2016 *Guiding Principles for Sustainable Federal Buildings*, which has since been replaced with the 2020 *Guiding Principles for Sustainable Federal Buildings*. Inherent to the GPs, new construction is designed to be 30% more energy-efficient than the baseline established by American National Standards Institute/ASHRAE/Illuminating Engineering Society of North America Standard 90.1. As of August 2022, the current version in effect is ASHRAE 90.1 2019 (10 CFR 433.100). In the past, ORNL used 3D energy models created for newly designed and constructed facilities to calculate the energy consumption to ensure the ASHRAE 90.1 Standard is met.

9.2.2 Plans and Projected Performance

ORNL is expecting at least two other new constructions projects in the next 5 years that will realize GP compliance. Per the Action Memo from Deputy Secretary David Turk to Heads of Departmental Elements regarding Climate Adaptation Resilience and Sustainability in Project Management, ORNL is working to develop a strategic approach to ensure new construction and modernization projects greater than 25,000 ft^2 are being designed to meet net-zero energy, water, and waste by 2030. To achieve the net-zero initiative, ORNL is collaborating with key stakeholders to ensure a well-rounded effective approach is developed.

9.3 SUSTAINABLE BUILDINGS: NET-ZERO

9.3.1 Performance Status: ORNL Annual Lab Plan Submittal on Net-Zero

The ORR (inclusive of ORNL and Y-12) constitutes a small city, ideal for demonstration and deployment of a carbon-neutral test bed. ORNL's net-zero carbon campus efforts will include approaches that demonstrate a variety of technologies such as electrical storage, carbon capture, integration of renewables, transition to an all-EV fleet, and efficiencies gained through infrastructure modernization that reduce or eliminate carbon emissions. Carbon capture research will be conducted in a phased manner, developing prototype technologies, with potential implementation planned across campus. Disposition of captured carbon will also be evaluated for potential reuse, conversion to fuel, or disposal.

In addition to these efforts, deployment of new nuclear generation will help ORNL to reach net-zero. TVA has approved up to $200 million to prepare for the potential construction of a small modular reactor (SMR) at its Nuclear Regulatory Commission–licensed site, which could provide CFE for the reservation and the region.

To further ORNL's progress toward net-zero, UT-Battelle has established a memorandum of understanding with TVA focused on decarbonization technologies. Activities considered include the following:

- Point source and direct air carbon capture
- Carbon utilization
- Hydrogen generation and utilization
- EV charging and vehicle to grid interaction applications
- Light water small modular reactors and fourth-generation advanced nuclear reactors
- Long duration energy storage
- Electrification of parts of economy that are currently fossil fuel
- Grid resiliency and security

Net-zero carbon campus projects will require programmatic and institutional investments. Traditional ECMs such as lighting improvements, HVAC upgrades, and temperature setbacks are being investigated and implemented to reduce energy consumption also resulting in GHG footprint reduction. The SLI-LI (Line Item) CIMP (CD-1 in process) will contribute to GHG reduction, resiliency, and energy/fuel efficiency.

9.3.2 Plans and Projected Performance: ORNL Net-Zero Assessment

As part of the FY 2022 lab agenda, an objective was defined to develop a strategy for a net-zero emissions ORNL campus. ORNL now has an opportunity to analyze potential solutions for significantly reducing GHG emissions over the near to long term. Such analysis would also consider measures of

economic impact, and specifications of factors underlying economic impact (e.g., changes at the lab required to reach net-zero that could impact equipment, personnel, and so on). Although ORNL has already taken early steps to identify possible solutions for emissions reduction, such as in the area of purchased electricity with TVA discussions, the map of potential solutions can be made more comprehensive—including articulations of cost and value for each.

To address this objective, the following steps were identified: (1) compile known data sources for ORNL GHG emissions via the SSP; (2) summarize other information needed, including sources of emissions, mitigation tools and methods, and the current and potential impact of ORNL R&D and demonstration projects for reducing GHG emissions; (3) develop a team of subject matter experts with relevant information; (4) engage a broader group of ORNL staff as needed; and (5) organize findings and related information into a strategy report that can be shared with appropriate stakeholders, as defined by the assessment team. Fulfilling these actions requires a team that includes individuals representing science and technology, operations, economic development, and lab strategy. Thus, a diverse group of ORNL operations and science and technology personnel, via conversations with lab leadership and programmatic representatives from Sustainable ORNL, organized a large development meeting. The meeting with all 19 members of the development team (Figure 27) involved discussing known emission sources and solutions. A small assessment leadership team was developed from this meeting.

ASSESSMENT TEAM

Assessment Leadership

Name	Position	Division
Christian Mealey – Lead	Strategic Planning Specialist	Office of Institutional Strategic Planning
Scott Sluder	Sr. R&D Staff	Sustainable ORNL
David McCollum	Sr. R&D Staff	Buildings and Transportation Science Division
Melissa Madgett	Engineer	Utilities Division
Amy Miller	Energy & Sustainability Engineer	Energy Efficiency & Sustainability

Assessment Support – Mission Support

Name	Position	Division
Jimmy Stone	Director	Facilities and Operations Directorate
Jens Dilling	Director of Strategic Planning	Office of Institutional Strategic Planning
Mark Goins	Complex Facility Manager	Facilities Management
Jim Serafin	Division Director	Laboratory Modernization
Swati Kirpekar	Institutional Planning Coordinator	Laboratory Modernization

Assessment Support – Science

Name	Position	Division
Xin Sun	Associate Laboratory Director	Energy Science & Technology
Robert Wagner	Division Director	Buildings and Transportation Science
David Sholl	Director	Transformational Decarbonization
Kashif Nawaz	Group Leader	Multifunctional Equipment Integration
Vivek Sujan	Distinguished R&D Staff	Vehicle and Mobility Systems
Christine Walker	Program Manager	Buildings and Transportation Science; DOE Federal Energy Management Program
Mike Twardy	Business Development Lead	Energy Science & Technology
David Skipper	Division Director	Environmental Protection and Safety
Anthony Walker	Group Leader	Environmental Sciences Division

Figure 27. Net-zero assessment team, including mission and support personnel.

In follow-up meetings, five members within the leadership assessment team are pursuing synthesizing the information collected into a framework for an assessment strategy. The data and recommendations provided via this assessment will be used by various stakeholders internal and external to ORNL, especially leadership developing the net-zero campus strategy and implementation teams using the data to benchmark and prioritize various mitigation strategies.

10. ACQUISITION & PROCUREMENT

10.1 PERFORMANCE STATUS

All applicable contracts in FY 2022 contained terms and conditions that invoke requirements for sustainable acquisitions as defined in the UT-Battelle prime contract as flow-down requirements. Standard contract terms and conditions, which are made part of all procurement actions for commercial items and services, invoke the pertinent federal acquisition regulation (FAR) subcontract sustainability requirements:

52.223-2 Affirmative Procurement of Biobased Products Under Service and Construction Contracts.

52.223-13 Acquisition of EPEAT®-Registered Imaging Equipment

52.223-14 Acquisition of EPEAT®-Registered Televisions

52.223-15 Energy Efficiency in Energy-Consuming Products

52.223-16 Acquisition of EPEAT-Registered Personal Computer Products

52.223-17 Affirmative Procurement of EPA-designated Items in Service and Construction Contracts

Neither federal acquisition regulation FAR 52.223-4 nor 52.223-9 as referenced in the SSP guidance definition table is included in the prime contract as a flow-down requirement. Because ORNL includes all of these in each subcontract/purchase order, the required information can be found in the multi-statutory column of Table 7.

Table 7. Type of sustainable acquisition (SA) clauses in contracts.

	Recycled	Energy-efficient	Biobased	Multi-statutory	Environmentally preferable	Statutory+
Number of contract actions with SA clauses	-	-	-	4,106	-	-
Total contract dollars with SA clauses ($)	-	-	-	1,150,228,624	-	-

Each of the ORNL Buy catalog/punchout vendors' Basic Ordering Agreements require the submission of a quarterly Environmental Preferable Procurement Report, highlighting commodities that fall into the environmentally preferable, recycled, postconsumer, waste prevention, pollution prevention, and biobased categories. The vendor sends four reports per year to recycle@ornl.gov, highlighting all efforts. This report is analyzed by the Pollution Prevention Program Coordinator. Any efforts to promote and track data for the new initiative, phasing out single-use plastics, as mentioned in the current SSP guidance document will be undertaken through a similar process.

- No new janitorial contracts were issued in FY 2022. Kelsan, ORNL's janitor contract vendor, recognizes the lab's interest in sustainability and has made sustainable acquisition products a point of emphasis in its product line for ORNL, including biobased products. Kelsan offers more than 100 items that are sustainable, including bio-preferred, postconsumer recycled content, and Green Seal–certified options. The items include janitorial products such as paper, hand care, and cleaning products. This product line provided by Kelsan helps support ORNL's sustainability goals. In FY 2022, $139,415 of $530,471 (26%), of Kelsan's contract spend was for bio-preferred products alone.

- Office supply vendor A&W offers remanufactured ink cartridges and provides a rebate to ORNL on printer cartridges that are recycled back to A&W through central receiving. In addition, the vendor offers a variety of recycled content office supplies, such as paper, binders, notebooks, and planners.

- ORNL IT Operations administers the IT Managed Hardware program, which pushes administrative controls for all requisitions for IT equipment. Both IT Operations and the Subcontract Division are responsible for 100% compliance for all eligible equipment. More information can be found in the Electronic Stewardship section.

- The Waste Management section contains more information on biobased preferred product tracking, and on sustainable disposition of federal property, including electronics.

- The Contracts Division uses subcontract language in communications with key commodity suppliers, requiring that the vendors provide detailed reports on the purchases of electronics products designated as ENERGY STAR and Electronic Product Environmental Assessment Tool (EPEAT)–certified.

Minimization of products that contain perfluoroalkyl and polyfluoroalkyl substances

In FY 2022, ORNL focused on better understanding the existing inventory of perfluoroalkyl and polyfluoroalkyl substance (PFAS)–containing materials. The Environmental Protection Services Division took the lead with a PFAS search that was conducted using the ORNL chemical inventory system. Several relatively small amounts of PFAS-containing material were identified. In addition, the ORNL Fire Department currently has approximately 50 gallons of short chain PFAS-containing aqueous film forming foam in inventory. This material will not be disposed of until further guidance is issued by DOE. The Fire Department no longer uses aqueous film forming foam that contains PFAS for fire training exercises.

In FY 2023, ORNL plans to roll out a screening tool that will allow potential purchases of PFAS-containing products to be identified and reviewed to determine whether a suitable alternative exists. In addition, ESPD will work with the procurement organization to add PFAS restrictions to applicable contracts.

In FY 2023, the Environmental Protection Services Division and Sustainable ORNL will also closely monitor actions taken by regulators and DOE related to PFASs. For example, DOE issued a PFAS Strategic Roadmap late in FY 2022 that will likely require ORNL action over the next several years.

10.2 PLANS AND PROJECTED PERFORMANCE

The ORNL Contracts Division includes several working groups aimed at sustainable acquisition. The Contracts Compliance Manager is responsible for policies, procedures, records, reports, and compliance with all prime contract terms and conditions. Advances and improvements in these processes to promote sustainable acquisitions and procurement are among the highest priorities, as the division remains

committed to maintaining 100% compliance with DOE 436.1 SSP goals. FY 2023 initiatives include the following:

- The Contracts Division will work with the Environmental Protection Services Division toward progress on the minimization of products that contain PFASs.

