



Fiscal Year 2023 Site Sustainability Plan

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Executive Summary

This document is presented as the Site Sustainability Plan (SSP) for Lawrence Livermore National Laboratory (LLNL), consistent with the guidance provided by the Department of Energy (DOE) and the supplemental guidance provided by the National Nuclear Security Administration (NNSA) received in September 2022 as a deliverable for DOE Order 436.1 *Departmental Sustainability* requirement. LLNL is certified in environmental management (ISO 14001) and aligns sustainability efforts with the environmental management system (EMS).

Lawrence Livermore National Security (LLNS) completed the following deliverables required by new sustainability requirements in FY 2022:

- *Vulnerability Assessment and Resiliency Plan (VARP)*
- *5-Year Electric Vehicle (EV) Infrastructure Plan*
- *Contribution to NNSA's Carbon Free Electricity (CFE) Plan*

Major accomplishments contributing to sustainability goals in fiscal year 2022 (FY 2022) included the following:

- Installation of 10 new level 2 electric vehicle charging ports
- Construction of a new LEED Gold Emergency Operations Center
- Equipment and roofing upgrades/replacements completed in FY 2022 will have an estimated energy savings of 483 MWh per year, which is about 1% of the Lab's total energy use
- Implemented a greenhouse gas (GHG) emissions reduction action plan to identify inefficient gas boilers, minimize use and institutional risk of sulfur hexafluoride (SF6) in gas insulated equipment, and improve the refrigerant management program

The \$100 million Exascale Computing Facility Modernization (ECFM) project was completed in FY 2022 providing the additional power and cooling to operate two exascale supercomputers in building 453 (B453). Although designed with energy saving controls and innovative cooling technology, ECFM will have a significant impact on the future energy and water use at the Livermore Site. In response, LLNS is exploring energy and water conservation opportunities, including the feasibility of wastewater reuse, alternative data center cooling technologies, and energy saving in other areas. In addition, the sustainability team is working closely with the Office of Laboratory Infrastructure to integrate and fund sustainability initiatives in site planning.

New and existing resources will be leveraged as much as possible to help achieve LLNS's sustainability goals. Funding has been allocated through Cooling and Heating Asset Management Program (CHAMP) for HVAC replacement projects, several sustainability projects were submitted for Energy Resilient Infrastructure and Climate Adaptation (ERICA) funding, and class 3 estimates are included in the *5-Year EV Infrastructure Plan*. Funding is needed to repair or replace failing meters and add new meters. Accurate metering data are the foundation for energy and water conservation projects that can support LLNL's sustainability goals, resilience, and reduce vulnerabilities.

The primary goals for FY 2023 are to complete a water management plan, identify and implement water savings opportunities through recycled wastewater projects, revitalize the metering program, and expand electric vehicle charging infrastructure. Development of the Lab’s first comprehensive net-zero plan is also a priority for FY 2023.

Table 1 summarizes the goal category targets for each DOE sustainability goal.

Table 1. Summary of goal category targets.

Prior DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Non-Attainment
Energy Management			
Reduce energy use intensity (Btu per gross square foot) in goal-subject buildings.	-29.43% reduction from FY 2003 baseline. Negligible increase from FY 2021.	Energy savings through proposed Energy Conservation Measure (ECM) projects will be actively pursued; however, significant funding for energy savings projects is required to meet the goal.	High
EISA Section 432 continuous (4-year cycle) energy and water evaluations.	LLNS has completed 50% of its EISA audit portfolio for the 2021-2024 round. Desk audits were performed for 18 facilities in FY 2022.	Funding is allocated for HVAC controls upgrades and replacement and metering of boilers in several facilities in FY 2023.	Low
Meter individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	90% of electricity achieved (loss of meters has been experienced; 120 of 312 meters have failed since 2012). 60% of natural gas achieved.	An analysis of LLNL’s electrical meters was performed and a prioritized list of non-functioning electrical meters has been identified for repair. Funding is allocated for replacing and restoring prioritized meters is FY 2023.	Medium
Water Management			
Reduce potable water use intensity (Gal per gross square foot).	In FY 2022, LLNL’s water intensity is estimated at -7.05% relative to the FY 2007 baseline. Savings from FY 2021 is - 4.4%.	Continue to evaluate the feasibility of recycled water options and implement landscaping water reductions and turf removal.	High
Reduce non-potable freshwater consumption (Gal) for industrial, landscaping, and agricultural.	LLNL uses potable water for ILA (non-potable water is not used).	NA	NA

Prior DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Non-Attainment
Waste Management			
Reduce non-hazardous solid waste sent to treatment and disposal facilities.	LLNL consistently diverts over 70% of nonhazardous solid waste from landfill.	The recycling and composting program will be added to more facilities in FY 2023.	Low
Reduce construction and demolition materials and debris sent to treatment and disposal facilities.	The subcontractor reporting process was improved to ensure accurate tracking of C&D waste.	Continue efforts to improve tracking of C&D waste.	Low
Fleet Management			
Reduce petroleum consumption.	Will be entered in FAST when available	Seven additional electric vehicle charging ports were installed at the Livermore Site and 3 at Site 300.	Low
Increase alternative fuel consumption.	Will be entered in FAST when available	Focus is on purchasing electric vehicles.	Low
Acquire alternative fuel and electric vehicles.	Will be entered in FAST when available	Vehicles that are up for exchange that can be replaced with an electric or plug-in hybrid vehicle have been identified and will be replaced as these types of vehicles become available through GSA.	Low
Clean & Renewable Energy			
Increase consumption of clean and renewable electric energy.	73% allotment of renewable power generated by the 3.3 megawatt (MW) solar plant and with the purchase of 19,365 MWh of renewable electric energy and 290 MWh of renewable energy credits (RECs) through Western Area Power Administration (WAPA).	Currently working with WAPA to procure off-site solar energy that could potentially contribute ~13% increase in CFE starting in FY 2025.	Medium

Prior DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Non-Attainment
Increase consumption of clean and renewable non-electric thermal energy.	Non-electric thermal usage was 424 million cubic feet of natural gas in FY 2022 compared to 404 MCF in FY 2021.	Continue to track non-electric thermal usage. Completed a GHG Action Plan that identified inefficient boilers for replacement and metering.	High
Sustainable Buildings			
Increase the number of owned buildings that are compliant with the Guiding Principles for Sustainable Buildings.	Construction was completed for one building in FY 2022 - the Emergency Operations Center is LEED Gold.	Eight facilities are currently under construction or in the design phase that will meet the Guiding Principles.	Low
Acquisition & Procurement			
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all sustainability clauses are included as appropriate.	100% of applicable contracts contain a clause requiring environmentally preferable products and services including biobased products but tracking needs to be improved.	Look for opportunities to improve tracking of environmentally preferable products purchases and implement where feasible.	Medium
Efficiency & Conservation Measure Investments			
Implement life-cycle cost effective efficiency and conservation measures with appropriated funds and/or performance contracts.	CHAMP projects; study completed to identify inefficient boilers for replacement and metering.	Additional CHAMP projects; funding requested for facility audits.	Medium
Electronics Stewardship & Data Centers			
Electronics stewardship from acquisition, operations, to end of life.	LLNL has a process to evaluate excess electronics for either reuse or recycling.	Continue with program. Some challenges exist as recycling options continue to decrease and markets fluctuate (cost to recycle continues to increase).	Low

Prior DOE Goal	Current FY Efforts	Planned Efforts	Overall Risk of Non-Attainment
Increase energy and water efficiency in high-performance computing and data centers.	Continue efforts in evaluating options to further optimize, consolidate or close remaining unclassified data centers. Moved core services to cloud provider.	A pilot study on future technology for cooling is underway (emersion in oil rather than water-based cooling).	Medium
Adaptation & Resilience			
Implement climate adaptation and resilience measures.	Six adaptation and resilience solutions were identified in the VARP.	Proposed implementation of 4 of the 6 resilience solutions in FY 2023 (dependent on funding).	Medium
Multiple Categories			
Reduce Scope 1 & 2 greenhouse gas emissions.	Action plan for refrigerant management, SF6 management, and natural gas combustion reduction completed. Infrastructure investment needs noted, but no new infrastructure procured.	ERICA funding requested for SF6 switch replacement. Funding is allocated for priority boiler replacements and metering.	Medium
Reduce Scope 3 greenhouse gas emissions.	Increase in employees on-site may lead to increase in scope 3 emissions. Pending data.	Scope 3 emissions are likely to increase slightly due to more travel and employee commuting.	Medium

Energy Management

Current Performance

The daily electrical and natural gas demand at the Livermore Site and Site 300 is significant. LLNL uses 60 or more megawatts of electricity during peak times and 12,005 therms of natural gas each day. The average energy use intensity is 131 kBtu/ft², without the excluded areas (i.e., data centers and energy intense mission critical facilities). Figure 1 shows energy-use intensity over time compared to a 30% reduction from the 2003 baseline plus 1% each year (e.g., the target for the end of FY 2022 was a 35% reduction) The energy intensity reduction observed at the end of FY 2022 was 29.4%, about 6% off the target reduction.

For FY 2022, the total site electricity use was 358,012 MWh while for FY 2021, the electricity use was 355,925 MWh or a very slight increase of 0.0059% (Figure 2). Natural gas use was also slightly more at 423,927 MCF compared to 404,203 MCF the year before, even as the heating degree days were about the same.

Figure 2 also includes electricity use compared to 2019 (426,320 MWh) and 2020 (387,012 MWh) showing a continued downward trend since the COVID-19 pandemic. This may indicate an impact from the shift to some level of telecommuting for 37% of the Lab population, however further analysis of the data is needed and will be conducted in FY 2023.

