



FY 2022 Site Sustainability Plan

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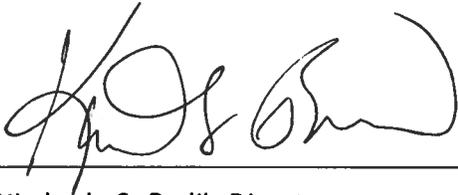
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Executive Summary

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 August 2021 as a deliverable for the DOE Order 436.1 *Departmental Sustainability* requirement.

Overview of Lawrence Livermore National Laboratory

LLNL is a DOE laboratory dedicated to strengthening the nation's security through the development and application of world-class science and technology. Lawrence Livermore National Security (LLNS) is the management and operating prime contractor responsible for LLNL. LLNL's defining responsibility is stockpile stewardship, ensuring the safety, security, and reliability of the nation's nuclear stockpile. Yet LLNL's mission is broader than stockpile stewardship, as dangers ranging from nuclear proliferation and terrorism to energy shortages and climate change threaten national security and global stability. The Laboratory's science and technology are being applied to achieve breakthroughs for counterterrorism and nonproliferation, defense and intelligence, energy, and environmental security. LLNL has long engaged in the practice of sustainability, which is integral to the Laboratory's mission, and the mission is vital to the nation's sustainable future.

LLNL is certified in environmental management (ISO 14001), occupational health and safety management (ISO 45001), and quality management (ISO 9001). Environment, safety, and health (ES&H) action plans are in place under the Laboratory's environmental management system (EMS) to facilitate SSP goals.

Site Management Vision

LLNL's vision for site sustainability encompasses many objectives including the following:

- Supplying its programs with optimal conditions for success while undergoing continual improvement to existing energy infrastructure.
- Collaborating with growing mission areas to identify ways of innovating toward more energy and water-efficient solutions for energy/water intensive facilities.
- Pursuing innovative renewable energy generation—both for on-site use and as an ongoing research area.
- Incorporating energy and water efficiency improvements into the ongoing energy management and facility operations of LLNL.

Funding Strategies

New and existing resources will be leveraged as much as possible to help achieve LLNS's sustainability goals. An NNSA program to recapitalize and rehabilitate infrastructure funded by the Office of Safety, Infrastructure, and Operations (NA-50) continued to provide life-extension projects for enduring facilities and infrastructure such as boiler and chiller improvements, and heating, ventilation, and air conditioning systems. Within limits of practicality, these projects help us ensure that the most energy and water efficient equipment is used.

The Cooling and Heating Asset Management Program (CHAMP)—an asset management program funded by NA-50 and managed by LLNS—continues to perform heating, ventilation, and air-conditioning (HVAC) projects throughout the National Security complex. CHAMP projects provide NNSA sites with HVAC

replacement projects that include energy and water savings features and implement equipment level energy monitoring to demonstrate savings and concepts.

Funding has been allocated by NNSA for installation of at least 8 electric vehicle charging spots (1 dual cable pedestal at Site 300, 2 dual cable pedestal and 1 dual wall mount at Site 200) in FY 2022.

Successes

LLNS had several successes realized in FY 2021. Some highlights include:

Energy

- Deferred maintenance: Projects totaling more than \$8.5 million were executed in FY 2021 to replace old HVAC systems with new energy-efficient equipment, cool roof replacements, and lighting with more efficient LEDs.
- Research: Continued to lead a robust scientific and research program that advances renewable energy and climate change research, builds energy efficiency, and mitigates GHG.

Water

- Water Infrastructure Project: The water disinfectant booster plant project at Site 200 has been operational since August 2020. The system allows for use of the higher-quality Hetch Hetchy water supply instead of ground water, and as anticipated has reduced make-up water use at the cooling towers. The return to use of Hetch Hetchy water late in FY 2020 resulted in a 17% (22 million gallons) reduction in cooling tower make-up water use in FY 2021.
- Water Reuse Study: A detailed engineering and feasibility study was completed in FY 2019 to evaluate water reuse options. In FY 2021, LLNS continued discussions with stakeholders regarding the possibility of extending the City of Livermore's reclaimed water system (purple pipe system) to LLNL which would improve resilience and provide an additional water supply with the largest potable water offset for cooling and irrigation. It is estimated that 340 million gallons of non-potable water could be provided if the preferred option to extend the City of Livermore water reclamation system to LLNL is implemented.

Fleet

- Electric Vehicle Program: Thirty of LLNL's 85 sedans are electric. Additional charging stations were added in FY2021 to bring the total to 22 Level 2 charging stations at Site 200. Future building construction will add 19 additional charging stations (with the potential to expand to at least 15 additional stations - 'EV ready'). The additional electric vehicle infrastructure will allow the Laboratory to add electric vehicles to the fleet.

Sustainable Buildings

- LEED Certification: Two buildings were completed in FY 2021 that are under review by the United States Green Building Council (USGBC) for LEED Gold certified and another 9 new facilities are planned for construction in the next two years and will meet the Guiding Principles and/or LEED certification.