- Per section 3b of DOE's Climate Adaptation and Resilience Plan, sites are to complete a Supply Chain Risk Assessment to determine the reliability and vulnerability of critical supply chains. SPD is currently developing the guidance for this assessment and will work with programs to set the due date. SC will work with the science laboratories to roll out this guidance, including due dates, when available.

- SPD has committed to holding training sessions that will address the requirements and logistics needed to access and report laboratory procurement data, the Federal Procurement Data System–Next Generation as a preferred data reporting system. ORNL has provided contact information to SPD and believe the training will be available in FY 2023.

- The Contracts Division will coordinate with the ORNL Pollution Prevention Program to determine if Procurement can play a meaningful role in ORNL efforts toward phasing out of single-use plastics.

11. INVESTMENTS: IMPROVEMENT MEASURES, WORKFORCE, & COMMUNITY

11.1 PERFORMANCE STATUS

11.1.1 Energy Act of 2020

ORNL develops an annual ECM list from the following two primary conduits of information sources throughout the year.

- The EE&S program meets early each new fiscal year with FMD managers and facility engineers to identify ECM and funding requests. The majority of ORNL's annual ECMs are identified through this process.

- EISA building audits also provide ECMs. These can be identified through the walk down of the facility and/or directly from the facility representative who are interviewed during the audit.

In the past, ORNL has found that building facility engineers and supervisors are the most knowledgeable about facility conditions and can provide valuable information and suggestions concerning ECMs. Identification, evaluation, funding, and ECM project execution is mutually beneficial for both those requesting the funds and the EE&S program itself. The facility owners are provided with funds and made responsible for performing the project on schedule and within budget. The facilities are turned over with a new energy-efficient and reliable system and/or equipment, and the EE&S program benefits from being able to report the energy savings that are realized. In the past few years, the ORNL EE&S program, on average, funds over $500,000/year toward ECMs. The EE&S program analyzes the preliminary list and funds the ones that provide the shortest payback period and best benefit for the building owner and occupants, while still working within the limitations of our program budget.

In FY 2022, the ORNL EE&S program funded $557,120 toward projects for ECMs or energy efficient equipment such as LEDs (not including metering and FDD). EE&S representatives met with facility engineers and managers from across the various ORNL complexes and brainstormed ECM ideas. Facility engineers formally submitted their top ideas to the EE&S program, a comprehensive prioritized list was developed, and then ECM projects were funded accordingly. Life cycle cost analysis, annual energy savings, or a combination of both were used to rank ECMs. Life cycle cost analysis uses building/system/equipment data, engineering principles, and employee expertise to perform the calculations and validate efficiency measures.

The following six energy reduction projects were funded in FY 2022:

- Building 7012 lighting renovation (phase 2)
- Building 5700 credit union LED conversion
- Building 5700 2nd floor corridor LED conversion
- Building 5800 D105 high bay LED conversion
- Building 7917 LED conversion
- Building 7603 high bay heating renovation (started but not completed by end of the year)

ORNL bought more than $75,000 worth of LEDs at the end of FY 2022 for FY 2023's ECMs. ORNL also supported other smaller LED room installations that were not part of a large ECM.

The ORNL EE&S program recognized that the passing of EAct 20 would mean more substantive reporting and funding changes to the EISA auditing process, especially because ORNL averages more

than 20 building audits per year to meet the requirements. The passing of EAct 20 highly emphasized the importance of finding ECM projects via the EISA auditing process that will increase operational and organizational performance while reducing energy and water consumption. To take this new requirement head on, in FY 2022, the EE&S program hired a dedicated engineer to lead the EISA auditing process (also discussed in the Energy: EISA section). Along with supporting the EISA process, the position will lead the new EAct 20 ECM identification, tracking, and reporting process needs. The new engineer started in late FY 2022, and ORNL hopes to use this new position to continue to build a foundation of awareness to make energy efficiency increasingly part of daily operations. The EISA Plans and Projected Performance section elaborates further on the upcoming plans for the growth and development of the position.

As EAct 20 requirements get underway, ORNL has a limited list of past ECM ideas that were not funded. New FY 2023 ECMs will be added to the ECM list moving forward. The revised list will then be evaluated to see if ECMs are life cycle cost-effective, and if found to be so, ORNL will determine the funding process and begin installation to the maximum level of funding available.

ORNL's current understanding of life cycle cost effectiveness is as follows:

- The ECMs that prove to have a simple payback of 10 years or less should be funded internally.
- ECMs with a payback between 10 and 25 years should be funded internally, or performance contracting should be considered/pursued.

Since ORNL has a large selection of building to audit each year (approximately 20 to 25 meet the one-fourth annual EISA requirement), ORNL plans to investigate a reasonably acceptable number of ECMs per audited building. The number of EMCs for a given building is heavily reliant on building design and size, so the number of ECMs per building will vary across a diverse portfolio like ORNL. With this approach, ORNL anticipates that an ample number of ECMs will be identified. After the audit cycle has been executed for several 4-year iterations, ORNL expects that the list will shorten by addressing the majority of the ECMs through the cyclical process.

11.1.2 Energy Savings Performance Contracts

ORNL's ESPC with JCI was the primary mechanism for achieving the goals established to meet EPAct of 2005 directives. A delivery order with JCI was awarded in July 2008 and was accepted in July 2012. This ESPC is creating opportunities for ORNL to improve its depth of experience in performance contracting and to develop an understanding of the most effective use of this funding mechanism. The ESPC is currently in the middle of year 11 of the 21-year contract term. Year 10 contract savings of $11,858,300 derived from $8,725,000 (335,558 million Btu) of electricity, natural gas, and fuel oil, $400,000 (186 million gallons gal) of water, and $2,733,000 of operations and maintenance savings were achieved as a result of the installation of modern and more efficient equipment.

A dual-fuel natural gas/fuel oil boiler replaced the biomass gasification system, which had experienced operational difficulties. The new boiler has been in operation since FY 2016, and reductions in natural gas and fuel oil consumption have been achieved, complementing two similar dual-fuel natural gas/fuel oil boilers that replaced a vintage boiler installed under a separate activity. Steam distribution decentralization, including the new Melton Valley Steam Plant and steam production efficiency improvements, further increase ORNL's steam service and reliability.

Other ESPC improvements include lighting upgrades and water conservation measures. Equipment upgrades, a building management system, and modernized HVAC control systems provide the means to

significantly reduce or eliminate energy-intensive simultaneous heating and cooling in several large air-handling units.

M&V of the ECMs completed under the ORNL ESPC is ongoing per the contract between JCI and DOE. JCI employs an on-site performance assurance engineer who leads the M&V effort. M&V activities are reviewed by the ORNL DOE Site Office contracting officer's representative with the engagement of UT-Battelle's EE&S program and Utilities Division staff. Monthly ESPC performance reviews are held by JCI with ORNL DOE Site Office personnel and ORNL personnel. An annual M&V report review and comment resolution process is conducted with the same group.

ORNL is not currently pursuing any other performance contract options. Further discussion and planning are underway for how to proceed with the EAct 20 performance contracting requirements and carbon net-zero initiatives. ORNL will be better informed to develop funding plans, whether via performance contracting or internal funding, after implementing and integrating the new approaches to ECM identification and life cycle cost-effective funding strategies per EAct 20.

11.1.3 Funding

ORNL assesses the environmental, economic, and social benefits of proposed activities on an individual, project-specific basis. Through the mission readiness process, ORNL gauges the abilities of its facilities and infrastructure to accomplish mission objectives now and in the future. Projects are identified to meet the safe, compliant, efficient accomplishment of mission objectives, including sustainable operations. Funding sources for projects are evaluated and established by considering all available and appropriate funding venues, including private sector financing, cost sharing, institutional investment, and programmatic appropriations. Allocation of funds is based on multiple considerations, including mission impact, sustainability, and return on investment (Table 8).

Table 8. FY 2022 budget and future funding for sustainability funding categories

ORNL sustainability funding categories ($ × 1,000)	FY 2022 actual ($K)	FY 2023 planned/ requested ($K)	FY 2024 projected ($K)
Sustainability projects (including ECMs and metering)	780	790	800
Sustainability activities other than projects	331	340	350
Sustainability program division-funded projects (SPD funding portion only)	0	0	0
SLI GPP ECM funding	227	0	2,000
Site contribution to Sustainability Performance Division funded project	0	0	0
ESPC	11,781	12,168	12,568
REC purchase costs	181	197	197
Total	**13,300**	**13,495**	**15,915**

In FY 2022, ORNL received mission readiness SLI GPP funding for expansion of the FDD system, which included implementation of 13 new buildings added to ORNL's SkySpark system. ORNL has submitted for SLI GPP funding for large scale LED implementation for FY 2024–FY 2025 to support the new FMD policy of 100% LED replacement moving forward.

In FY 2022, the F&O director and Sustainable ORNL co-sponsor allocated three times more than the past project funding to the Sustainable ORNL Showcase projects to support projects and research focused on decarbonizing the ORNL campus and improve energy efficiency (more specifics in the Environmental Justice, Workforce, and Community section). The Sustainable ORNL program invests in sustainability activities (other than projects/research, ECMs, and so on) in support of the 15 roadmaps that correlate with the main report needs of the SSP, all at varying stages of implementation. Each roadmap has specific fiscal year deliverables that are kept on schedule by holding regular review updates with individual roadmap owners and team leads. In addition, the F&O associate laboratory director reviews these roadmaps biannually. The scheduled reviews also provide a forum for the program associates to present new roadmap proposals.

A few years ago, the EE&S program conducted a review with the manager of the F&O Business Operations Division for the requirements outlined in DOE Order 436.1 to implement a savings reinvestment program. A series of meetings and discussions were held detailing the processes required to satisfy the condition that verified savings from departmental sustainability projects must be invested to fund additional sustainability projects at that site. The DOE order further requires the chief financial officer to develop and implement guidance on the reinvestment of those savings. The DOE policy to meet these requirements was added to DOE Financial Management Handbook. The Appendix for Chapter 15, "Cost Accounting: Reinvesting Cost Savings from Sustainability Projects," provides more information (http://energy.gov/sites/prod/files/2015/03/f20/AH-Chap15_0.pdf).

ORNL reviewed the requirements from both DOE Order 436.1 and the approved cost accounting guidance update to Chapter 15 and considered the accounting, business, and workflow procedures that would need to be implemented to satisfy the directives. The ORNL Business Operations manager determined that ORNL has no ECM projects that satisfy all the qualifying conditions and project definitions. All of this discussion was conducted more than 5 years ago. ORNL is planning to revisit the applicability for a reinvestment program moving forward into the next fiscal year since so many new requirements, such as EAct 20, have been released since applicability was last investigated.

11.1.4 Training & Education

Five Sustainable ORNL personnel (and an unknown number of non–Sustainable ORNL personnel) attended the FY 2022 Energy Exchange in October. In FY 2021, ORNL's EE&S program began participating in the Technical Resilience Navigator training that continued into FY 2022 with the culmination of the VARP submittal in September 2022.