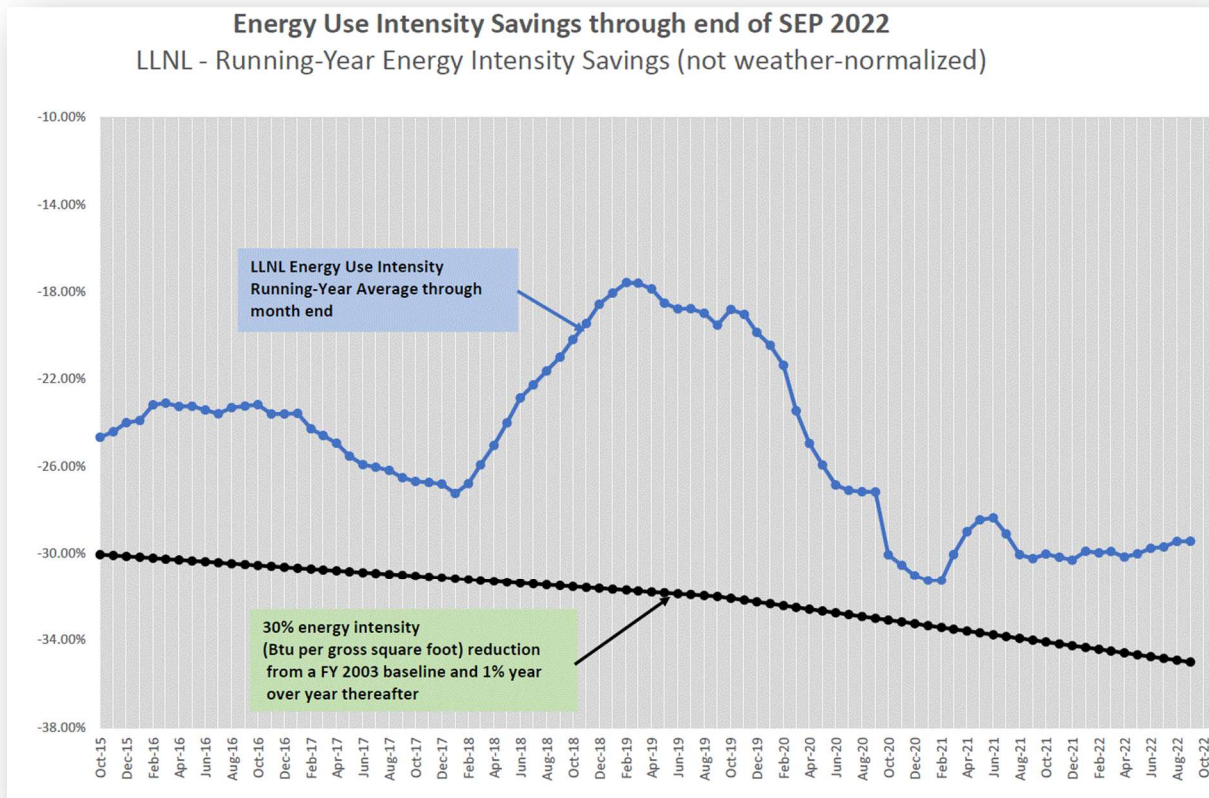


Figure 1. Energy-use intensity savings through end of FY 2022.

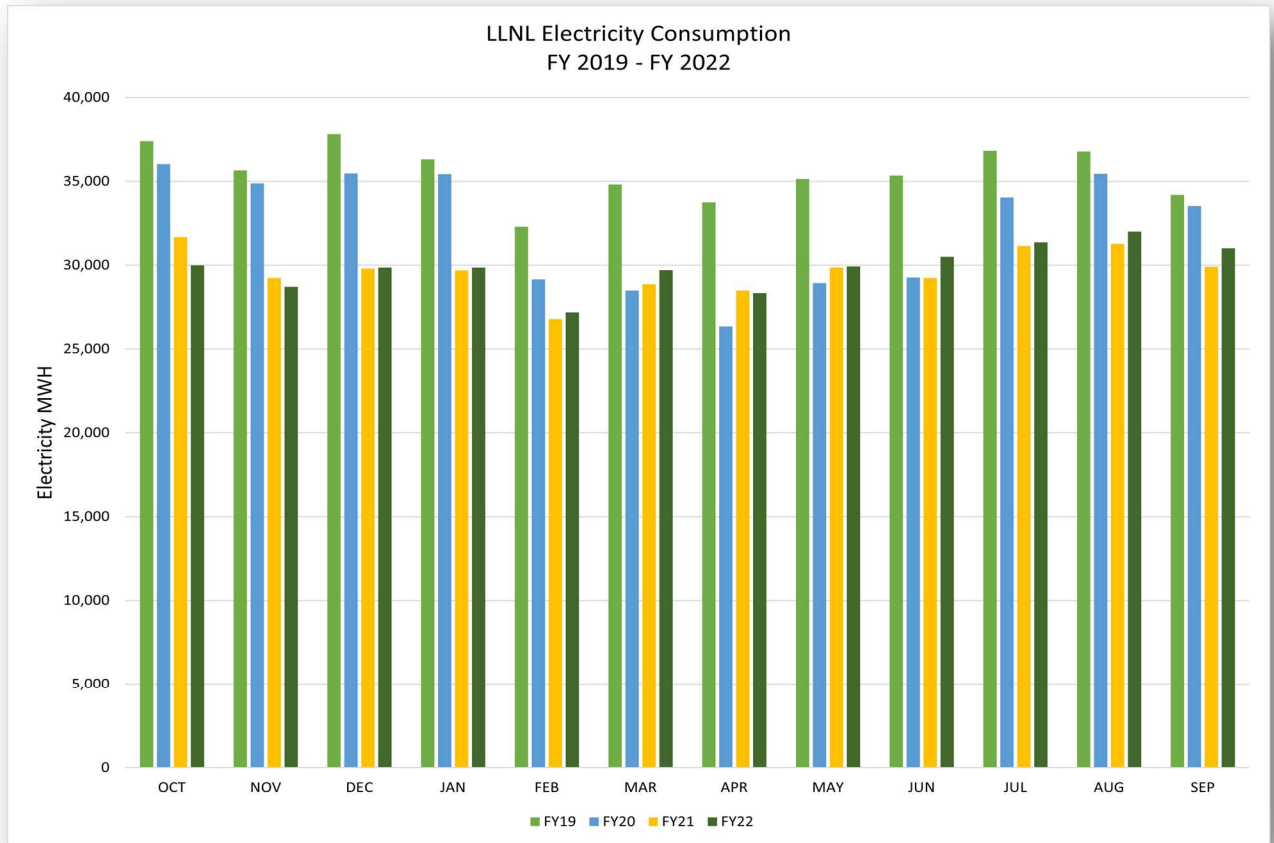


Figure 2. Total site electricity comparison.

Metering

LLNS implemented an advanced electricity metering program in 2012 that included buildings accounting for 90% of the Lab’s consumption of electricity. However, since that time many of the meters have lost communication with the software or have failed entirely. Without continued maintenance and upgrade, LLNL’s electrical metering infrastructure cannot be relied on to produce accurate and timely data. In FY 2022, an evaluation of electrical meter status was conducted to develop a prioritized list of meters needing repair or replacement. Funding was allocated in FY 2023 to begin to restore this capability. The list of nonfunctioning meters was aligned with planned building demolitions over the next twelve years to avoid replacing meters in facilities that will be demolished between 2023 and 2027.

Energy Management and Efficiency Projects

LLNL’s Livermore Site and Site 300 each have a site-wide direct digital control (DDC) system that is used to control temperatures, pressures, and humidity in many buildings. The system is state-of-the-art and uses approximately 1200 (increased from 941 last year) high-speed, connected digital processors in 63 buildings with several more installations planned. The system allows subcontractors and trained on-site AC mechanics to program complex algorithms that optimize the use of electricity and natural gas in many of the HVAC systems without negatively affecting occupant comfort, and in many cases improving it through tighter control of temperature in offices and labs. Each system uses constant monitoring and remote alarming to alert building and maintenance staff of malfunctions so that they can be repaired in time to reduce programmatic impact as well as minimize discomfort and overall energy usage. As always, available advanced energy-saving control algorithms are implemented depending on the hardware installed and programmatic needs.

In the last year, digital HVAC controls have been added to or expanded in several buildings as detailed in Table 2.

Table 2. Digital HVAC detailed additions.

Building	Digital HVAC Controls Replaced, Expanded, or Added
B031	The Emergency Operation Center is a LEED certified building.
B141	Replaced malfunctioning VAV boxes with new.
B154	Replaced the malfunctioning controls on ACU01.
B170	Complete replacement of the obsolete and malfunctioning control system. Replaced the chiller with a more efficient unit.
B321E	Installed new chilled water plant including new DDC system and replaced chilled water pumps.

LLNS has made progress in increasing HVAC funding for preventive and corrective maintenance for HVAC systems, as well as increasing staff and focusing attention on distributed elements of the HVAC system. As air conditioning and heating units get replaced, the replacements being chosen are of a higher efficiency model. For example, at B321E the entire chilled water plant, including new DDC system and chilled water pumps, was replaced. With the new variable speed pumping design and efficient control strategies, the estimated savings are on the order of 30% to 40%. Other buildings with notable HVAC equipment replacements are B298, B431, B682, and B873. Several central heating and cooling plant replacement projects currently in design will feature new high efficiency boilers and chillers that will reduce energy consumption by at least 30% compared to the old equipment. All HVAC unit replacements at LLNL will help achieve the 30% energy reduction from the FY 2003 baseline. As standard practice, LLNS uses *California Building Standards Code* (Title 24), part 6, California Energy Code to guide in the design and replacement of new HVAC equipment. Participation of a minimum LEED certification and/or Guiding Principles for Sustainable Buildings (GPs) also supports the energy efficiency and sustainability effort.

Internal desk audits were performed on 18 buildings, including 328C, 481, 365, 162, 435, 571, 115, 313, 551E, 492, 364, 671, 439, 411, 431, 583, 1677, 154. *Energy Independence and Security Act of 2007* (EISA) section 432 requires agencies to perform comprehensive energy and water evaluations for approximately 25% of covered facilities each year so that all covered facilities are evaluated on a 4-year cycle. The facilities audited in FY 2022 made up the second 25% for the 2021-2024 round of audits. Due to a lack of resources allocated to the Sustainability Program, only desktop audits have been performed. With resources facility audits could be performed to identify specific energy and water conservation projects.