Energy and Water Challenges

LLNL continues to face three ongoing energy challenges. The first is that LLNL continues to grow in mission areas that are particularly energy and water intensive, such as high-performance computing (HPC) and the National Ignition Facility (NIF). This demonstrates the success of the DOE and the Laboratory's efforts in

science and technology development. However, these programs will impact LLNL's GHG emissions and potable water intensity. The LLNL mission is expanding with more personnel on-site, additional mission capabilities, and increased construction activities. Also, the rate of personnel onboarding exceeds the rate of new building development. As a result, older buildings with higher energy intensity and water intensity are being refurbished.

The second issue is that—while the cost of electricity to LLNL is relatively inexpensive at approximately \$0.05 per kWh—many energy savings opportunities that have been identified through the Energy Savings Performance Contract (ESPC) or facility audits cannot demonstrate sufficient payback (of less than 20 years) to warrant the investment.

Third is the issue of aging facilities. Approximately 75% of LLNL buildings are over 30 years old. LLNS has consistently replaced and upgraded its basic real property with the most efficient and cost-effective equipment; however, older facilities are still less energy-efficient than new construction.

Mission Change

A 30 Year Site Development Plan for LLNL was approved by Senior Management in December 2020 to guide planning for the facilities and infrastructure needed to best support the LLNL mission considering the needs identified by all eight Directorates. The plan is intended to create an approach for physical development of the campus over time, confirm the phasing of projects with mission needs and priorities, and support future project requests for direct and indirect funding. The plan projects that approximately 30% of the Laboratory's square footage will be replaced over a thirty-year planning horizon and includes a net gain of more than 400,000 square feet for possible mission growth. Planned new construction represents an approximately 5-15% planning growth by space type as compared to all facilities on-site and the plan relies heavily on generic office and laboratory buildings that can pivot easily to accommodate emerging needs. The plan also introduces practical concerns for implementation in the relationship of buildings to the campus and for the durable, adaptable, and sustainable features of those structures.

For sustainability of the LLNL campus, the plan proposes to focus on the existing issues that are of importance including system-wide gains in efficiency through repairs to utilities, reduced reliance on vehicles in a pedestrian-friendly environment, and water conservation in a low-maintenance, regionally appropriate landscape.

Current key projects worth mentioning and included in projections discussed in other sections of this Site Sustainability Plan, are the Exascale Computing Facility Modernization (Exascale) and Emergency Operations Center (EOC). Construction for the new EOC broke ground in late FY 2020 to provide a replacement emergency operations facility and will be LEED Silver. Significant progress was made on this new facility in FY 2021 with an anticipated completion date of February 2022. Exascale is part of a collaboration with DOE's Exascale Computing Project (ECP) designed to accelerate delivery of a capable Exascale computing ecosystem to provide breakthrough modeling and simulation solutions to address the most critical challenges in scientific discovery, energy assurance, economic competitiveness, and national security. The project will have a significant impact on the future energy and water use at the LLNL Site 200.

A key DOE (including the NNSA) requirement is for offices and sites to conduct climate vulnerability assessments and develop resilience plans no later than September 30, 2022, in accordance with the DOE Vulnerability Assessment and Resilience Planning Guidance. LLNS has created a Climate Action Team supported by the Director's Office that will pilot the Federal Energy Management Plan's (FEMP) Technical Resilience Tool (TRN) and will work with expert stakeholders at LLNL from across a spectrum of programmatic research and development (R&D) and site operations to develop a climate Vulnerability Assessment and Resilience Plan (VARP) by the end of FY 2022.

Goal Category Targets

Table 1 summarizes the goal category targets for each DOE Strategic Sustainability Performance Plan (SSPP) goal.

Table 1. Summary of goal category targets.

DOE Goal	Performance Status	Planned Actions & Contribution	Risk of Non-Attainment
ENERGY MANAGEMENT			
30% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2015 from an FY 2003 baseline and 1% year over year thereafter.	-29.11% reduction from FY 2003 baseline. -2.0% reduction from FY 2020.	Energy savings through proposed Energy Conservation Measure (ECM) projects will be actively pursued; however, significant funding for energysavings projects is required to meet the goal.	High
Energy Independence and Security Act (EISA) section 432 energy and water evaluations.	LLNS has completed 25% of its EISA audit portfolio for the 2021-2024 round. Desk audits were performed on ten (10) facilities in FY 2021.	Significant funding will bring about the recommended energy conservation projects. The recommendations need to be refined to be cost effective to implement.	Medium
Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	90% of electricity achieved (some loss of meters has been experienced; 84 of 305 meters have failed since 2012). 60% of natural gas achieved.	Metering Services Project funding will help arrest the declining state of advanced electric meters. Additional funding will upgrade natural gas meters to meet the FY 2021 goal requirements.	Medium
WATER MANAGEMENT			
20% potable water reduction from an FY 2007 baseline and 0.5% year over year thereafter.	In FY 2021, LLNL's water intensity is estimated at minus 2.65% relative to the FY 2007 baseline. Savings from FY 2020 is -8.89% versus a target of -0.5%. This is primarily due to the switch back to Hetch Hetchy water supply in August of 2020.	LLNL was able to switch back to the Hetch Hetchy water supply upon completion of the disinfectant booster plant and receipt of the permit in August 2020. This switchover has enabled the Laboratory to start regaining water savings. The Laboratory will continue irrigation reduction plans with a focus on water-wise landscaping. An initial study has been completed to determine the feasibility of reusing reclaimed wastewater as make-up to the cooling towers and irrigation. The preferred alternative is to extend the City of Livermore's reclaimed water system to LLNL.	Medium