ORNL's EE&S program personnel also participated in periodically scheduled webinars for the Energy Facility Contractors Group Sustainability & Environmental Sub-Group. In FY 2022, Jamie Herold from ORNL's Reservation Natural Resources program and Amy Albaugh Miller from ORNL's EE&S program were selected to receive a Teamwork Award for their contributions to the Energy Facility Contractors Group. Jamie and Amy were nominated for this award because of their work on the Sustainable Climate Ready Sites Task Team within the Sustainability & Environmental Sub-Group.

At least 11 F&O ORNL personnel hold and maintain the Association of Energy Engineers' Certified Energy Manager (CEM) credentials across various positions and fields throughout the campus. ORNL has one known Energy Manager In-Training designees. This certification indicates that the personnel have taken the appropriate steps and testing to pass as a CEM but do not yet have the required years of experience. ORNL hired a new engineer in FY 2022 to focus on EISA audits and EAct 20 ECM reporting and implementation. ORNL plans to have this engineer pursue the Association of Energy Engineers Certified Energy Auditor training and certification.

The ORNL EE&S program has members that have been involved with the local chapter of the Association of Energy Engineers. The local chapter has held two local CEM trainings in the past. In FY 2017, ORNL EE&S program members participated in the planning committee for the local certification training, which allowed 5 out of the 11 CEMs at ORNL to receive their certifications. ORNL was working with the local Association of Energy Engineers chapter prior to 2020 to plan another in-person training, but the training was cancelled because of the COVID-19 pandemic.

ORNL EE&S engineers take opportunities to participate in facility and operation training that is offered to facility and utility engineers at ORNL. In FY 2022, two EE&S engineers participated in an Industrial Ventilation Training offered to facility engineers. When possible, ORNL used facility and maintenance training to glean more energy-efficient methods for operations and improved system performance.

11.1.5 Environmental Justice, Workforce, and Community

Environmental justice

In FY 2022, ORNL prepared a National Environmental Policy Act (NEPA) Environmental Assessment for the construction and operation of the Stable Isotope Production and Research Center (SIPRC). The SIPRC is a planned ~60,000 ft^2 facility that will be located at ORNL. This facility will expand current stable isotope production capabilities at ORNL and reduce dependencies on foreign suppliers. As required by the (NEPA) regulations, the environmental justice impacts of the construction and operation of the SIPRC were evaluated in the Environmental Assessment. Since the SIPRC will be constructed and operated within the established ORNL site, no adverse environmental justice impacts were identified.

Tribal engagement

ORNL represents the DOE ORR as a participant in the Southeaster Appalachian Man and the Biosphere Cooperative, a collaborative group of land management agencies promoting sustainability. The cooperative has collaborated with the Eastern Band of Cherokee Indians (EBCI) to form the Culturally Significant Plant Species Initiative, an organization promoting education, research, and restoration of plant species that have cultural uses for the EBCI and across the region.

In FY 2022, ORNL began participating in the Extended Cultural Corridor initiative, focused on raising awareness of Cherokee cultural resources through recreational opportunities that expose people to Cherokee culture and sustainable practices, including natural area protection and low-impact use.

In FY 2023, ORNL received a grant from the DOE Water Power Technologies Office by leveraging the Southeaster Appalachian Man and the Biosphere Cooperative's connection with EBCI. A goal of the project is to build new partnerships between ORNL and the EBCI in clean energy development and in optimizing restoration efforts for aquatic connectivity within the Qualla Boundary of the EBCI Reservation.

Natural resources

The ORNL Natural Resources Management Program provides land management for the 32,000-acre DOE ORR. The objectives are to (1) provide high quality, efficient, and proactive stewardship of the ORR natural resources for DOE; (2) provide natural resources expertise to DOE, as needed, for complying with federal, state, and other requirements; (3) manage the DOE Environmental Research Park as a national, outdoor laboratory resource for science and education; and (4) serve as a model for exemplary natural resources management among DOE sites. Tasks include integrated ecosystems management, wildlife management, wildland fire response, forest stewardship, field access and surveillance, land use planning,

Aquatic Resource Alteration Permit preparation for areas outside of facility responsibilities, and management, coordination, and communication with the public, contractors, agencies, and stakeholders.

In FY 2022, ORNL conducted sensitive resources surveys for the potential land transfer from Consolidated Nuclear Security to the Oak Ridge Utility District, land transfer to the city of Oak Ridge, preliminary design of the Radioisotope Processing Facility, preliminary design of the Fusion Energy Campus Development, and potential Central Training Facility Drive Track. ORNL also participated in preparation for the SIPRC Environmental Assessment. ORNL continued land management activities, including prescribed burns, reducing fuel load along the wildland–urban interface to mitigate wildfire risk, planted grasslands for pollinators and wildlife, conducted invasive species management, and collected data on sensitive flora and fauna.

In FY 2023, ORNL will continue natural resource management and sensitive resource surveys. ORNL will provide input on natural resources in DOE Order 436.1A as needed and determine goals for participation in the Habitat Quality section of the Sustainable Climate Ready Sites Initiative. ORNL will begin by evaluating how current and ongoing natural resource management efforts at ORNL and the ORR apply to Order 436.1A and Sustainable Climate Ready Sites Initiative.

Workforce and community

Several environmental stakeholder engagement activities were conducted in FY 2022. Public (including regulatory agency) review and comment was solicited on the SIPRC Environmental Assessment in April 2022. All comments received were reviewed and responses developed.

Each year in September, DOE publishes an Annual Site Environmental Report for the ORR. The report contains detailed information on ORNL's environmental performance in the areas of compliance and sustainability. The report is accessible to ORNL stakeholders through an external DOE website. DOE solicits stakeholder comments on the report through the DOE Annual Site Environmental Report website.

Each year, Sustainable ORNL hosts the annual Earth Day celebration with engagement activities for staff and community. FY 2022's Earth Day was titled "Sustainable ORNL 2022 Earth Day – Invest in our Planet." Because of COVID-19 pandemic restrictions, the ORNL Annual Earth Week celebration was held virtually in the form of five seminars outlined here. Three of the five seminars were posted on the public-facing Sustainable ORNL website so the community could view them, as shown in Figure 28. The seminars were as follows:

"Studying Urban Microclimates" was held on April 18, 2022 and was hosted by ORNL's Melissa Allen-Dumas.

> Urban areas are full of complex human processes interacting with those of the natural environment. For example, cities contain buried pipes and sewers, impervious surfaces interrupted by open areas and parks, buildings of various geometries, and moving vehicles. All of these systems interact with the soils and vegetation that we have typically modeled in isolation in environmental studies. With large datasets now available, along with new technology and methods, we are now building better tools for understanding the humans' and cities' contributions to the Earth system.

"Sustainable ORNL Showcase Projects" was held on April 19, 2022 and was hosted by ORNL principal investigators.

> Each year Sustainable ORNL releases a call for proposals for submission as a Showcase Project of the year. In 2022, Sustainable ORNL received 14 proposals, a record-setting response. The proposals covered a wide variety of topics and ideas that could help ORNL become more sustainable. In the end, three proposals were chosen. One funded by Sustainable ORNL, one funded by the Utilities Division, and one funded by the Facilities Management Division.

"Concrete and the Environment" was held on April 20, 2022 and was hosted by ORNL's Denise Antunes da Silva.

> Concrete is the man-made material used in largest volumes in the world, being only behind the volume of water that we consume. The annual volume of concrete used globally corresponds to thirteen times the volume of concrete existing in Manhattan Island. Concrete is much less polluting than most other materials, on the same volume basis. However, the scale of use makes the concrete industry responsible for large CO_2 emissions. Most of the carbon footprint of concrete is due to Portland cement, its main binder. For every ton of cement produced, there is emission of 1 ton of CO_2. Cement production is responsible for around 8% of the global anthropogenic emissions of CO_2 because of the usage. More than 4 billion tons of cement are produced annually in the world. The demand for cement is expected to only increase in the next decades. To minimize catastrophic effects of global warming, measures must be taken to reduce the emissions from this industry.

"The Backyard Beekeeper" was held on April 21, 2022 and was hosted by ORNL's Amanda Killingsworth.

> Amanda has been a hobbyist beekeeper for 17 years experiencing many ups and downs. But she's learned that she still knows very little about these intelligent, fascinating, and magical creatures. Life is a constant learning journey and beekeeping is no exception.

"Crafting a Circular Future with Molecular Recycling" was held on April 22, 2022 and was hosted by Eastman Chemical Company's Chris Layton.

> In the session, the global plastic waste crisis and why that is driving us toward a more circular economy was discussed. Molecular recycling can be a vital component to mechanical recycling to tackle the plastic waste challenges we face. Learn the ins and outs of molecular recycling technologies, what technologies work best for which materials, and how Eastman is working to develop more sustainable materials while influencing the broader ecosystem to ensure their long-term adoption.

A recording of three of the five 2022 Earth Week virtual seminars, as well as other sustainability and Earth Week seminars, are provided at https://www.ornl.gov/sustainable-ornl/sustainability-seminars.

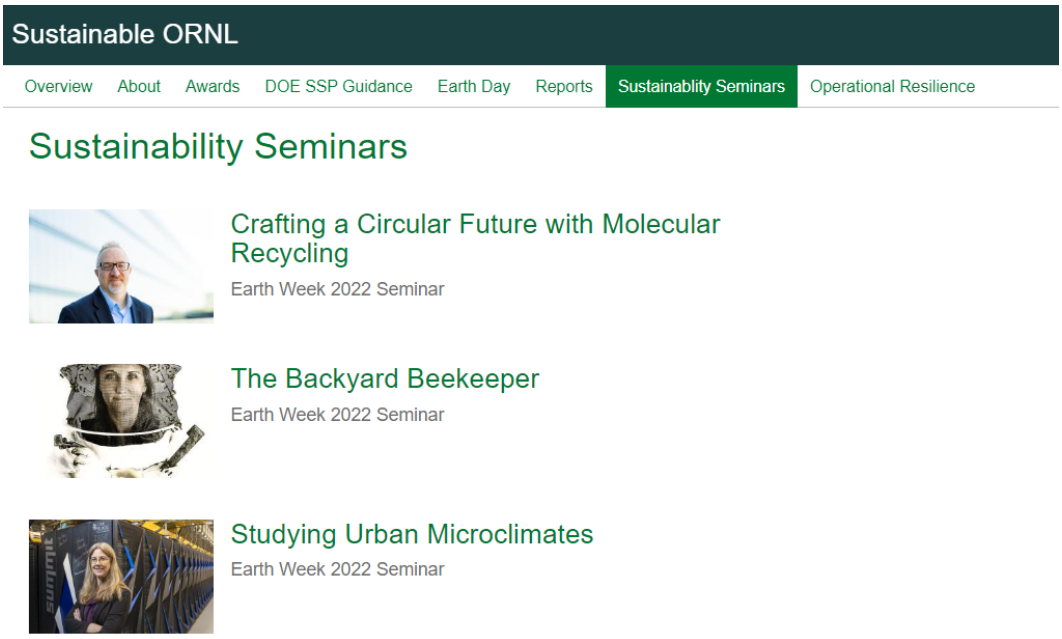


Figure 28. Public-facing Sustainable ORNL website presenting three 2022 Earth Day seminars.