Plans and Projected Performance

Table 3 lists specific projects that will assist LLNS in making progress towards energy-intensity reduction goals. A focused effort will be placed on installing variable frequency drives (VFDs) on compressors and other equipment. Several projects will be implemented under the Cooling and Heating Asset Management Program (CHAMP), the metering program will be revitalized, prioritized boilers will be replaced and metered, and progress will continue to be made on installing and replacing existing site-wide lighting with LEDs.

Figure 3 shows the predicted electricity load forecast once Exascale comes online in FY 2023. The ECFM was completed this year and will have a significant impact on the future energy use at the Livermore Site.

Table 3. Proposed projects in support of energy management.

Project	Project Cost (\$M)	Annual Savings (\$M)	Simple Payback (Yrs.)	FY23 (\$M)	FY24 (\$M)	FY25 (\$M)	FY26 (\$M)
Building Automation Systems/EMCS	5	0.9	5.6	2	2	0.5	0.5
Electric Motors and Drives, Variable Speed Motors and Drives	2	0.54	3.7	0.5	0.5	0.5	0.5
Site-wide Lighting Improvements, Exterior	2	0.4	5	1	0.5	0.25	0.25
Site-wide Lighting Improvements, Interior	5	3.8	1.3	1.5	1	0.5	0.5
CHAMP Projects (DDC controls and HVAC replacements)	TBD						
Repair/replace/add electrical and gas meters	5	0.5	10	1.5	1.5	1	1

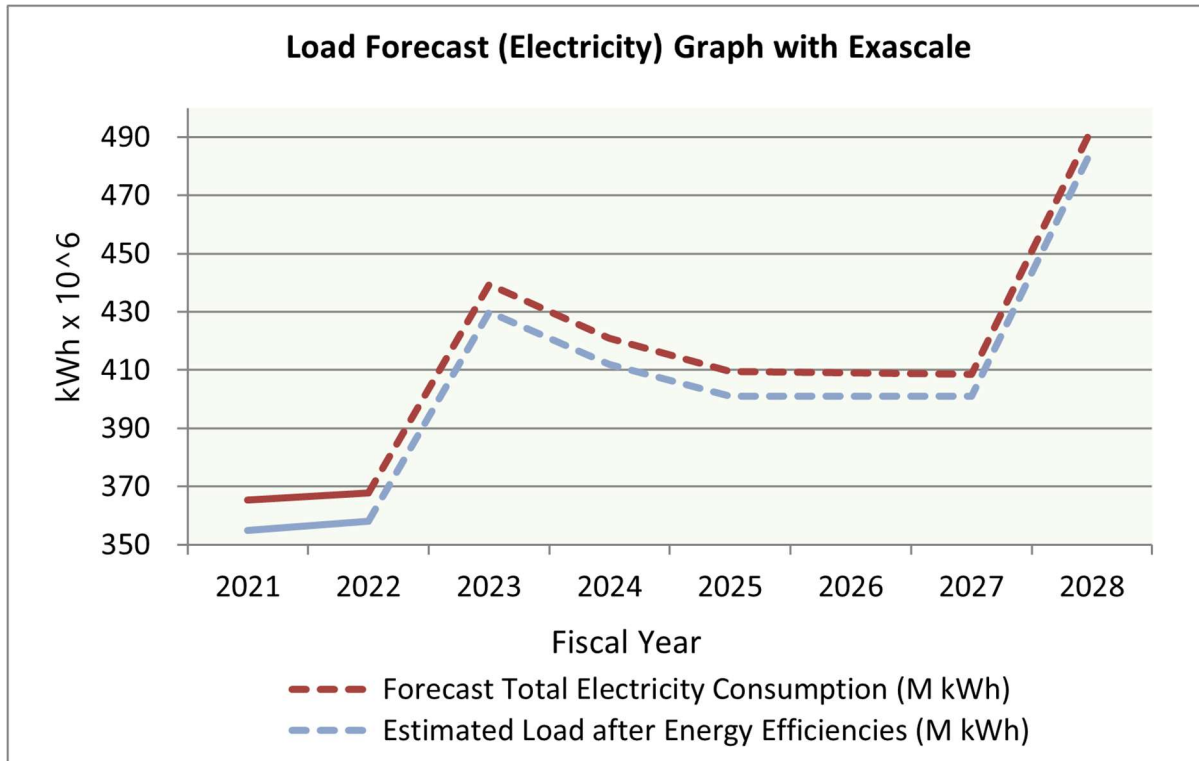


Figure 3. Load Forecast (Electricity) with Exascale

In addition, LLNL is currently in the early stage of a major recapitalization effort that will replace roughly half of the active square footage over the next 15 years. It is safe to assume that office and lab space will be more energy efficient if building specifications, bid packages, and planned funding support the current design standards. As covered in the Sustainable Buildings section, new facilities will adhere to the GPs and/or LEED. However, the total active square footage will increase overall requiring a continued focused on energy management and implementation of conservation measures.

Carbon Free Electricity (CFE) Plans

Based on current electricity purchases through WAPA and including the 3.3 MW on-site solar field, the baseline CFE for LLNL is estimated at nearly 57%. While LLNS does not currently have plans for on-site renewable energy projects, there is a focus on securing renewable energy from additional off-site sources. Procurement of off-site solar energy is being worked with WAPA for the DOE/NNSA California sites (LLNL, LBNL, SNL/CA, and SLAC) that has the potential to contribute an approximate 13% increase in CFE starting in FY 2025. Once this project is complete, LLNS will likely begin work on a second procurement of off-site CFE.

In FY 2023, LLNL will incorporate into the Lab’s master plan out year projects that will contribute to the relative increase or decrease of net electricity use and supply of CFE.

Net-Zero and Low Carbon Future Plans

During the development of LLNL's VARP, LLNL came to profoundly understand the risks of unheard-of extreme heat events, extreme rain, prolonged drought, and extreme wildfires (and accompanying smoke) on the Lab's operations and missions. LLNL intends to take ambitious action to maintain and improve operations while preparing for and seeking to mitigate the effects of increasingly extreme weather events and a changing climate.

The VARP document is one half of LLNL's budding climate strategy, that identified climate change hazards and assessed exposures and vulnerabilities to extreme events. Companion plans are under development, that intend to address holistically the innovative and progressive actions needed for LLNL to achieve a low-carbon future while maintaining a high degree of resiliency. Opportunities to implement projects that will support net-zero emissions continue to be identified and catalogued while strategic goals are developed. At the same time, LLNL will review net-zero plans developed by the four national labs participating in the Net Labs Pilot Initiative. Ultimately, LLNL is working to draft the Lab's first comprehensive net zero plan in 2023.

Water Management

Current Performance

In FY 2022, LLNL's contribution to the DOE potable water intensity savings goal was -7.05% (Figure 4) relative to the FY 2007 baseline. LLNL's drop in potable water intensity savings from the previous year was -4.4%. As shown in Figure 4, LLNL's water use significantly increased in July 2016 when a switch was made to Zone 7 ground water because Hetch Hetchy was unavailable due to disinfection concerns. Zone 7 ground water contains greater concentration of minerals thus reducing cooling tower efficiency and requiring more water than Hetch Hetchy surface water. In August 2020 the Lab was able to switch back to the Hetch Hetchy water supply upon completion of a disinfectant booster plant. This switchover has enabled the Lab to regain water savings. It is important to note, however, that the Hetch Hetchy water supply is unavailable each year during maintenance periods which are currently 64 days per year (i.e., Jan-Mar 2022) but will increase to 102 days in future years.

The water consumption and cost data report are entered into the dashboard.

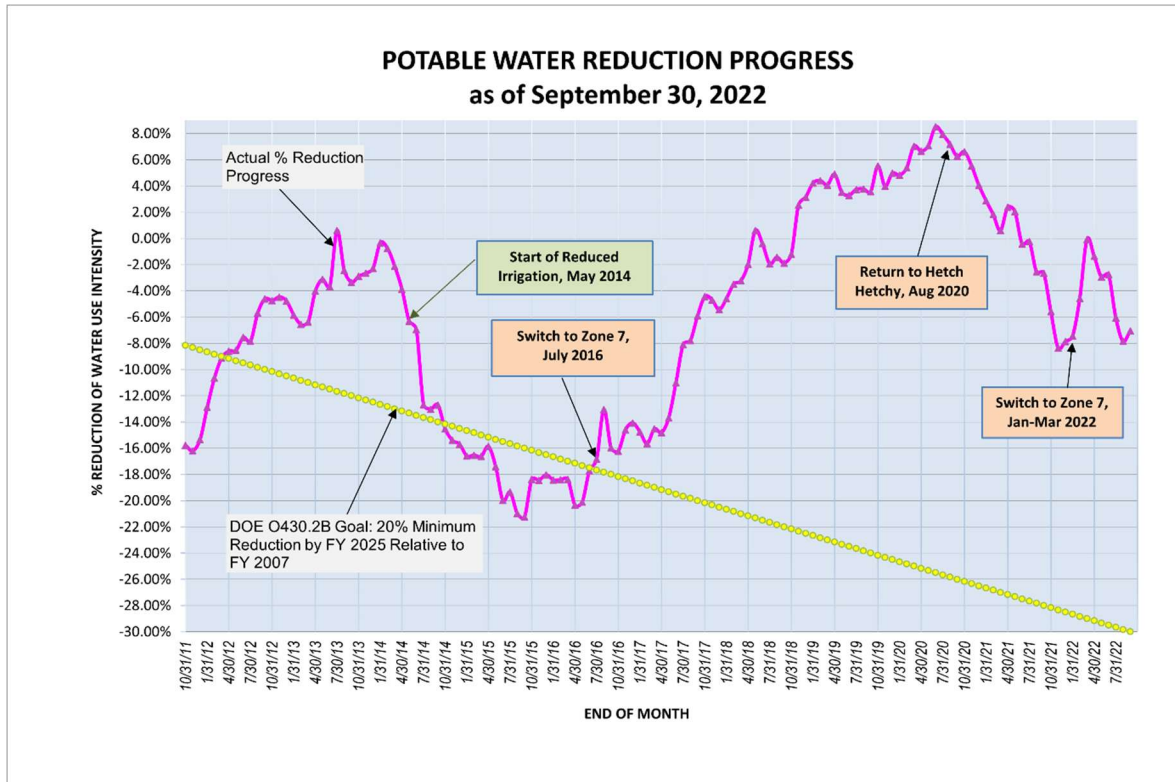


Figure 4. Potable water use intensity savings through end of FY 2022.

The sources of LLNL water impact efficiencies in the largest user of water at the Livermore Site: cooling for high performance computing. With demand for high performance computing growing while climate change projections include increase in extreme heat days, water reuse and employing next generation cooling technologies will be required to meet LLNL’s water reduction goals.

A breakdown of LLNL potable water consumption is illustrated in Figure 5. The cooling tower make-up component is the highest user at 42.4%, with irrigation use at 21.09% and facility process use at 21.47%. Potable water use at LLNL’s cooling towers was 7.75% less than FY 2021 due to remaining on the primary water supplier (Hetch Hetchy).

Most of California, including the Livermore area remains in a severe drought. Extreme heat days combined with declines in precipitation have resulted in less annual snowpack in California’s high elevations, which in turn is straining reservoir levels in the state. LLNL’s water suppliers have requested about a 15% water use reduction and the State Water Resources Control Board established a statewide ban on watering of non-functional turf in the commercial, industrial, and institutional sectors in June 2022.

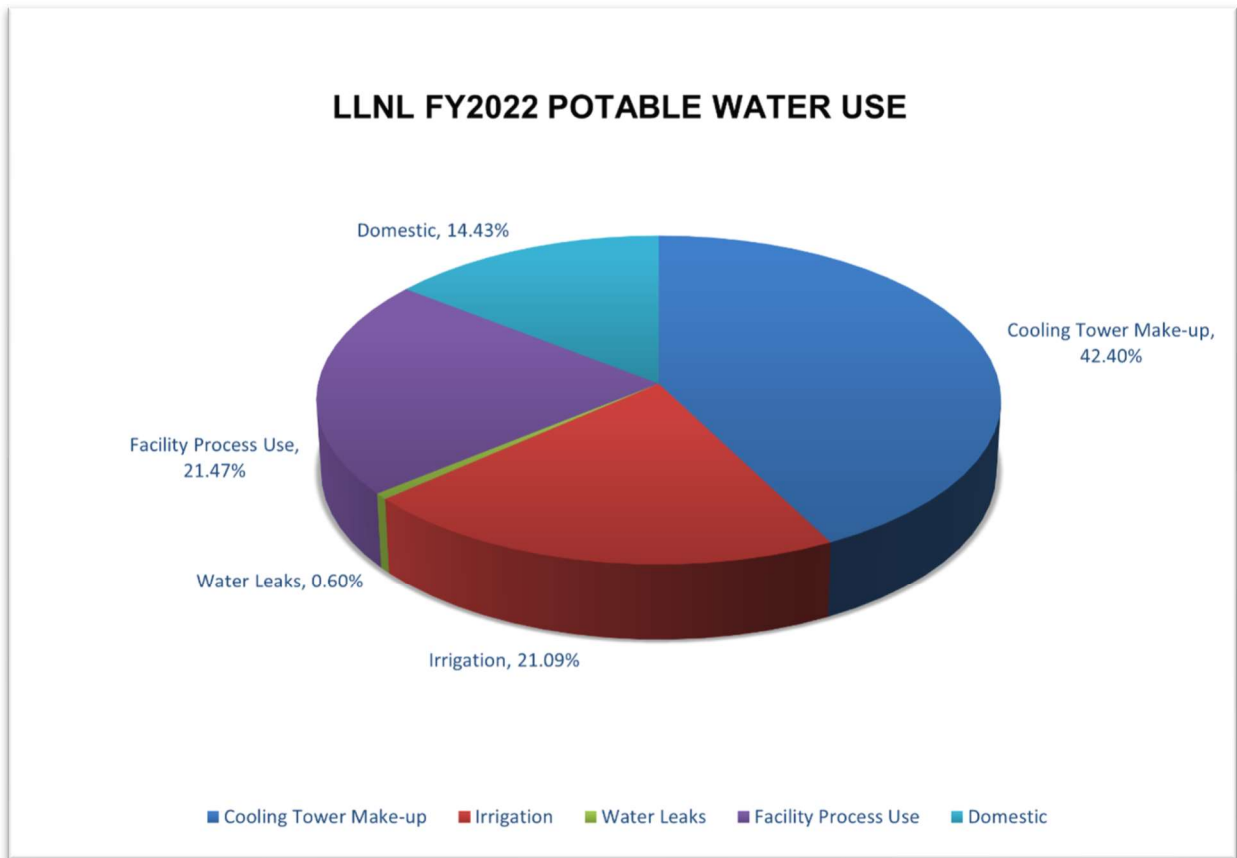


Figure 5. LLNL FY 2022 potable water use breakdown.

Plans and Projected Performance

Currently cooling tower make-up is the Lab’s largest consumer of potable water at 42% of the Lab’s total water consumption (See Figure 5). With growing demand for high performance computing, LLNL may need to take on a grand challenge of next generation cooling technologies to close the gap on LLNL’s water reduction goals. A planned infrastructure project for FY 2024 includes the U291 cooling tower refurbishment. A hybrid version of the traditional cooling tower is being investigated. This hybrid, although more costly than the traditional tower would save 30-50% of the make-up water. With the rising cost of potable water the payback is estimated to be less than 1-2 years.

Use of recycled water (also known as purple pipe) is a strong non-technical option for reducing potable water for cooling tower make-up. LLNS plans to continue to investigate options including building an on-site wastewater treatment facility and extending the existing purple pipe from the City of Livermore Wastewater Reclamation Plant (LWRP).

LLNL has reduced lawn irrigation and initiated a planning exercise, in response to The State of California ban on using potable water for non-functional turf at commercial, industrial, and institutional properties. The planning exercise, scheduled for completion in 2023, will result in designs and plans for transforming the entire Livermore Site campus to drought tolerant and sustainable landscaping. Transitions to the sustainable landscapes would proceed in future years according to the plan and would be tracked for influence on LLNL’s consumption of potable water for irrigation.

Significant growth is planned at Site 300 over the next few years including construction of two office buildings that will accommodate approximately 200 employees each. This increase in employees at the site will stress the existing water and wastewater systems. In response, permitting of a new Site 300 ground water supply well is currently underway as well as a utilities capacity study. Estimated water use over the next years is depicted in Table 4, including the new ECFM cooling tower at B453. Refinement of the current water balance and development of a water management plan will be completed in FY 2023.

Table 4. Estimated water use.

Fiscal Year	2022	2023	2024	2025	2026	2027	2028
Total water consumption (Mgal)	261	287	263	264	266	267	320
B453-COMP (Cooling Tower)	40	100	60	70	80	80	200
B581-NIF (Cooling Tower)	17	17	18	18	20	20	22
Water efficiencies (Mgal)	247	267	249	252	254	257	310

Waste Management

Current Performance

LLNS has a mature recycling program that continues to divert over 70% of waste from landfill. Separate recycling streams are established for scrap metal, cardboard, landscaping waste, wood, paper, organics, commingled items, sawdust/woodchips, cooking grease, and toner cartridges.

In FY 2022, LLNS continued to expand the LivGreen waste reduction program by adding three bin (recycling, organics, and landfill) waste stations in 11 new facilities. Educational roadshows were held at each of these facilities to inform employees of the new program, answer questions, and receive feedback. An informational booth highlighting the program was also part of the Lab’s 70th anniversary employee engagement day attended by over 5,000 employees.

Due to an increase in construction and demolition (C&D) activities at both sites, a strong focus was placed on improving tracking of C&D waste and strengthening the existing process. A requirement is included in the LLNS subcontractor construction specifications requiring subcontractors to submit a solid waste management plan (SWMP) prior to project implementation. Subcontractors must identify the materials to be collected, estimated quantities, and disposition (e.g., recycling or disposal facility) of the materials. The subcontractor is required to submit the final SWMP with actual quantities and associated weight tickets. Although these measures were in place, it was discovered that SWMP's were not always being submitted. To alleviate this problem, the plan is now required under the Lab's work planning and control process and is reviewed by the construction program environmental analysts. In addition, subcontractors and construction managers were educated on the proper procedure for reporting waste disposal and recycling. The topic was presented in the Construction Management division Safety Newsletter and at a quarterly construction safety meeting. LLNS has already seen an improvement in C&D waste tracking since these improvements were put in place.

Several successful pollution prevention efforts were completed in FY 2022. Legacy refrigerant was inventoried and a scope of work for the sale of this refrigerant was sent to vendors at the end of FY 2022. LLNL anticipates this unwanted refrigerant will be sold and moved off site during quarter 1 of FY 2023. A process to avoid accumulation of unneeded refrigerant in the future will also be established. Second, the Engineering Division installed a vapor phase cleaning system that will dramatically reduce the use of high purity alcohol in circuit board cleaning. Finally, LLNS continued to participate in the state PaintCare program recycling 780 gallons of latex paint.

LLNS continually looks for new opportunities to reuse or recycle. The Donation, Utilization, and Sales (DUS) group maintains an outlet—the Second Time Around Store (STARS)—where new and used items are made available to employees free of charge for use on site. Over 9,400 items with an estimated value of \$753,600 were reused through the STARS during FY 2022.

Plans and Projected Performance

Additional facilities will be added to the LivGreen waste reduction program in FY 2023. Over a dozen buildings are scheduled for demolition in FY 2023 and the improvements made in FY 2022 will support accurate tracking of C&D waste going forward. An emphasis on refining the tracking and reporting procedure for C&D waste and identifying pollution prevention projects will continue in FY 2023. With the intent to assure more efficient tracking and life cycle management, LLNL will revitalize the Non-Hazardous Waste Subject Matter Expert role in 2023, into a consolidated central service function.

Fleet Management

Current Performance

Fleet management at LLNL falls under the Business Directorate as the Fleet Management Operations group and is managed by a fleet manager and supported by one lead fleet technical coordinator and two supporting fleet technical coordinators. One of the supporting coordinators is assigned to support S300 and the other two coordinators support S200. The primary responsibility of the Fleet Management Operations group is to keep each vehicle in compliance with applicable General Services Administration (GSA)/NNSA/DOE policies and procedures and to support each organization with their vehicle needs. Each organization at LLNL has an assigned associate directorate vehicle representative (ADVR) that is responsible for ensuring directorate compliance with fleet management policy, including the care and protection of the vehicle.