2022 Sustainable ORNL showcase projects

Each year, Sustainable ORNL makes funding available to support showcase projects that focus on creative measures that can improve ORNL's sustainability. The projects need to be closely aligned with at least one of the Sustainable ORNL roadmaps, and preference is put on those that crosscut multiple roadmaps.

In FY 2022, the program invited studies in the following areas:

- Studies that analyze innovative opportunities to reduce the GHG emissions associated with steam generation on campus. These studies should focus on means/methods that can be deployed at demonstration scale within 5 years.
- Studies and/or demonstrations that explore recovery of waste heat from buildings and equipment to reduce steam and/or electricity use.
- Studies and/or demonstrations of net-zero carbon solutions for off-road vehicles and equipment used to support operations at ORNL.
- Other topics that represent a creative means to further the sustainability of ORNL that are directly tied to one of the Sustainable ORNL roadmaps.

The showcase projects selected for FY 2022 were as follows.

"Towards the Living Laboratory with Buildings as an Energy Hub for Sustainable Campus"

In response to Sustainable ORNL Program's goal of identifying opportunities to optimize energy and environmental performance, reduce waste, and cut costs by building partnerships between the R&D staff and our mission support organizations, this project team consisting of both R&D and F&O staff proposed

to study and showcase advanced control and coordination strategies for buildings to work with other onsite distributed energy resources in increasing energy efficiency, improving operational resilience, and reducing carbon footprint.

This project aimed to deliver a low-cost, scalable, robust, and autonomous building energy management solution that enabled buildings as an energy hub to integrate load flexibilities, that is, demand response with various distributed energy resources, such as solar photovoltaics, battery energy storage system, and thermal energy storage system for energy-efficient and emission-aware operations. The resulting building performance enhancement significantly improved ORNL's annual performance assessment in facility management and maintenance. The underlying efforts also contributed to the establishment of living laboratory for sustainable campus operations.

"Investigating the Production of Renewable Natural Gas from Anaerobic Digestion of Solid Waste to Decarbonize ORNL Steam Boilers"

This project proposed to demonstrate a circular economy on the ORNL campus using anaerobic digestion of locally sourced waste materials to produce renewable natural gas for steam generation. ORNL's natural gas–powered steam boilers are one of the largest contributors to the laboratory's environmental footprint and one of the best ways to reduce GHG emissions. ORNL steam boilers consume hundreds of million Btus/day of conventional natural gas to meet the current demand for steam. The primary goal of the proposed project was to decarbonize ORNL's steam boilers by displacing significant quantities of the natural gas supply with renewable natural gas from the anaerobic digestion of locally sourced organic wastes. To create a strong foundation for an integrated anaerobic digestion system at ORNL, the main thrusts of this proposed project were (1) quantifying and selecting a diversified portfolio of local waste material (including food waste, paper waste, and forest trimmings) to create operational resilience, (2) demonstrating anaerobic digestion of organic waste to maximize process intensification and scalability, (3) establishing the capability to clean and purify renewable natural gas from anaerobic digestion to meet the technical and safety requirements for the steam boilers, (4) integrating the anaerobic digestion system with ORNL's carbon capture technology at the steam boilers to minimize the carbon capture cost, and (5) estimating the overall cost and emissions benefits of deploying anaerobic digestion at ORNL. Waste heat from ORNL's HPC facility to improve overall campus energy efficiency was also utilized in this project.

"Increasing Condensate Recovery in ORNL Steam Plants to Reduce Primary Fuel Consumption and the Associated Emissions"

This project aimed to conduct a systematic diagnostic campaign to identify the reasons for the current low condensate recovery percent. An energy flow diagram (Sankey diagram) was generated, which describes the losses incurred in the ORNL steam generation, distribution, and condensate recovery system. The ORNL plant is equipped with the relevant sensors and data acquisition systems to enable thermodynamic and heat transfer calculations which are required to generate one such diagram. The status of the current condensate recovery system was presented and major causes for low recovery yield were identified. This involved working with the facilities to locate all the condensate collection and distribution points on campus. This activity produced a detailed map of the condensate return system with major losses identified at each location. Experimental variables such as mass flow rates, pressure, and temperature measurements (using infrared cameras and thermocouples) were used to calculate the losses in the existing system. Measures were recommended to improve the condensate recovery of the ORNL steam plant.

University of Tennessee/Pellissippi State Community College/ORNL Transportation Route

In August 2015, ORNL and the University of Tennessee partnered on a new bus route that connected the University of Tennessee, Knoxville campus, Pellissippi State Community College in west Knox County, and ORNL providing transportation to staff, students, and faculty offering three round-trip routes each day to all three sites based on the University of Tennessee's semester schedules. In March 2020, because of the COVID-19 pandemic, the bus route was suspended. Partial spring service for the bus was restored in April 2022, with ridership of 150 for the month. The transportation route has grown with stops at ORNL's National Transportation Research Center and SNS campuses and expanded the service to year-round except federal holidays and the week of Christmas. Ridership grew in the summer months with the influx of ORNL summer interns (June, 567; July, 519). With this ongoing initiative, ORNL and the University of Tennessee continue to support alternative commuting.

11.2 PLANS AND PROJECTED PERFORMANCE

- ORNL will continue to develop and define the plans and action items necessary to meet EAct 20 requirements, including funding strategies.

- ORNL will continue life-of-contract activities associated with its current ESPC. This includes participation in monthly project performance review meetings, review of the annual M&V report, and other support as requested by DOE. All funding paths for ECMs, including performance contracting, will be considered as ORNL works to meet sustainability goals.

- ORNL will continue to investigate and submit for new funding paths for implementing ECMs, and revisit investigation of the applicability of a savings reinvestment program.

- ORNL's EE&S program plans to continue promoting CEM credentials through collaboration with the local chapter of the Association of Energy Engineers.

- ORNL employees from several research and operations divisions plan to attend the 2023 Energy Exchange.

- In FY 2023, ORNL plans to prepare an Environmental Assessment for another proposed facility—the Radiochemical Processing Facility. The proposed facility is a 40,000 to 60,000 ft^2 facility that will be designed to accommodate modular hot cells for the purpose of isotope processing. The environmental justice impacts of construction and operation of the facility will be evaluated in the Environmental Assessment. There will be a public review and comment period associated with this Environmental Assessment.

- In FY 2023, DOE will publish an Annual Site Environmental Report, which will be accessible to ORNL stakeholders and stakeholder comments will be solicited.

- ORNL will continue to promote Sustainable ORNL showcase projects and engage the workforce with Earth Day FY 2023 activities (hopefully in-person) to promote environmental justice, resiliency, and net-zero efforts with ORNL and within the community.

12. INDIRECT EMISSIONS

To respond to new federal priorities and DOE directives to attain a net-zero emissions economy, current SSP guidance asked sites to study the standards for 15 sources of Scope 3 (indirect) emissions. Information about this standard is available at https://ghgprotocol.org/standards/scope-3-standard.

ORNL has followed DOE guidance and tracked four categories of indirect emissions since the first GHG inventory in 2008. Tracking and calculation methodologies for determining the amounts of these emissions have been developed using standards available by data entries into the DOE Sustainability Dashboard. Of the 15 categories listed in the standard, many apply to commercial entities but are unlikely to apply to government operations and research activities.

Fifteen Scope 3 categories

Certain Scope 3 categories, such as business travel and employee commuting, are included in ORNL's current baseline and yearly goal progression. The categories currently reported and tracked by ORNL are indicated by the categories as individually outlined here.

1. Purchased Goods and Services

    - This is partially tracked and reported. ORNL Buy vendors are required to submit quarterly reports covering environmentally preferred products, highlighting commodities that contain recycled and postconsumer content, waste prevention, pollution prevention, and biobased categories. The vendors send four reports annually highlighting all their efforts. Reports are analyzed by the Pollution Prevention Program Coordinator and shared with the procurement organization. No indirect emissions are calculated for these products as there is no protocol and the tools needed for GHG calculations are not included in the DOE Sustainability Dashboard at this time.

    - Boundaries, parameters, calculation tools, and standard assumptions are not available and should be provided by DOE to ensure consistencies among sites.

2. Capital Goods - examples include extended life items, equipment, machinery, and vehicles

    - ORNL tracks and reports electronic products purchased under the Acquisitions & Procurement, and Waste Management sections of this report. Associated indirect emissions, specifically the upstream supply chain indirect emissions, are not reported as the tools needed for GHG calculations are not included in the DOE Sustainability Dashboard at this time.

    - Boundaries, parameters, calculation tools, and standard assumptions are not available and should be provided by DOE to ensure consistencies among sites.

3. Fuel and Energy-Related Activities Not Included in Scope 1 or Scope 2

    - ORNL does not report upstream indirect emissions of purchased fuels.

    - Boundaries, parameters, calculation tools, and standard assumptions are not available and should be provided by DOE to ensure consistencies among sites.

4. Upstream Transportation and Distribution (i.e., transmission and distribution [T&D] losses)

    - This is tracked and reported.

5. Waste Generated in Operations

    - Direct generation of waste and recycling activities are tracked and reported as part of the SSP process, but not as indirect emissions.

    - Resulting GHG emissions are reported as Scope 1 only. Scope 3 emissions, if any, are not tracked.

6. Business Travel

    - This is tracked and reported.

7. Employee Commuting

    - This is tracked and reported.

8. Upstream Leased Assets

    - ORNL tracks and reports electricity used for company operations conducted at leased facilities. Therefore, indirect emissions associated with T&D losses from electricity usage are included in the GHG inventory. See item #4.

    - Other indirect emissions from leased facilities are not tracked or well understood at this time. Boundaries, parameters, calculation tools, and standard assumptions are not available and should be provided by DOE to ensure consistencies among sites.

9. Downstream Transportation and Distribution

    - Indirect emissions could be tracked via vendor contractor requirements for reporting, but this is unlikely to add value. Small local vendors would likely comply but would require extensive definitions, assumptions, formulas, and training. Large companies such as FedEx and UPS are unlikely to comply with guidance.

10. Processing of Sold Products

    - This category is applicable to commercial entities but is unlikely to apply to government research.

11. Use of Sold Products

    - This category is applicable to commercial entities but is unlikely to apply to government research.

12. End-of-Life Treatment of Sold Products

    - This category is applicable to commercial entities but is unlikely to apply to government research.

13. Downstream Leased Assets

    - This category is applicable to commercial entities but is unlikely to apply to government research.

14. Franchises

- This category is applicable to commercial entities but is unlikely to apply to government research.

15. Investments

- This category is applicable to commercial entities but is unlikely to apply to government research.

12.1 PERFORMANCE STATUS

As described in the Energy Management section, ORNL's critical missions require extensive use of electricity, resulting in one of the largest indirect emissions category, T&D losses. The processes for tracking and reporting T&D losses are established and well developed by using DOE and federal GHG inventory protocols. The values are determined using regional eGRID factors combined with the amount of electricity purchased annually from TVA. The most direct way to reduce T&D indirect emissions is to reduce the amount of electricity consumed for ORNL operations. However, critical mission needs will limit the effectiveness of this tactic. Long-term strategies to approach CFE goals for the US economy will prove successful by improvements in eGRID emissions over time.

Employee commuting options continued to pose a challenge into FY 2022, though impacts stabilized as COVID-19 transmission levels lowered throughout the year. GHG emissions from employee commuting have been reduced by 14% when compared with FY 2019, which was the latest year of conventional business locale activities. As FY 2022 progressed, more employees reported back to the site full-time, and others worked remotely largely when travel and/or exposure risks were of concern.

With the help of Sustainable ORNL and leadership support, employees are educated in the benefits of using carpools, alternative work schedules, and public transit where available. The ORNL National Transportation Research Center and Sustainable ORNL co-leads work together to study the development of more efficient transportation options and how those options could benefit ORNL and its employees in the near term and over time.

Data reports from business trip entries are used to develop air travel data from ORNL TravX System (Business Services Division). Air and ground business mileage is reported into the DOE Sustainability Dashboard using standards developed by SPD. GHG emissions from SSP business travel categories experienced a sustained reduction in FY 2022 as safe and healthy travel options were often unavailable, resulting in a 95% reduction in business air travel emissions compared to pre-Covid estimates from FY 2019. Video conferencing, virtual discussions, remote workshops, email communications, and phone calls are still reasonable methods to conduct business meetings. Business ground travel, including local and regional travel by automobiles, saw a 90% reduction from pre–COVID-19 pandemic levels.

Other sustainable commuting activities

- **University of Tennessee/Pellissippi State Community College/ORNL Transportation Bus Route**: As discussed in the Investments section, and more specifically the Environmental Justice, Workforce, and Community topic within this section, the bus service has been expanded to include more exchange locations and extended to a year-round workweek schedule.

- **EV Owners Club**: In years past, ORNL managed employee EV charging stations at SNS, the National Transportation Research Center, and ORNL's main campus. An EV program allowed ORNL employees access to charging stations while at work. An additional five charging stations, devoted to the fleet (government-owned EVs), are located throughout ORNL. The EV Owners Club was active through FY 2021. Due to technical limitations associated with charging, the club could not continue into FY 2022. The EV chargers used for this program reached obsolescence late in calendar

year 2021. The obsolescence was a result of the end of wireless 2G service that the equipment was dependent upon. Federal rules do not allow ORNL to financially support charging costs for personally owned vehicles. In the past, club membership payments had allowed for maintenance and as-needed replacements of charging equipment, but the need for a complete replacement was not affordable under the current club model. ORNL is currently examining pathways for a new program that will be scalable as larger numbers of EVs penetrate the marketplace. Sustainable ORNL is following the progress of the fleet organization as they work with DOE to navigate the best options for a new EV charging network at ORNL. After critical technical, financial, and contractual decisions are made, a new version of the EV Owners Club can begin to develop. ORNL is evaluating demand for charging of personally owned EVs on campus and options for meeting that demand.

The FY 2022 GHG inventory for currently tracked categories of indirect emissions are listed in Table 9.

Table 9. Sources of indirect GHG emissions at ORNL in FY 2022

Source of indirect emissions	FY 2022 inventory ($MTCO_2e$)
Employee commuting	13,948
T&D losses (net after RECs)	8,939
Business air travel	555
Business ground travel	85
Total	**23,527**

These Scope 3 emission values are also included in Table 1. Table 1 is more inclusive and demonstrates all sources of GHG emissions (Scopes 1, 2, and 3) and their relative values and percentages compared with total emissions.

12.2 PLANS AND PROJECTED PERFORMANCE

- ORNL will work with SPD and other DOE offices to help develop baselines and tracking methods for other sources of indirect emissions as they apply to our business organization.
- ORNL will ensure that the second phase of an EV Owners Club will provide useful charging service to employee owners of EVs while advancing data analysis to provide scalable models and information for other federal facilities.
- ORNL will document the transition to a new, better normal as employee commuting and business travel recovers after the COVID-19 pandemic but recognizes that previous activity levels were not optimal for sustainable operations.
- Sustainable ORNL will work with laboratory leadership to design, conduct, and analyze a new employee commuter survey that better represents current modes of transportation.
- ORNL will develop systems to track the benefits of alternatives to business travel and upgraded virtual systems for better employee experience and increased productivity
- ORNL will increase efforts to inform employees of the benefits of carpooling and encourage local commuting partnerships.
- ORNL will develop additional demonstration of ORNL transportation research such as alternative fuel/plug-in EV research.

13. FUGITIVE EMISSIONS AND REFRIGERANTS

13.1 PERFORMANCE STATUS

Fugitive emissions (unintentional releases such as leaks) from refrigerants and industrial gases are included in federal GHG inventories to track and reduce Scope 1 GHG emissions. Commonly used materials in this category contain substances that can cause disproportionate climate influence due to exceptionally high global warming potential (GWP) values. Fugitive emissions from refrigerants and laboratory gases contain substances that have GWPs that are hundreds to several thousand times more potent than released CO_2. A common but very potent gas used for industrial process is SF_6, which is estimated to be 22,800 times more threatening to the climate than CO_2.

Direct emissions from purchased industrial gases for standard processes, such as testing and laboratory applications, are included and tracked by DOE in this category to help identify the need for alternative substances. In FY 2022, ORNL's Environmental Management systems indicated GHG emissions from this category was 8,378 $MTCO_2e$, approximated 4% of all emissions from lab operations. Releases are measured using complex materials handling procedures and balances, and resultant calculations using the individual GWP of each type and volume of gas released. Since ORNL's final decommissioning of a large SF_6 process in 2018, this category has remained less than 5% of total emissions at ORNL, which is expected to remain at a minimum over the coming years.

Fugitive emissions increased for this category in FY 2022 because of the increase of on-site activity related to easing of pandemic restrictions, as well as improved data tracking accuracy. Compliance specialists, researchers, and other subject matter experts track inventories and ensure proper storage by utilizing a complex materials management system. Special leak detection equipment is generally available for deployment when needed to monitor large quantities of refrigerants. Environmental staff also encourage researchers to consider refrigerants with lower GWPs when conducting investigations. Compliance with National Environmental Policy Act (NEPA) reviews will also reveal if new materials or large quantities of material with high GWPs are indicated. Processes and procedures within science research projects are also reviewed any time there is a new circumstance. A compliance specialist will work with F&O moving forward to identify aging equipment with high GWP for replacement considerations, as well as to follow new projects through to completion, ensuring that requests during the NEPA phase are properly implemented.

Supply chain economics indicate that the availability of high-GWP refrigerants will decrease, resulting in steady price increases. Laboratory staff will naturally decrease use of these materials in favor of lower-cost, readily available products.

13.2 PLANS AND PROJECTED PERFORMANCE

No on-site process at ORNL utilized SF_6 in FY 2022, and no process use of SF_6 is expected in the future.

Site-wide fugitive emissions should continue to decline as research scientists are made aware of less potent alternatives for tracer gases and are introduced to more compelling gases for use in experiments and research projects. Project costs will also favor less potent (and less expensive) gases.

Site-wide fugitives and refrigerant GHG emissions will continue to have a minor impact on the GHG emission estimates across ORNL.

14. ELECTRONIC STEWARDSHIP

14.1 ACQUISITION STRATEGIES

The ORNL Buy is an ORNL procurement site designed to connect ORNL users to value-added resellers (VAR), selling products from a wealth of manufacturers. This procurement vehicle improves the user experience for acquiring goods while decreasing the procurement effort. Additionally, ORNL ensures that products acquired through the VAR meets the laboratory's requirements: EPEAT and power manageability being the primary focus for this discussion.

For cases in which products are not found within the ORNL Buy catalogs, such as from a specialty provider, staff can request an exception for nonstandard hardware. The request initiates a special review process in which approval falls to an appropriate subject matter expert, who will determine if there is a legitimate business or research need to acquire the commodity. Often, an EPEAT-certified ORNL Buy offering will be sufficient for the needs of the user and an exception becomes unnecessary; in the few cases in which the nonstandard hardware is the only acceptable commodity, a bevy of documentation for the justification, risks, and exceptions is notated and agreed to by the requestor and their manager prior to approval.

14.1.1 Computers

ORNL acquired 2,541 client devices (e.g., laptops, desktops, workstations) in FY 2022 that fall into ORNL's EPEAT validation goal of bronze or higher. Of the devices purchased in FY 2022, only 28 devices required exceptions due to business or research requirements, yielding 98.9% compliancy. The 1.1% of devices that required an exception fell into one of four categories:

1. Instrument devices that come bundled with client computers will often be supported by the instrument provider if the computer was part of the initial instrument acquisition. An effort is made to discuss potential pitfalls of using the instrument provider's equipment and sway the user to using a VAR supported system, though if necessary, the exception is approved.

2. CAD engineers and the Graphics group often work with specific applications that require specific Central Processing Unit needs and GPU customizations beyond what ORNL's traditional vendors support. Boxx Systems is the primary vendor that provides machines that are sufficiently capable for their workloads; given that the devices are not in the EPEAT registry, an exception is required.

3. ORNL's HPC groups often require "bleeding edge" technologies not found within the EPEAT registry to accomplish AI and machine learning initiatives. These include device manufacturers such as Nvidia.

4. Many using the Linux platforms find that traditional manufacturers have poor support for the Linux platform. The majority of Linux users have a strong need for Linux-focused driver, BIOS, and firmware support to mee their research needs. The preferred Linux manufacturer, System76 Systems, is not EPEAT-certified, so an exception is only granted if there is a strong need for their specific level of support. ORNL initiated talks with System76 Systems to encourage them to work toward an EPEAT certification, but it was deemed by System76 Systems to be too costly.

14.1.2 Displays

ORNL does not asset tag displays, so tracking exact FY 2022 numbers are difficult. An estimated 2,654 displays were purchased and only 35 required EPEAT exceptions; thus, the compliancy rate of 98.6% is

slightly lower than that of the computer compliancy rate. An EPEAT exception justification is typically based on one of the following reasons:

1. Size and dimensions where configuration requirements dictate specific needs (e.g., kiosks)

2. Technical specifications that are beyond the needs of the average user (e.g., environmentally ruggedized needs, specialized portability)

14.1.3 Miscellaneous Products

TVs: ORNL staff are discouraged from purchasing TVs following the changes to the category's EPEAT requirements in 2020. Nonetheless, there are instances in which TVs are required for specific purposes, and those instances do not always align with EPEAT-compliant devices; fortunately, the volume of TVs purchased continues to remain very low.

Mobile devices: ORNL has worked to significantly reduce the number of government-funded mobile devices. Nearly all mobile devices, consisting almost exclusively of Apple and Samsung devices, are EPEAT-certified; however, there was a single instance of a tablet purchased that did not meet the EPEAT bronze minimum certification.

14.2 PERFORMANCE STATUS: OPERATIONS

14.2.1 Power Management: Computers

ORNL continues to meet the electronic stewardship goal of power-managing 100% of the eligible personal computers, laptop computers, and monitors in use by ORNL staff since 2009. Device information is generated from an application, Device Monitor, that provides users with a wealth of information about their devices. The Device Monitor dashboard is a window into the health and management of their devices, beyond general information such as the make, manufacturer, and serial number. Discovered issues, vulnerabilities, and baseline requirements (e.g., power management of a device) and further details are provided for users to address when needed.