LLNL has seen an increase in funding and employees and continues to add an unprecedented amount of large-scale construction projects to expand the campus footprint. To support the Lab's mission, fleet numbers were increased over the past several years. However, a substantial number of underutilized vehicles still exist primarily due to the increase in employees working from home/having flexible on-site work schedules. The LLNL Fleet Management Operations group will continue to work with the programs to determine optimal fleet size and encourage reassignment of vehicles prior to adding to the overall fleet numbers.

LLNS fleet management is supported by three cornerstone applications. Commercial applications are used for maintenance/servicing and fuel management and a custom application is used for utilization inventory. Additional small custom applications are also employed to support integrations and workflow. A project is underway to consolidate existing applications into one custom application. Additionally, LLNS uses GSA's FedFMS and FAST applications for reporting.

LLNS is focused on transitioning light duty fleet vehicles to electric vehicles (EVs) to meet the E.O. 14057 goal of 100% zero-emission vehicle acquisitions by 2035, including 100% light-duty acquisitions by 2027. To provide charging infrastructure for government EVs LLNS hired two architecture/engineering firms to fully evaluate the Livermore Site and Site 300 for installation of charging stations for all GSA vehicles on site by 2027 and to provide class 3 estimates for the installations. The infrastructure study identified the electrical capacity for over 1200 level 2 charging ports at about 50 different parking lot locations at the Livermore Site. A prioritized list of locations to be installed over the next 5 years was presented in the 5-Year Infrastructure Plan submitted to NNSA in September 2022 and is summarized in Table 5.

LLNS installed 10 new level 2 charging ports in FY 2022, including 7 at the Livermore Site and 3 at Site 300, adding to the existing 85 charging ports that are a mix of level 1, level 2, and solar charging stations. The new stations were purchased from ChargePoint along with a one-year cloud service contract. This allows LLNS access to the ChargePoint dashboard, which provides real time power usage, station usage and status, energy use per station and overall, average session length, as well as an estimate of greenhouse gas emissions avoided.

EVs were requested during the last ordering cycle; however, due to supply issues, all contracts for plug-in hybrid electric vehicles (PHEVs) and EVs between GSA and the manufacturers were cancelled.

Plans and Projected Performance

In FY 2023 LLNS will evaluate leveraging a GSA telematics solution. Potential benefits include utilization reporting and real-time location reporting for dispatching. Additional benefits could include maintenance alerts that would improve fuel consumption.

LLNS is in the reviewing and planning phase of understanding the impact of three proposed California Air Resources Board (CARB) regulations; Advanced Clean Fleets Regulation, Off-Road Diesel Vehicle Regulation, and Zero-Emission Forklifts Regulation. The next steps are to determine stakeholders and prepare them for the adoption and roll-out of these regulations and define and implement an institutional plan to ensure compliance with these regulations.

LLNL Fleet Operations Group is partnering with each organization’s ADVR to identify which vehicles, either up-for-exchange or additional vehicles, can be replaced with PHEVS or EVs. PHEVs or EVs will be considered first, but replacement or the addition of these types of vehicles is based on availability.

LLNS has requested ERICA funding to begin installing the electric vehicle charging stations identified in the 5-Year Electric Vehicle Charging Infrastructure. The 5-year plan and upper bound anticipated costs to add electric vehicle charging stations is summarized in Table 5.

Table 5. Electric vehicle charging station plan.

Year	Total EVCS	Estimated Cost
2023	244	\$10M
2024	291	\$11M
2025	220	\$12M
2026	297	\$11M
2027	240	\$11M

In response to a significant demand for employee electric vehicle charging, a working group was created to determine the best way to address this demand. The working group released a survey to all LLNL employees to better understand the need and interest in personal electric vehicle (PEV) charging on site. The results can be used in long-term planning activities around EV charging station locations, costs, and infrastructure. LLNS plans to roll out a pilot charging program in quarter 2 of FY 2023 to allow all employees to charge at most level 2 charging stations currently installed on site and any new stations installed in the future.

LLNS has not yet evaluated bi-directional charging but will look at this as more electric vehicles are acquired.

Clean and Renewable Energy

Current Performance

LLNL is a member of the Northern California Sites Electric Power Consortium (the Consortium). The Consortium includes LLNL, Lawrence Berkeley National Laboratory (LBNL), and Stanford Linear Accelerator Center (SLAC). The Consortium currently uses two sources of power to meet its annual energy requirements: the Central Valley Project (CVP) base resource allocation of hydropower, and wholesale market power purchases. WAPA is the Consortium's procurement agent and makes any required wholesale purchases on the Consortium's behalf.

The wholesale power rates are considerably less expensive when compared to local public utilities, such as Pacific Gas and Electric (PG&E). These low rates have also made renewable energy development incur a longer ROI relative to projects with standard utility rates. The 7.5% renewable energy consumption requirement was exceeded at 10% through the purchase of RECs and renewable electric energy in FY 2022. LLNS purchased 290 MWh of RECs, 19,365 MWh of renewable electric energy from incremental hydropower, plus 4,534 MWh of renewable electric energy from the on-site solar plant. The on-site solar plant is located at the northwest buffer zone and started commercial operations in February 2016. This renewable energy plant generated a total of 6,279 MWh in FY 2022.

LLNS has deployed solar energy at a smaller scale—including several pathway and parking lot lights, electric car chargers, and environmental sensors.

Details of the REC purchases can be found in the dashboard under Renewables.

Plans and Projected Performance

As mentioned in the Energy Management section, LLNL is pursuing a 50 MW off-site solar project in collaboration with WAPA. Off-site procurement through WAPA is the most promising, cost-effective path forward to make major strides in support of the CFE goals in California.

Sustainable Buildings

Current Performance

One new facility, the Emergency Operations Center, was completed in FY 2022 and met LEED Gold certification. This provides an additional 20,550 square feet to the assessed and/or certified total.

A new office building design standard, Standardized Acquisition and Recapitalization (STAR) was developed by NNSA to reduce the complexities typically associated with building on a DOE site and to streamline the design and construction of a STAR office building. The STAR design standard incorporates the 2020 Guiding Principles for Sustainable Federal Buildings. LLNL's sustainability team provided input on the STAR design criteria requesting inclusion of life-cycle cost effective methods to utilize alternative water sources (e.g., installing purple pipe for future use of reclaimed water), however NNSA denied the inclusion.

Plans and Projected Performance

To achieve mission deliverables, LLNL needs new office space that can meet current and future capacity demands. As mentioned above, conceptual design has been drafted for a new general office building that can be efficiently adapted for subsequent office buildings as part of the STAR initiative. Through the STAR program, LLNS plans to design and build four to six new general office buildings over the next five years. To ensure sustainable design is incorporated, the STAR projects will abide by the Guiding Principles for Sustainable Buildings (GPs).

These projects and others planned for adherence to the GPs and/or LEED certification in FY 2023 and FY 2024 are summarized in Table 6. B183 is a design-build office building that will go into the STAR program. These projects provide an additional 141,924 square feet to the assessed and/or certified total.

Table 6. Summary of new construction FY 2023-2024.

Building	Rating	Square Feet	Status (anticipated completion date)
B321G	Guiding Principles/LEED Silver	11,257	2023
B310	Guiding Principles/LEED Silver	12,122	2023
B265	Guiding Principles	21,309	2023*
B449	Guiding Principles	21,309	2023*
B183	Guiding Principles	21,309	2023*
B654 addition	Guiding Principles	12,000	2023
B144	Guiding Principles	21,309	2024*
B266	Guiding Principles	21,309	2024*

*STAR projects

Acquisition & Procurement

Current Performance

LLNS has a Sustainable Acquisition Program that ensures environmentally preferable products and services, recycled-content products, and bio-based products are purchased to the maximum extent practicable and are consistent with federal law and related procurement requirements. Sustainable acquisition clauses requiring subcontractors to use environmentally preferable products/services and recovered, or recycled content have been incorporated into all LLNS' General Provisions for purchase orders and subcontracts. As a result, LLNS is 100% compliant with the requirement to include sustainable acquisition clauses in eligible contract actions.

LLNS continues to implement Procurement Standard Practice 23.5, *Environmental Affirmative Procurement and Waste Reduction Requirements*. This standard practice describes the requirements for acquiring environmentally preferable products and services, products with recycled content, and bio-based products, to promote cost-effective waste reduction in Laboratory subcontracts. It is reviewed periodically by the environmental functional area (EFA) to ensure all regulatory revisions, updates, and changes have been incorporated. The standard practice was last updated on June 30, 2020.

LLNS utilizes the Laboratory Integrated Network for Contracts and Supply (LINCS) System to manage purchases, requisitions, subcontracts, suppliers, and receiving. The LINCS system allows for tracking of the total number of transactions for the year including all new subcontract awards, any modifications issued to existing subcontracts/purchase orders, and number of releases issued under blanket agreements. Through LINCS the applicable, eligible contracts under DEAR 970.5223-7 that contain sustainable acquisition clauses was determined, this information is provided in the dashboard.

LLNS also receives reports from key blanket agreement vendors that provide data on the numbers and dollars spent on recycled content items, biobased products, EPEAT, etc. Through LINCS purchasers can note if a product meets specified environmentally preferred attributes (e.g., recycled content, biobased, etc.).