Power management is one of the baseline requirements for Windows and MacOS devices. One element of this baseline is the forced enablement of a screen saver in 15 min or less, which coincides with a security baseline (on Mac computers, the setting is variable, which is discussed later); ORNL allows modification to less than 15 min if a user would like to maintain an environment of even greater security. A complete display power-down is enacted after 20 min of inactivity on Windows, as well; on Mac, the display is disabled between 10 and 30 min depending on whether the machine is a desktop or a laptop, and whether the latter is connected to power or using the onboard battery. In previous years, a blank screen saver was enabled after the allotted time, but upon further research of the various display technologies currently being used by manufacturers, there was little value gained from this practice.

These power management settings are applied through configuration management tools and further monitored within Device Monitor to ensure the baseline requirements are met. For cases in which a user might need an exception to any of these requirements, such as an electronic bulletin board, an exception request with justification details and any mitigations needed for the requirement is submitted by the user. If the exception is approved, Device Monitor will communicate with the appropriate configuration management tool responsible for enforcing the setting to disable the enforcement for that device. The user can then view any approved exception within Device Monitor and request a renewal of the exception upon its expiration (a maximum of 6 months from the approval date).

Baseline requirements and their enforcement can differ depending on the operating system and defined usage. However, for standard computing desktops and laptops at ORNL, power management policies for the computer and the displays are enforced using operating system controls via configuration management tools and/or Avolin Verdiem products.

Exceptions for power management settings on monitors (which act as a secured screen saver) are rarely permitted because of the security implications of an active console. Justification must provide strong mitigation solutions to ensure that the computer is secured. These exceptions are typically found on kiosks and electronic bulletin boards that display active information and use very specific configurations and locking solutions to protect the equipment.

ORNL continues to face some unique challenges and opportunities in the manageability space for computer devices. Effects of the COVID-19 pandemic, although lessened from FY 2021, continued to present obstacles in the current hybrid workforce employed by ORNL. However, the brunt of the challenges faced in completing the original objectives set for FY 2022 arose from the very energy management solution utilized.

One of FY 2022's objectives, to install a new Verdiem server instance on the latest software and migrate existing clients (and introduce to Mac clients), has experienced several unforeseen challenges. Initially, the project was progressing well at the onset of the new fiscal year; a support technician had been assigned to assist with the tasks and the new Verdiem instance was deployed. Being a new implementation, all the policies and parameters needed to be rebuilt, which presented an opportunity to also optimize and potentially improve energy management, and thus energy savings.

This process proceeded well into testing an initial set of Mac and Windows workstations until the start of calendar year 2022. At this point, a critical vulnerability involving Apache's log4j software library was flagged on the new Verdiem instance (but not the older, in-place instance). Because of the severity of the vulnerability, the migration to the new instance had to be completely halted until an updated client was provided (3 weeks before the end of FY 2022).

Customer support has been compromised as the product management and technical staff has changed over two separate acquisitions, and its original developers and support staff have limited or no availability to assist with support. The continuous issues with the vendors owning the Verdiem client have called into question the validity of the usage of the product in the long term. Therefore, the primary goal for energy management on workstations in FY 2023 is to migrate Windows and Mac clients to the new Verdiem instance solely to retain the current Wake-on-LAN functionality and expand reporting capabilities. Once completed, a Wake-on-LAN solution (separate from the energy management tool) and necessary reporting capabilities will be researched to divest from Verdiem long term.

14.2.2 Automatic Duplexing: Imaging Devices

A few years ago, ORNL implemented a shared print services program to update existing multifunction print devices (print/scan/copy/fax devices) and to provide for other shared print devices. All new print services include automatic duplexing set as the default. An individual can override duplexing for a print job that requires single-side printing. Existing printers without duplexing capability are being replaced with printers that require duplexing capability.

The shared network printer services model is helping to standardize equipment, reduce energy consumption, reduce landfill waste, reduce the cost of operations, improve printing services in general, and provide more efficient use of consumable products. Over time, ORNL plans to shrink the printer equipment footprint even further and to save essential overhead costs by reducing toner purchases,

support costs, and power demands. While automatic duplexing is enabled and set as default on all (100%) print devices, user modifications are possible for each individual print job.

ORNL's printer management suite continues to allow real-time audits of printer data. When the data are combined, ORNL's black and white/duplex requirements are less than favorable. However, since implementing the Managed Print Services contract at the beginning of FY 2020, the numbers are trending upward. These increases are attributed to the implementation of PrinterLogic into the environment during the second quarter of FY 2020 as part of the Managed Print Services contract. PrinterLogic allows IT to gently enforce black and white/duplex profiles to meet DOE sustainability goals.

IT-managed networked imaging devices: Duplex print jobs decreased slightly from 54.04% in FY 2021 to 53.58% in FY 2022, as described in Table 10. Black and white print jobs also decreased from 62.74% in FY 2021 to 57.59% in FY 2022. This can be attributed to a considerable increase in on-site staff with a 30% jump in printing from 2,909,153 pages in FY 2021 to 4,138,832 pages in FY 2022.

Table 10. IT-managed networked imaging devices data breakdown

Paper size	B&W	Color	B&W duplex	Color duplex	Total pages	Total B&W	B&W (%)	Total duplex	Duplex (%)
A0	0	1	0	0	1	0	0.00	0	0.00
A1	44	84	0	0	128	44	34.38	0	0.00
A2	3	16	0	0	19	3	15.79	0	0.00
A3	106	61	88	20	275	194	70.55	108	39.27
A4	1,364	847	2,968	2,130	7,309	4,332	59.27	5,098	69.75
A5	15	56	38	6	115	53	46.09	44	38.26
A6	15	48	18	0	81	33	40.74	18	22.22
ANSI C	157	828	0	0	985	157	15.94	0	0.00
C5	12	39	594	144	789	606	76.81	738	93.54
Executive	17	57	8	8	90	25	27.78	16	17.78
Government legal	1	21	2	0	24	3	12.50	2	8.33
Half letter	67	82	2,416	118	2,683	2,483	92.55	2,534	94.45
Junior legal	3	0	108	0	111	111	100.00	108	97.30
Legal	10,178	6,955	3,298	3,504	23,935	13,476	56.30	6,802	28.42
Letter	882,010	757,533	1,191,371	804,849	3,635,763	2,073,381	57.03	1,996,220	54.91
Other	105,925	61,161	113,505	72,821	353,412	2,194,30	62.09	186,326	52.72
Tabloid	58,295	35,341	11,092	8,384	113,112	69,387	61.34	19,476	17.22
Total	**1,058,212**	**863,130**	**1,325,506**	**891,984**	**4,138,832**	**2,383,718**	**57.59**	**2,217,490**	**53.58**

Non–IT-managed USB imaging devices: Although IT does not have the means to enforce profiles on USB-connected printers, desktop printing has slightly improved. Duplex print jobs increased slightly from 15.85% in FY 2021 to 18.54% in FY 2022, as described in Table 11. Black and white print jobs also increased from 38.17% in FY 2021 to 40.59% in FY 2022. More staff are being hired remotely, but the trend is to not purchase printers unless required, so the total pages only slightly increased from 2,061,230 in FY 2021 to 2,150,105 in FY 2022 (an increase of 4%).

Table 11. Non–IT-managed USB imaging devices data breakdown

Paper size	B&W	Color	B&W duplex	Color duplex	Total pages	Total B&W	B&W (%)	Total duplex	Duplex (%)
A2	3	6	0	0	9	3	33.33	0	0.00
A3	13	52	0	0	65	13	20.00	0	0.00
A4	820	1,291	442	3,082	5,635	1,262	22.40	3,524	62.54
A5	15	72	0	6	93	15	16.13	6	6.45
ANSI C	2	11	0	0	13	2	15.38	0	0.00
B6	0	5	0	0	5	0	0.00	0	0.00
C5	2	23	0	14	39	2	5.13	14	35.90
Executive	15	11	2	0	28	17	60.71	2	7.14
Government legal	7	40	0	0	47	7	14.89	0	0.00
Government letter	0	19	0	0	19	0	0.00	0	0.00
Half letter	1	28	0	0	29	1	3.45	0	0.00
Legal	917	2,156	72	256	3,401	989	29.08	328	9.64
Letter	516,642	950,499	83,272	310,994	1,861,407	599,914	32.23	394,266	21.18
Other	270,180	7,450	122	254	278,006	270,302	97.23	376	0.14
Tabloid	187	1,014	6	102	1,309	193	14.74	108	8.25
Total	**788,804**	**962,677**	**83,916**	**314,708**	**2,150,105**	**872,720**	**40.59**	**398,624**	**18.54**

14.3 ELECTRONIC PRODUCTS END-OF-LIFE STRATEGIES

Because of ORNL property management and environmental management policies and procedures within its Standards-Based Management System, ORNL ensures that 100% of used electronics are reused or recycled using environmentally sound disposition options. Options include transfer to other DOE contractors, nonprofits, and schools by means of programs such as the Computers-For-Learning Program. Electronics that have reached end of life are recycled through a Responsible Recycling Practices–certified recycler. Beyond using certified programs, current and future success is based on a strong, corporately engrained foundation.

- ORNL continues to be strongly proactive in the transfer of specific electronic components to other DOE contractors, nonprofits, and the Computers-For-Learning Program as it has for decades.

- Since May 2012, ORNL has exclusively used a Responsible Recycling Practices–certified recycler to recycle its electronics that have reached end of life.

- ORNL continues to abide by established processes to reuse and recycle electronics in an environmentally sound manner, even before certifications were available by doing on-site assessments of the recycling facilities.

- ORNL continuously reviews procedures and certifications to ensure that recyclers are in compliance with all regulations, are using best practices, and are in good standing with professional recycling associations.

- In FY 2022, 100% (121,014 lbs) of bulk weight electronic equipment was recycled through the Certified Recycler process.

- More than 4,730 itemized units of electronics equipment were donated or recycled through the Certified Recycler process in FY 2022.

14.4 PLANS AND PROJECTED PERFORMANCE

- Acquisitions: In the future, ORNL plans to work toward maintaining compliance with EPEAT purchase electronic stewardship goals (95%).

- Power management: The primary goal for energy management on workstations in FY 2023 is to migrate Windows and Mac clients to the new Verdiem instance solely to retain the current Wake-on-LAN functionality and expand reporting capabilities. Once completed, a Wake-on-LAN solution (separate from the energy management tool) and necessary reporting capabilities will be researched to divest from Verdiem long term.

- Automatic duplexing: IT Operations plans to continue to implement shared network print devices with automatic duplexing set as the default and reduce the number of local print devices by providing additional shared network printers.

- End of life: ORNL will continue to be strongly proactive in the transfer of specific electronic components to other DOE contractors, nonprofits, and the Computers-For-Learning Program. In FY 2023, ORNL will continue to work to ensure that 100% of bulk weight electronic equipment is recycled.

14.5 DATA CENTER STRATEGIES

14.5.1 Performance Status

ORNL's Computational Facilities have expanded to support mission growth and will continue to evolve as it responds to demand for computational capability. Energy and water efficiency are top priorities as the ORNL HPC data centers successfully serve critical mission needs and effectively meet federal Data Center Optimization Initiative goals. Figure 29**Error! Reference source not found.** summarizes the current cooling loads for ORNL data centers and their supporting cooling system utilization. As mentioned in FY 2021, ORNL has adopted calculating power usage effectiveness (PUE) at the space level to effectively identify where areas of opportunity exist for improving efficiency.