Sustainable Acquisition Highlights

- EPEAT: 97% of all computers, monitors, imaging equipment, televisions, mobile phones, and servers purchased during FY 2022 successfully met the EPEAT bronze, silver, or gold criteria.
- LLNS continues to utilize sustainable integrated contractor purchasing team (ICPT) agreements. In FY202 LLNS used ICPT agreements with the following companies Lyme Computer Systems, CDW Government Inc., Wiley Subscription Services, Inc., Royal Society of Chemistry, and American Chemical Society (ACS). These agreements offer special promotional pricing discounts off GSA pricing.
- Blanket agreements with Holman's, Wildflower, and ImageOne (LLNS' managed print services (MPS) vendor) have requirements to include EPEAT ratings by product on their electronic ordering system and to provide quarterly EPEAT reports.
- LLNS continues to award subcontracts to suppliers who offer DOT-critical carbon steel drums made from 15% recycled content material. During FY 2022, LLNS awarded Skolnik Industries 7 purchase orders that included carbon steel drums. The total dollar amount spent with Skolnik for the carbon steel drums in FY2022 was \$18,481.
- LLNS computer subcontractors maintain an EPEAT-rated description field on their websites.
- The Office City manages a punch-out list that identifies recycled content and biobased items offered to its customers. The catalog allows LLNS' TRRs to see and search for recycled and biobased products. Biobased contract actions in FY 2022 totaled 398, all attributed to compostable cafeteria products.

- The controlled items/services list (CISL) identifies the items and services requiring guidance, notification, or approval from a specific LLNL organization prior to their acquisition by a TRR. It lists the types of approvals that are required to be obtained from an EFA subject matter expert when the purchase of non-EPEAT-rated desktops, notebook workstations, computer monitors, imaging equipment, or televisions is requested on a requisition.

Plans and Projected Performance

LLNS will continue to support the purchase of environmentally preferable products and services, recycled content products, and bio-based products—to the maximum extent practicable—by ensuring the clauses identified in the General Provisions are included in all purchase orders and subcontracts.

LLNS will conduct additional training to remind and instruct TRRs on their role in ensuring sustainable products are purchased by their Program/Directorate. EFA and SCM will investigate adding a mandatory field in LINCS that improves the categorization of sustainable purchases so more comprehensive reports can be generated.

EFA will investigate how sustainable products reporting can be improved by construction subcontractors. EFA will meet with SCM's Construction Group Leader to discuss how construction subcontractors can easily and efficiently report the types and amounts of sustainable products being used under construction subcontracts.

LLNS will also continue to revise Standard Practice (SP) 23.5 as required and have each revision reviewed and updated by an appropriate member of EFA. This review ensures all appropriate regulatory revisions, updates, and changes have been incorporated into the standard practice. When all updates have been added to the SP it is then forwarded to the LLNS' Contracting Officer for review and approval. This process allows LLNS to remain compliant with our prime contract requirements.

Investments: Improvement Measures, Workforce, and Community

Current Performance

Calendar year 2022 was year 9 of an Energy Savings Performance Contract (ESPC) that includes the implementation of two energy conservation measures (ECMs): energy management control systems upgrade (ECM 3.1) and advanced metering system (ECM 3.2). Initially, HVAC controls and WebCTRL software were installed in 24 facilities as part of ECM 3.1 and 79 advanced electric meters and energy management software (EEM Suite) was installed as part of ECM 3.2. Over the years LLNS has added 2-3 facilities per year on average to the original WebCTRL system. The objectives of these ECMs are to improve comfort, building controls, monitor operating conditions, and save energy. The year 9 Monitoring and Verification (M&V) report verified annual energy savings for both ECMs: 20% for ECM 3.1 and 2% for ECM 3.2.

While the Lab strives to be a leader in responsible environmental stewardship and sustainability, not everyone in the Lab community is aware of the various programs and efforts being made that conserve energy, divert waste, conserve water, reduce fuel consumption and reduce pollution. The sustainability team recognized that improvement could be made in communicating these efforts and decided to create an interactive site sustainability map that displays the Lab's building electrical energy data, electric vehicles spaces, LLNL's sustainable buildings, and ways for employees to reuse and recycle. The sustainability map was launched in the summer of FY2022 through the Lab's existing Environmental Management System (EMS) website and provides the Green Hotline contact information for employees to provide feedback and ask questions.

LLNS signed climate Memorandum of Understandings (MOUs) both locally and internationally this year. In April, LLNS partners signed an MOU with the City of Livermore to collaborate on advancing climate action in Livermore and building community-wide resilience to climate change impacts. In August the Lab and the Korea Institute of Science and Technology (KIST) signed an MOU to collaborate on basic science and technology in the renewable energy, climate science, data science and characterizations arenas. The MOU proposed the exchange of researchers to each other's facilities, faculty sabbaticals, and student/postdoc internships.

Plans and Projected Performance

LLNL's low cost of power and water has traditionally been an obstacle to justifying the payback on projects. This hurdle is expected to continue. Small investments upfront can buydown the project and life cycle cost analysis can assist with improving the project's payback; these measures will be applied as appropriate.

Indirect Emissions

Tracking Methodologies

Indirect emissions, or scope 3 emissions, stem from business operations LLNS engages in that are not on site and do not result from LLNL's electrical power. Indirect emissions at LLNL reported in this plan include:

- Emissions from employee air travel
- Emissions from gas-powered employee rental cars
- Emissions from employee-owned gas-powered vehicles used in place of rental cars
- Emissions from gas-powered employee commuting
- Emissions from waste-water treatment operations on site
- Emissions from waste-water treatment operations off site

The calculation methodology for each of these emissions are described below.

Air-Travel

Data on employee air-travel are reported quarterly by CWT to LLNL's Travel and Special Disbursements group leader as excel files logging travel by employee and by airline. Additional data, including miles traveled, are provided in these files. The group leader then provides that data to the emissions SME for calculation. Trip mileage is used to categorize each flight as follows:

- Flights longer than 700 miles are LONG
- Flights longer than 300 miles but less than or equal to 700 miles are MEDIUM
- Flights greater than 0 but less than or equal to 300 miles are SHORT
- Negative mileage is categorized as refunds from the flight provider and used to refund the LONG, MEDIUM, and SHORT flights
- 0-mileage flights are categorized as NONE

Using these categories in an IF statement in Excel, pivot tables of flight length are prepared summarizing total flight mileage by SHORT, MEDIUM, and LONG for entry into the dashboard.

Rental Car Travel

Rental car travel emissions are limited to emissions from gas-powered vehicles. Data on emissions from this category are based on data sent quarterly to the Travel and Special Disbursements group leader as excel files from National/Enterprise and from Hertz. The National/Enterprise data includes total distance driven, gallons or liters of fuel used, and an estimate of GHG emissions of CO₂e. Hertz data includes distance traveled and miles per gallon for the vehicle. The sustainability dashboard data is prepared from the distances traveled, which are a simple sum of the distances provided by the vendor.

Employee-Owned Car Travel – Non-Commuting

Data on employee use of personally-owned vehicles is based on expense reports employees file with LLNS for reimbursement of mileage when they use their vehicles for work-related travel. Data on the total reimbursed miles is sent by the Travel and Special Disbursements group leader as a line item in an email to the emissions SME for entry into the dashboard. The data provided is currently limited to the total miles reimbursed; additional data may be available to allow for analysis and recommendations by the sustainability team for methods of improvement.

Employee-Owned Car Travel – Commuting

Emissions from employee commuting are based on several data sources and potentially outdated bases. LLNS offers flexible work options, including alternate work schedules as 9/80 and 4/10. Additionally, following the COVID-19 pandemic, LLNS has begun to offer more flexible work-from-home (WFH) arrangements for employees. WFH arrangements are made at the payroll supervisor level for 80% telecommuting or less and at the associate director level for higher levels of telecommuting to ensure effective lab mission outcomes. The percentage telecommuting is used in this year's analysis for the first time, lowering emissions somewhat from before COVID-19. Additional factors affecting emissions from worker commutes are the breakdown of transit choice and the distance of travel, along with the average miles-per-gallon (MPG) rating of employee vehicles. The current analysis does not include an estimate of employees using electric vehicles; the assumption is that 100% of vehicles used by employees are gasoline-powered. Breakdown of transit options are based on data from the US Department of Transportation published in 2013. The sustainability dashboard requires data in miles traveled, so the MPG rating of employee vehicles is not considered.

On-Site Wastewater Treatment

Site 300 operations include on-site wastewater treatment via treatment lagoons and septic systems. The basis for emissions from these operations are the number of employees at Site 300 and the daily schedules for those workers. This data is provided by Site 300 management and entered into the dashboard.

Current Performance

Air Travel

To trend LLNL's air travel emissions, data from the sustainability dashboard for the last 10 years were exported and plotted in Figure 6. GHGs from air travel had been on a steady increase until 2019, reflecting LLNL's continued growth in head count. GHGs plummeted during the pandemic, but they have since begun to rebound during FY22.

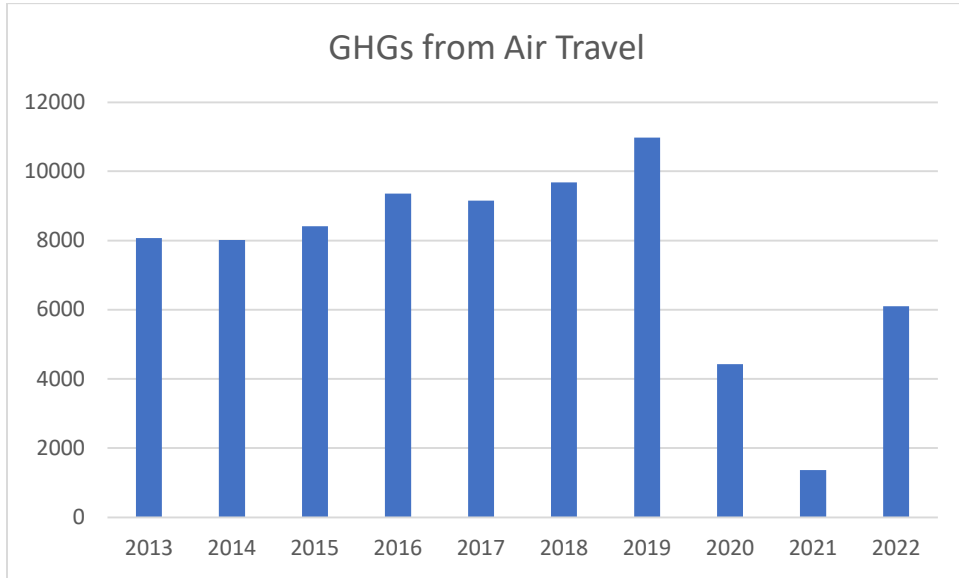


Figure 6. GHG emissions from air travel.