FY 2022 was a noteworthy year as ORNL HPC operations enabled the Frontier exascale supercomputer (Figure 30), which earned the top position in the June 2022 Top500 HPC list. The depiction in Figure 31 shows the scope of the infrastructure improvements completed in FY 2021 to support Frontier. With Frontier online, ORNL's shift to warm water-cooled HPC continues, which saves energy and water by drastically cutting the need for mechanically driven chillers. In total, ORNL's main data centers located in Building 5600 have reached a concurrent peak technical load of 36.5 MW. The PUE for the portion of the cooling systems supporting Frontier, thus far in the acceptance testing part of its life, has averaged 1.06. This time period has seen loads varying between idle and peak with much time spent at idle during the summer months. With this said, ORNL expects this PUE to further improve once Frontier goes into production for open science and the efficiencies gained with winter conditions are realized.

Building/ Space	~SF	Loads and Cooling System Utilization for Building 5600 Data Centers FY22								12 Month Energy Data		
		Loads (kW)		Chilled Water (CHW is 42°F @ 0.8kW/ton)		*Medium Temperature Water (MTW is 65-71°F @ ~0.4kW/ton)		High Temperature Water (HTW is <89.6°F @ 0.2kW/ton)		IT/Compute GBTU	Facility GBTU	PUE
		Normal	Peak	% of Total Load	Remaining Capacity (MW)	% of Total Load	Remaining Capacity (MW)	% of Total Load	Remaining Capacity (MW)			
5600/E102	18000	9761	27538	2	15	8	0.5	90	10	291.810	18.607	1.06
5600/E204	17000	1344	1438	100	7	N/A	N/A	0	7	40.170	11.677	1.29
5600/K100	9400	5561	10213	0	5	100	13	N/A	N/A	166.262	14.213	1.09
5600/K/L/Q200	15000	2704	3935	30	5	70	0	0	1.5	80.862	14.520	1.18
									Totals	**579.104**	**59.017**	**1.10**

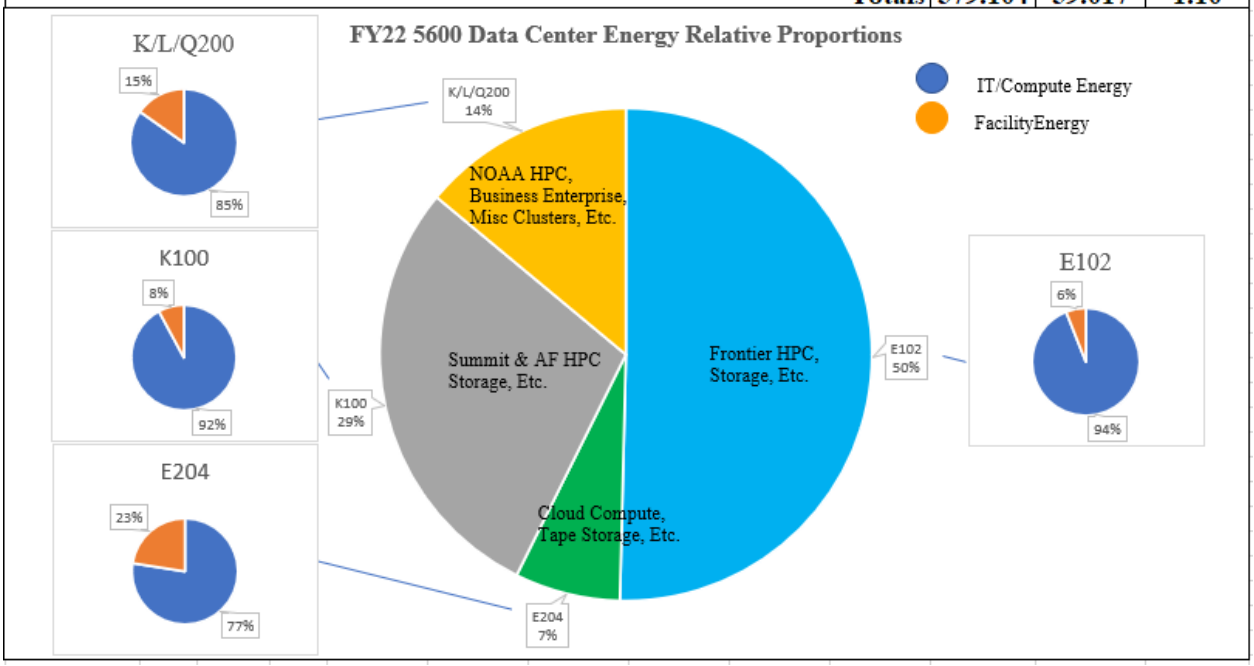


Figure 29. Current normal loads (peak load/capability) in FY 2022.

*Medium-temperature water loads use a high-temperature water system primarily and the chilled water cooling system when needed to trim the supply temperatures down to the necessary level.

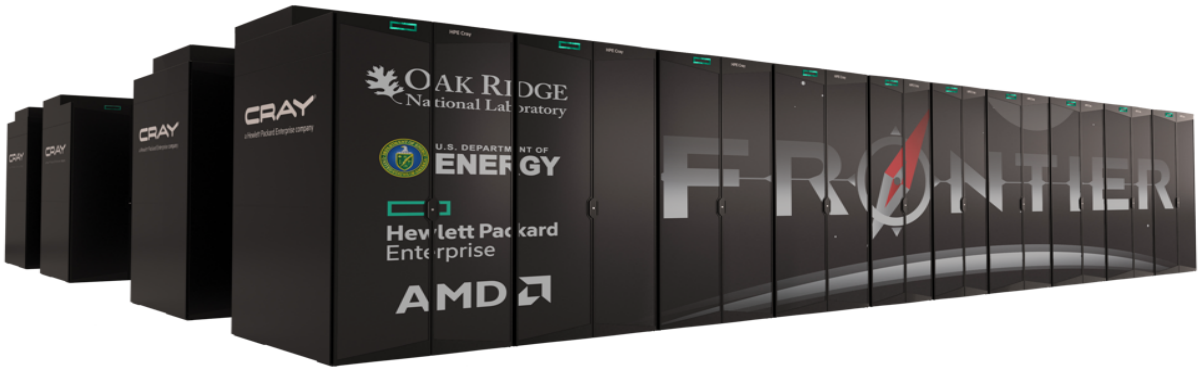


Figure 30. Frontier exascale supercomputer.

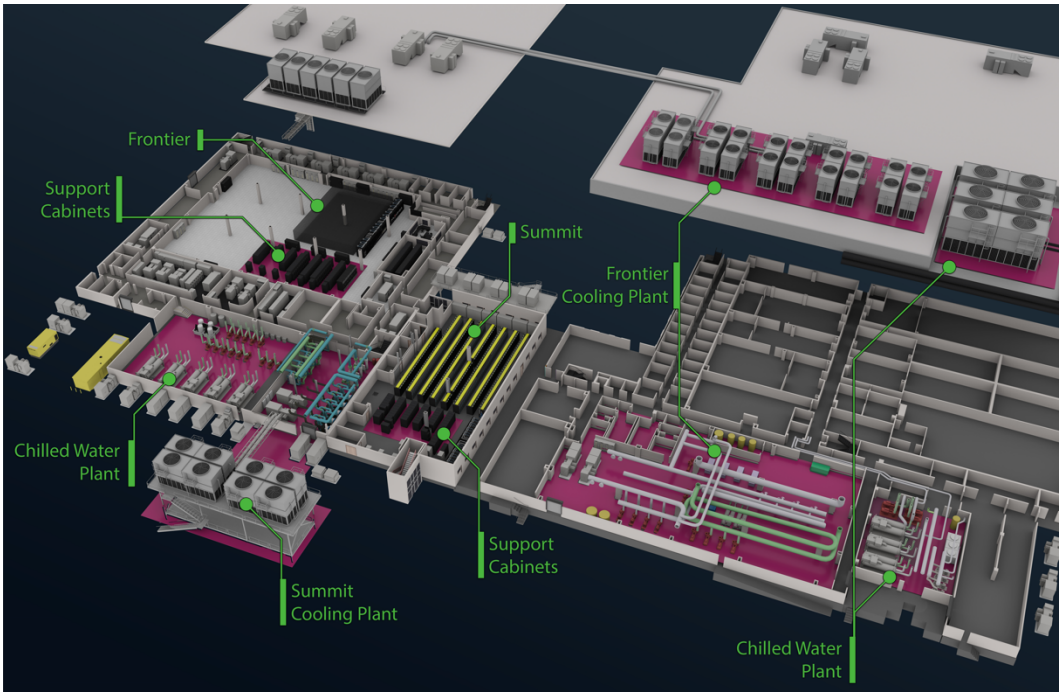


Figure 31. ORNL's Computational Facilities Complex support infrastructure.

ORNL's current portfolio of loads are cooled with about 50% on the high-temperature water system (~0.2 kW/ton), 35% on the K100 medium-temperature water system (~0.4 kW/ton), and 15% on the chilled water system (~0.8 kW/ton). Future efforts for improvement will focus on the 15% remaining on the chilled water systems. To this end, as ORNL stands up new higher-density "islands" of racks with rear door heat exchangers and cooling distribution units (CDUs), provisions are being added to eventually tie them together to enable the Trim CDU concept, which will bring all the loads that are currently chilled water–cooled to be medium-temperature water–cooled (economized).

Summit's cooling plant continues to perform very well. It cools 100% of the loads within the data center with supply water temperatures up to 71°F. In total, 85% of the annual cooling loads for this data center are cooled with the economized cooling tower part of the system. Even during the hottest, most humid times of the year, the economizer contributes to the cooling of the space. Figure 32 shows the total load on the cooling system with stacked columns representing chilled water (green) and cooling tower (yellow) contributions for May through September 2022.

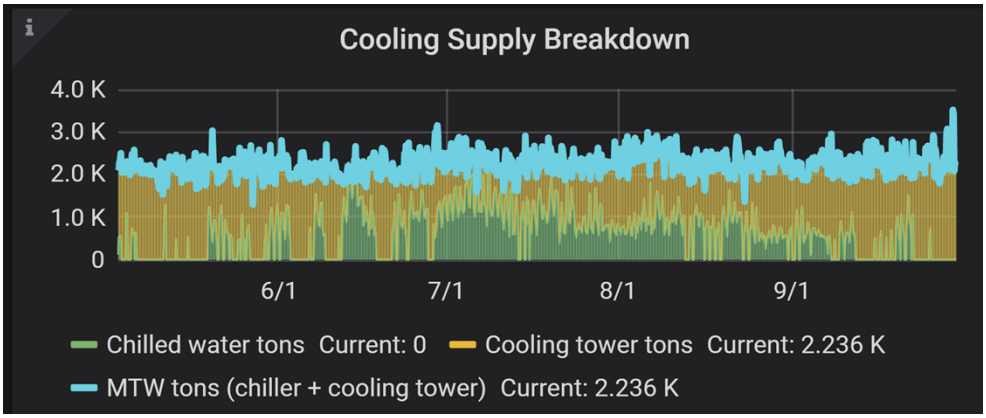


Figure 32. Supercomputing Room K100 cooling system utilization, summer 2022.

14.5.2 Plans and Projected Performance

Frontier and Summit will operationally overlap in FY 2023. This will lead to a spike in HPC power consumption until Summit is retired. ORNL is continuing to transition additional data center load to economized cooling systems. FY 2023 should see moderate improvements since ORNL has already optimized areas that are the easiest to complete for its largest systems. ORNL will continue to have high confidence that its data center operations, future strategies, and planning will continue to attain fulfillment of the desires of the Data Center Optimization Initiative.

Monitoring ORNL data centers is critical to ORNL's mission success. ORNL is migrating all data center–related monitor systems associated with the older BAS platform to the new platform that was upgraded for Frontier. This will provide enhanced trending capabilities and easier performance comparisons between various data centers. When integrated, the consolidated system will provide facility engineers and managers with the tools they need to monitor HPC operations in one place.

In FY 2023, ORNL is preparing for the possibility of adding a trim capability to the high-temperature water system, which will technically change it to another medium-temperature water system. If used, this will erode the current efficiency gains, but adding the capability is intended to protect against the possibility that cooler temperatures may be needed by current or future systems during specific times of year and if the allowable thermal envelopes of these systems become more demanding. ORNL has also experienced outdoor conditions resulting in higher-than-design wet bulb temperatures for the cooling towers, which is another reason to add this capability. Of course, if economizing cooling towers are struggling to keep up with the load, so can the chiller's towers, but the chillers have not experienced surging issues. This is partially because of the ability to unload chillers with a built-in design for redundancy. Two chiller plants are cross-connected, and they will be connected with other chiller plants. This enables spreading load out between chillers, reducing the risk of them surging should climate change continue to drive wet bulb temperatures up further.

ORNL is working toward another rear door heat exchanger/CDU "island" in E204, which will include provisions for connecting to a centralized Trim CDU system in the future. Researchers are starting to examine conceptual options to modify cooling systems to support ORNL's next supercomputer, OLCF-6, in several theoretical configurations and cooling needs. In addition, ORNL continues to anticipate current HPC systems going offline because of retirement. Impacts to the cooling systems and efficiencies will be seen especially for the cooling systems that have low load diversities. Table 13 includes this consideration, but knowing the extended impact is difficult given new systems coming online and older systems continuing to retire at unknown points in the future. One challenge in implementing the Trim CDU concept is that it requires a shift of capital expense to the construction phase. Payback depends ultimately on how much load is connected. When specifying new racks, design loads are notoriously reported higher than the actual load realized once in production. This worsens the payback period, but rack densities do continue to climb, and the economics will likely become more favorable.

Table 12 describes the projected PUE for various data centers. ORNL is still positioned to shift chilled water loads to economized cooling systems when dictated by economies of scale. Although no new migrations were accomplished in FY 2022, ORNL continues to look for opportunities for the concept.

Table 12. Supercomputing efficiency goals

Unclassified ORNL computer facilities PUE_2 goals vs. actuals								
Fiscal Year	5600 Rm. E102		5600 Rm. E-204		5600X Rm. K100		5600X Rms. K-200, L-200, and Q-200	
	PUE goal	PUE actual	PUE goal	PUE actual	PUE goal	PUE actual	PUE goal	PUE actual
2022	1.06	1.06	1.20	1.29	1.08	1.09	1.20	1.18
2023	1.06	—	1.25	—	1.08	—	1.18	—
2027	1.06	—	1.20	—	1.08	—	1.15	—
2032	1.06	—	1.15	—	1.08	—	1.15	—

Calculating the PUE for Frontier will require the use of 43 electrical meters, 13 chilled water meters, and 2 static estimations for various loads. Creating the data needed for Table 12 requires many more meters and sensors. Maintaining the ability to monitor these systems, obtain the data from the various sources, and compile and analyze the data requires great effort. ORNL will continue to automate the process into the foreseeable future. Figure 33 outlines a scenario to demonstrate the actual calculations in abbreviated notation just for Frontier's data center. This example demonstrates the complexity of calculating the data load and facility components of Frontier's PUE.

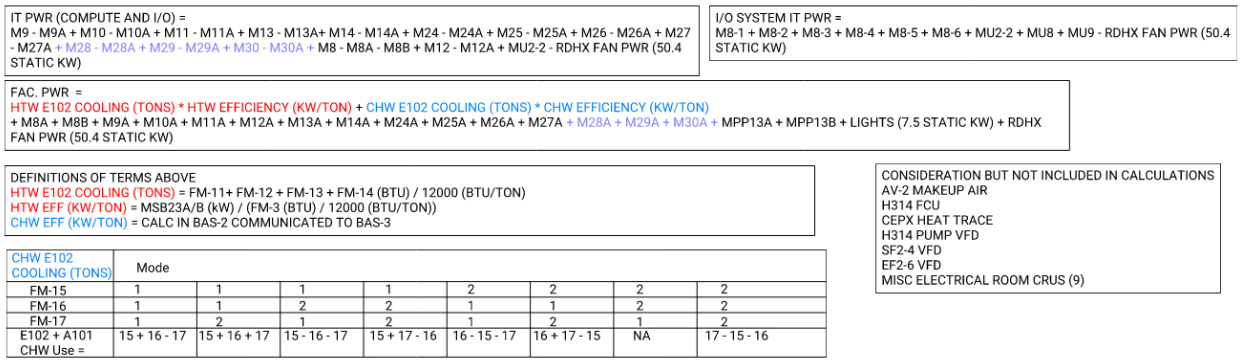


Figure 33. Abbreviated notation for calculating Frontier's PUE to demonstrate the complexity.

This complexity largely comes from the fact that cooling systems have multiple connections to the datacenter and the efficiency of those cooling systems vary, depending on their data load and outdoor conditions. Other challenges come from strategically integrating cooling systems dedicated specific IT systems to the same power distribution equipment feeding those IT systems. ORNL is interested to see how reliable the automated PUE calculation will be given the number of inputs. ORNL anticipates that additional analyses and efforts will be required to maintain the optimal PUE calculation.

The ORNL data centers continue to be best in class thanks to the integrated team that enables them. ORNL is in a stable place to continue to grow and adapt to accommodate future data center needs. The power and cooling systems are performing with the expected level of availability, efficiency, and resiliency.

15. ADAPTATION & RESILIENCE

15.1 PERFORMANCE STATUS

FY 2022 was a year of increased attention to climate vulnerability and developing solutions to climate challenges and other operational vulnerabilities in federal facilities. In response to EO 14008, DOE initiatives, and increased support from SC, ORNL is developing updated assessments and planning documents for the Sustainable ORNL program and integration into other planning programs. Following the release of DOE's VARP guidance and associated timelines, ORNL added operational resilience to the Sustainable ORNL roadmap structure and established a core team to develop a site-specific plan to meet VARP requirements. ORNL's VARP reporting team members participated in training and workshops offered by SPD and the Federal Energy Management Program (FEMP) to employ the new guidance and collective resources to improve vulnerability planning efforts.

The VARP team is also part of a self-initiated working group with the other DOE sites on the ORR. Because ORNL is in close geographic proximity to other ORR sites, this working group was especially helpful with deliberations concerning the numerous resources suggested by DOE for climate change projections and historical weather event data for the Oak Ridge, Tennessee area. Through collaboration with the ORR working group and use of recommended climate data sources, the following key determinations were made regarding ORNL's climate hazards:

- ORNL is located in a very low-risk area relative to the rest of the United States. Tennessee has seen temperatures rise by 0.5°F since the beginning of the twentieth century compared with the 1.8°F of the United States as a whole. Furthermore, the lab's geographical position (narrow valleys between linear and partitioned ridges) offers separation from and natural protection against environmental hazards.

- However, historically unprecedented warming is projected during this century with temperatures rising as much as 11°F for higher emissions projections (Figure 34). Heat waves are the only hazard expected to increase in frequency and intensity, leading to more intense droughts, as well.

- Although it is not certain precipitation events will increase in frequency, they will likely be more intense, which will increase the likelihood of flooding in a region that already experiences challenges from abundant precipitation.

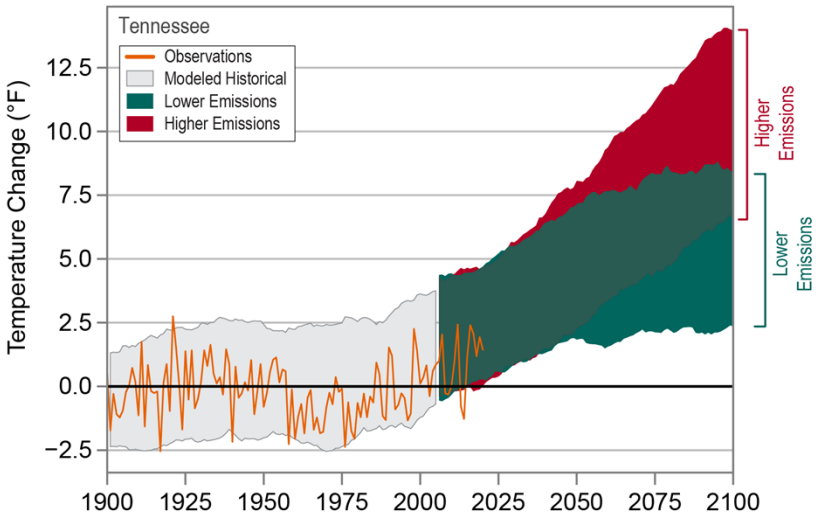


Figure 34. Tennessee observed and projected temperature change.
Source: NOAA Tennessee State Climate Summary 2022.

The ORNL VARP was centered on mission-essential facilities and utility infrastructure to ensure that the physical assets will be prepared to demonstrate a high degree of resilience in response to climate change. Operations stakeholders including building engineers, utility engineers and experts, and their management were included in the broader VARP team. Division- and directorate-level leadership in operations provided general direction and support for VARP team activities. Stakeholders provided input to complete the SPD-provided VARP Risk Assessment Tool, which is used to identify the climate vulnerabilities of ORNL's evaluated assets. A portfolio of solutions to address these factors was created and included newly formed proposals as well as projects from other lab infrastructure enhancement efforts, such as the SLI-funded CIMP. Currently in the planning stages, CIMP is a major effort to upgrade and improve conditions, utilization, mission readiness, and resilience of the facilities and infrastructure that are most critical to mission success and includes upgrades to and/or replacement of water and sewer systems, stormwater, chilled water, steam, electrical, natural gas, compressed air, and telecommunications. CIMP subtasks set to mitigate climate vulnerabilities were added to the portfolio of solutions and will be tracked by the VARP team through communications with the project manager and the Utilities Division.

In September 2022, the ORNL VARP team submitted the following deliverables to SPD through the DOE Sustainability Dashboard following a review with the DOE Site Office:

- VARP Narrative
- Risk Assessment Tool
- Portfolio of Resilience Solutions

15.2 PLANS AND PROJECTED PERFORMANCE

Updates of the implementation status of ORNL's solutions will be reported annually to SPD, starting in the fall of 2023. In recognition of the important goal of addressing operational and climate resiliency on critical missions and operations, ORNL leadership is on board to ensure that continued collaboration and focus on this topic is maintained. Clear communications and timely responsiveness will be required as this initiative is built upon and improved annually going forward.