Rental Car Travel

Rental car travel is currently handled by the Lab’s travel agency. GHG emissions from rental car travel are shown in Figure 7. Again, there was a major drop in emissions during 2020; however, there were higher GHGs from rental car travel starting in 2021 and through 2022 similar to historic levels.

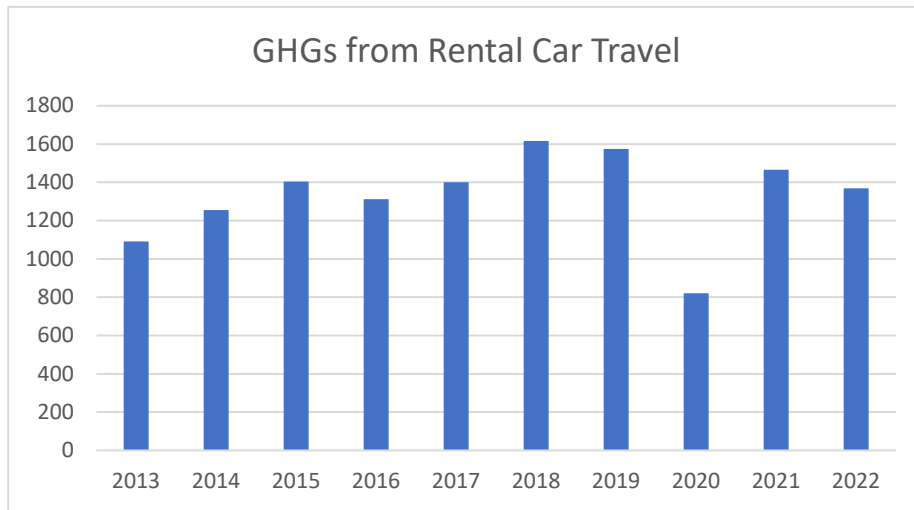


Figure 7. GHG emissions from rental car travel.

Employee-Owned Car Travel – Commuting

Data on employee commutes shows a drop in 2020 due to the pandemic, per Figure 8. Since the pandemic, LLNL’s emissions have largely rebounded to the historic average. Some emissions were avoided by LLNL’s shift towards telecommuting, but LLNL has also continued to grow its head count, offsetting the telecommuting emission reductions.

Following the COVID-19 pandemic, regional transit service from rail to the Lab via bus was discontinued. LLNS worked with the regional transit authority to return this bus line service. However, there is limited data on how LLNS employees reach the Lab.

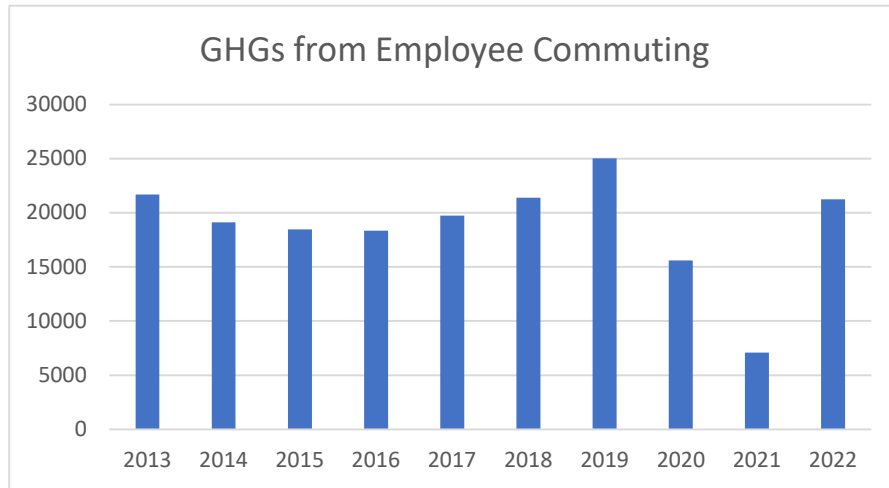


Figure 8. GHG emissions from employee commuting.

On-Site Wastewater Treatment

Wastewater treatment at Site 300 will be a challenge going forward. Head count at Site 300 is slated for increase in the coming years, which will likely stress the existing wastewater treatment infrastructure. Since the Lab’s emissions are head count based, projected emissions will likely increase in kind. Lowering these emissions must also be balanced against the appropriate wastewater treatment options LLNL selects going forward. Figure 9 shows the trend in GHGs from wastewater treatment operations. While onsite presence dropped emissions in 2020 and 2021, emissions are returning as Site 300 returns to normal operations.

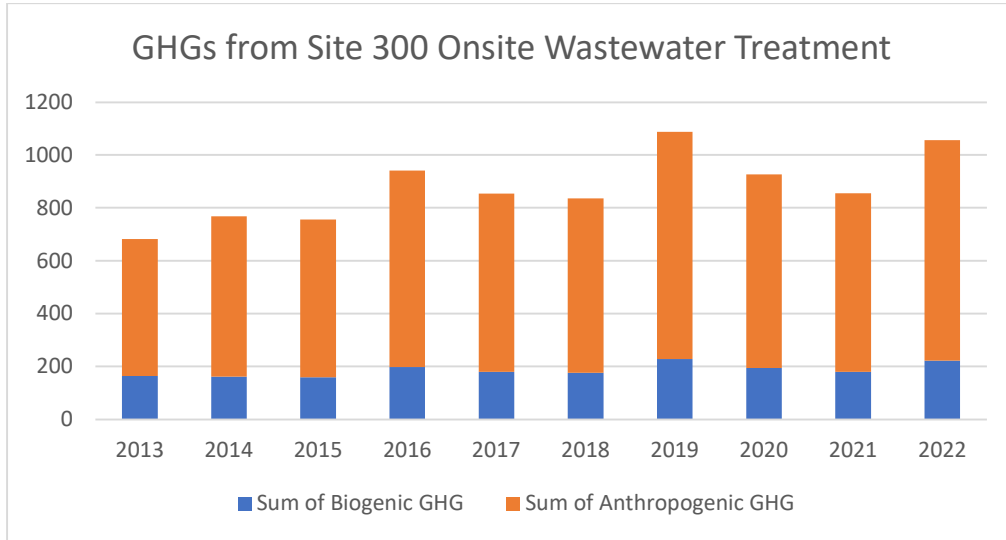


Figure 9. GHGs from site 300 onsite wastewater treatment.

Plans and Projected Performance

Plans presented here are subject to allocation of resources. Some low-cost opportunities are available as new data sources to present scope 3 analysis.

- Data is available for air travel in current reports on airline vendor. Using this data and comparing to airline sustainability plans, if any, together with discussions with planning could allow selection of better airline vendors with more developed plans in place. It should be noted that monitoring this approach could be challenging, as the dashboard only requests miles traveled as an input.
- One approach to reducing emissions from rental car travel would be to discuss options with the travel agency to prefer electric vehicle options where available and to discount miles traveled from these vehicles in the dashboard input.
- Electric options for personally owned vehicles for business travel are more difficult to shift. Instead, continued investment in electric vehicle charging infrastructure to entice more employees to go electric is the preferred approach to lowering personally owned vehicle emissions.
- Surveying and other approaches to data collection are some methods to improving the data basis for how employees get to work.

Fugitives & Refrigerants

Current Performance

LLNL uses refrigerants for on-site HVAC operation and other purposes. SF6 is also used as a dielectric and in certain experimental equipment. Leaks from these units results in emissions of potent GHGs. To estimate these emissions, called "fugitives," LLNS takes the conservative approach of assuming all purchases of refrigerant are emitted in the quarter of purchase. To estimate these emissions, data on procurements from ChemTrack is sent to the emissions SME each quarter. These procurements are summed by refrigerant type and entered into the dashboard.

FY 2022 included an action plan carried out jointly by LLNL's environmental and operations departments to address compliance concerns with new requirements in the state of California. The target GHGs were hydrofluorocarbons and sulfur hexafluoride, gasses that have global warming potentials in the thousands to tens of thousands on a 100-year time horizon. Administrative controls were prepared after consultation with the operations staff to better monitor procurement of these gasses and repair of leaks in the assets using these gasses. Implementation will continue, but it is too early to ascribe any changes in emissions of these materials to these administrative efforts.

Figure 10 shows the trend in GHGs over time. This category is not a function of the pandemic, as refrigeration system leaks and procurement continued regardless of LLNL's on-site presence. Additionally, as more buildings come online, the supporting HVAC systems of those buildings still requires refrigerants with larger global warming potentials. Please note that CARB and EPA regulations will likely lower emissions from this category over time, but SF6 emissions are the bulk of emissions from this category and won't be affected by recent regulatory action.

Two major sources of SF6 emissions at LLNL are Gas-Insulated Equipment (GIE) and the Building 801 flash x-ray (FXR). SF6 emissions from GIE were primarily due to leaks from the U424 substation and other aged equipment that were retired. The U424 substation leaks were repaired as part of a ten-year major maintenance effort and no additional leaks were found since the repairs completed in December 2021. In addition, LLNL's Electric Utility Division (EUD) updated its GIE preventative and maintenance plan with additional mitigation measures in place to minimize leaks from GIE. Significant SF6 emissions also occur at the Building 801 FXR, likely associated with its two compressors. A purge cycle, and associated machine control program, was added to the shutdown cycle to minimize the amount of SF6 released during shutdown. In addition, the compressor valves were modified to isolate the SF6 during equipment down mode. Future considerations include testing a new-design manifold accommodating more devices per manifold resulting in smaller volumes, reduced number of hoses, digital technology to better control flow and fitting upgrades.

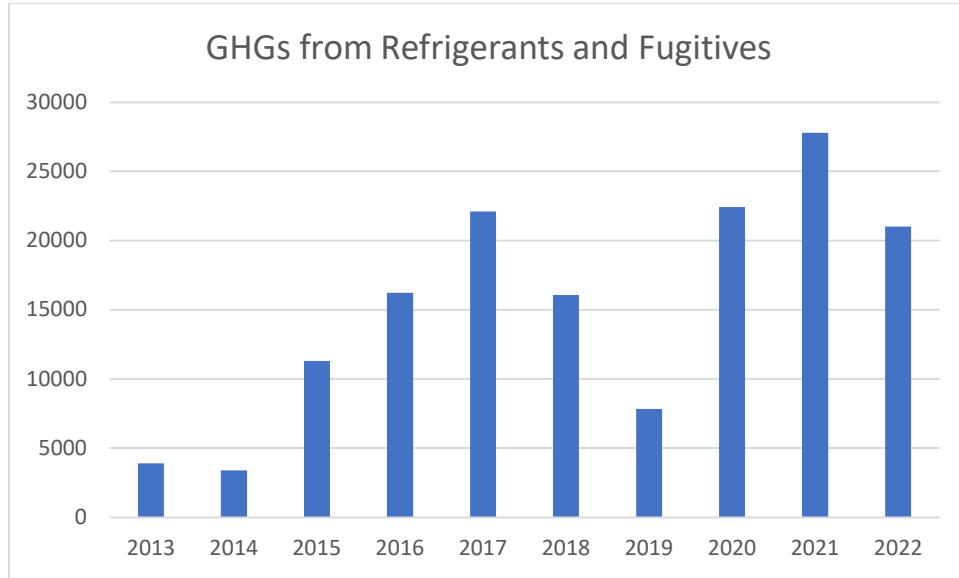


Figure 10. GHG emissions from refrigerants and fugitives.

Plans and Projected Performance

LLNL will also continue with implementation of its improved refrigerant management and SF6 management plans delivered as part of its FY22 action plans. These plans are administrative controls to curtail fugitive emissions and leaks of refrigerants and SF6.

Several regulatory drivers will also continue to affect these emission sources. The primary actions concern HFCs: the US is federally phasing out HFCs via the AIM Act and the recently ratified Kigali Amendment, while the state of California has banned certain HFCs in certain end-uses on a more aggressive schedule. These regulatory changes will lower LLNL’s emissions over time, but the institution may also need to replace systems sooner if replacement refrigerant becomes unavailable.

Electronics Stewardship & Data Centers

Current Performance

Electronic Stewardship – Power Management

LLNS continues to make progress in automating the electronic stewardship of its personal computing environment. Power management is actively managed on all eligible PCs, laptops, and monitors. New standard PCs, laptops, and monitors adhere to ENERGY STAR and EPEAT gold requirements whenever possible based on cost, performance, and availability. Power management data are included in the dashboard.

Electronic Stewardship – Managed Print Services

LLNS continued the Managed Print Services (MPS) contract (started in FY 2021) with participation of all eight directorates. LLNS' MPS blanket agreement states that at a minimum, all multifunction devices and printers purchased under the agreement must possess duplex printing capabilities. Devices installed by the vendor are by default to duplex. The MPS agreement also supports additional sustainability and environment stewardship efforts, such as sustainable offerings (bio-based cartridges, remanufactured toner/containing recycled content) and Electronic Product Environmental Assessment Tool (EPEAT) and Energy Star qualified products.

In FY 2022, LLNS implemented significant business operations enhancements. These enhancements include the launch of PaperCut within Weapons and Complex Integration (WCI) organization. PaperCut is advanced print management software that promotes duplex printing, improves control, increases reporting capabilities, and reduces paper use by eliminating unnecessary printing.

A data collection agent (DCA) was also set up within LLNS's classified areas to perform remote management, fleet monitoring, and page count pulls within classified areas. Lastly, with the approval from LLNS's Cybersecurity Program, LLNS's MPS identified a process to physically disable/remove wireless components (NFC reader) from commonly used Xerox multifunction printer (MFPs), enabling the use of these MFPs to be deployed throughout Classified Areas. The additional models provide increased availability for sustainable offerings and EPEAT requirements and Energy Star Qualified products for fiscal year end acquisitions.

Electronics Stewardship – End of Life

LLNS manages electronic assets through the donation, utilization, and sales (DUS) group within the property management division. DUS receives excess electronics and either donates, sells for reuse, or sends them to a certified recycling facility. DUS maintains a database that tracks the disposition of electronic devices sent off-site for reuse or recycling. Some electronic devices and storage media that contain sensitive information are handled by individual project areas and must first be purged of the information and then destroyed (e.g., shredded). All residual material is handled appropriately according to universal or hazardous waste regulations. Reuse and recycling data are included in the dashboard.

Data Centers

In line with the DOE Data Center Optimization Initiative (DCOI) and the DOE Data Center Working Group, LLNS will continue to look for opportunities to evaluate reductions in the data center inventory through consolidation and closure of existing tiered and non-tiered data centers. In addition, it is anticipated that through the Data Center Working Group, LLNS will support the migration of inter-agency, co-located data centers into the enterprise data center (EDC).

As mentioned, the ECFM project was completed in FY 2022 providing the additional power and cooling to operate two Exascale supercomputers in B453. The utilities grew from 45 MW to 85 MW of power and 10,000 tons to 28,000 tons of cooling. To reduce electrical losses, the 115 kV utility source is closer to the block load computer systems while utilizing high efficiency transformers. The electrical equipment has submetering down to the distribution circuit breakers and have infrared windows for maintenance to reduce the likelihood of unexpected downtimes. The ECFM liquid system is designed to operate without the use of chillers. By eliminating traditional chillers, the new system will save over 60,000 MWh annually to meet sustainability and energy efficiency goals. The cooling tower system is controlled modularly consisting of a cooling tower cell, a tower water pump, a heat exchanger, and a process cooling water pump. The modular approach and its controls allow for the most efficient operation of the cooling system.

LLNS will continue to optimize the efficiency of enduring HPC with the Sierra and Lassen platforms. When the next advanced technology system, El Capitan is sited in FY 2023, LLNS will center in on the most efficient operation of the exascale computer. A combination of liquid-cooling and air-cooling techniques will continue to be used for cooling with higher temperature facility water-supply (2 C to 32 C degrees) American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) thermal guideline W3 water being used to improve energy efficiency without the use of chillers.

The utility infrastructure for next generation of Commodity Technology Systems (CTS-2) will be installed in FY 2023. These will be connected to high-efficiency transformers with submetering down to the circuit breakers for the receptacles powering individual racks. The CTS-2 systems will be cooled by ASHRAE W3 water and apply lessons learned from the previous generation systems regarding rack architecture and air flow management. The CTS-2 systems will be sited in FY 2023 allowing for the less efficient first-generation CTS-1 machines to begin retirement by FY 2024.

LLNS is heavily involved in the energy efficiency HPC working group (EEHPCWG), which participates in many HPC events and LLNS co-leads the group with other DOE labs and industry leaders. One such event is the Institute of Electrical and Electronics Engineers Supercomputing annual all-day workshop where many energy efficient topics are reviewed and where HPC challenges and best practices are identified. The working group meets monthly and comprises nearly 1000 contributing members from the HPC industry—including national laboratories, universities, and vendors. This working group is also working with the Green Top 500 list to develop the required metering to attain standardized energy levels during linear equations software package (LINPACK) runs. A new working group was created for electrical commissioning, which developed a owner's project requirements document to aid in the planning, design, and construction of energy efficient electrical upgrades to data centers.

Plans and Projected Performance

Electronic Stewardship – Power Management

LLNL will continue its power management on all eligible PCs, laptops, and monitors. As computers are replaced, new systems will continue to be automatically included in the power management program.

Electronic Stewardship – Managed Print Services

Future initiatives include a print policy within the Operations & Business (O&B) organization, which will provide best practices on duplex printing and the requirement for capable printers to default to print/copy in duplex mode. In addition, efforts to enhance print management software to monitor and collect duplex data on all non-networked devices are underway.

Data Centers

Because HPC computational efficiency is an ongoing contribution to mission excellence, LLNL will continue to research and develop techniques to improve the energy efficiency of the highly energy intensive HPC. LLNS is involved in several efforts that not only aim to reduce the energy use of HPC but promote new standards of quantifying efficiency gains beyond gross energy use. It aims to drive the DOE complex to adopt the approach to use computational efficiency as a viable alternative to measuring advances in HPC sustainable stewardship.

LLNS also continues to install Tier III systems (i.e., the third of four classifications of data center design criteria increasing I to IV of redundant capacity components and distribution paths) that allow higher temperatures of water to the HPC systems eliminating the need for chillers and pumps. Additional Tier III water was added to B453 with the commissioning of the new 18,000-ton cooling tower from the ECFM project. LLNS will be expanding the Tier III water distribution at B654 during the FY 2023 building expansion project.

In FY 2023, further research is being conducted in the development of submersion cooled computer racks. The plan is to install one submersion cooled rack at building 654 and learning from its impact and potential sustainability savings.

Adaptation and Resilience

Current Performance

LLNS completed a VARP in September 2022 to identify the most significant climate impacts to Sites 200 and 300 and resilience solutions to address these impacts. For both the Livermore Site and Site 300 the climate impacts with the highest calculated risk include increased number of extreme heat days, extreme weather events (and riverine flooding at Site 300), drought (and reduced snowpack for the Livermore Site), actual loss from wildfires, and degraded air quality from wildfires. These hazards are anticipated to impact the on-site workforce, site buildings, specialized or mission-critical equipment, energy generations and distribution systems, IT and telecommunications, water and wastewater systems, transportation and fleet, and availability of critical materials.

Plans and Projected Performance

To begin to address the climate vulnerabilities identified in the VARP the resilience solutions in Table 7 are proposed and have been entered into the dashboard. As indicated, a few of these projects are viewed as relatively low-cost easy wins that can be implemented right away, while others are more difficult and will require feasibility analysis and significant funding.

Table 7. Identified resilience solutions.

Proposed Resilience Solution	Difficulty of Implementation
Incorporated climate change events and hazards into EOC tabletop exercises	Easy
Repair and expand electrical, natural gas, and water metering program	Difficult
Continue GHG emission reduction efforts under the existing ES&H action plan	Moderate
Revise Institutional Management Plan for Extreme Heat Days	Easy
Expand on-site renewable energy generation and storage	Difficult
Fund feasibility analysis for recycled water opportunities	Easy