DOE Goal	Performance Status	Planned Actions & Contribution	Risk of Non-Attainment
<p>Non-potable freshwater consumption (Gal) reduction of industrial, landscaping, and agricultural (ILA). Year over year reduction; no target.</p>	<p>LLNL uses potable water for ILA (non-potable water is not used for ILA).</p>	<p>LLNS is investigating multiple strategies for reducing potable water used for ILA including using reclaimed water and xerophytic landscaping.</p>	<p>Low</p>
<p>WASTE MANAGEMENT</p>			
<p>Reduce at least 50% of nonhazardous solid waste, excluding construction and demolition debris, sent to treatment and disposal facilities.</p>	<p>LLNS consistently diverts over 70% of nonhazardous solid waste from landfill.</p>	<p>In 2022 LLNS will continue the roll out of a municipal waste reduction strategy to increase diversion of mixed recycling and compostable waste.</p>	<p>Low</p>
<p>Reduce construction and demolition materials and debris sent to treatment and disposal facilities. Year over year reduction; no set target.</p>	<p>LLNS consistently diverts over 50% of construction and demolition materials and debris.</p>	<p>LLNS will continue tracking construction and demolition materials and debris in FY 2022.</p>	<p>Low</p>
<p>FLEET MANAGEMENT</p>			
<p>20% reduction in annual petroleum consumption by FY 2015 relative to an FY 2005 baseline, and 2% year over year thereafter.</p>	<p>In FY 2021, LLNS' petroleum fuel consumption increased 25% over last year but was 67% less than the FY 2005 baseline; data will be reported in Federal Automotive Statistical Tool (FAST).</p>	<p>LLNS will continue to strengthen its alternative fuel infrastructure by replacing conventional fueled vehicles with alternative fuel vehicles (AFV) and by promoting the use of alternative fuels.</p>	<p>Low</p>
<p>10% increase in annual alternative fuel consumption by FY 2015 relative to FY 2005 baseline. Maintain 10% increase thereafter.</p>	<p>FY 2021 alternative fuel consumption increased 13% over last year, attributed to more employees returning to working on-site. Overall decrease compared to the FY 2005 baseline will be calculated in FAST.</p>	<p>LLNS will maintain its AFV fleet and continue to replace the existing conventional fueled vehicles with E85, hybrid, plug-in and full electric vehicles, and will maintain and expand where possible infrastructure to support electric vehicles. Future building construction will add 19 additional charging stations (with the potential to expand to at least 15 additional stations - 'EV ready'). At least 8 additional EV charging spots will be installed with funding allocated by NNSA.</p>	<p>Low</p>

DOE Goal	Performance Status	Planned Actions & Contribution	Risk of Non-Attainment
75% of light-duty vehicle acquisitions must consist of AFVs.	LLNS continues to meet the required 75% replacement of fossil fuel light-duty vehicles with AFVs. Data will be entered in FAST.	LLNS will continue replacing its conventional fueled vehicles with AFVs as manufacturers and General Services Administration (GSA) make them available.	Low
CLEAN AND RENEWABLE ENERGY			
"Renewable Electric Energy" requires that renewable electric energy account for not less than 7.5% of total agency electric consumption by FY 2013, and each year thereafter.	FY 2021 requirement was exceeded with the 73% allotment of renewable power generated by the 3.3 megawatt (MW) solar plant and with the purchase of 46,126 MWh of renewable electric energy and 218 MWh of renewable energy credits (RECs) through Western Area Power Administration (WAPA).	The FY 2022 requirement will be met primarily with the 73% allotment from the renewable power generated by the 3.3 MW solar plant and through REC purchases as needed.	Low
Continue to increase non-electric thermal usage. Year over year increase; no set target but an indicator in the Office of Management and Budget (OMB) scorecard.	Non-electric thermal usage was 404 million cubic feet of natural gas in FY 2021 compared to 402.4 million in FY 2020.	LLNS will continue to track non-electric thermal usage.	N/A
SUSTAINABLE BUILDINGS			
At least 15% (by building count) of owned existing buildings to be compliant with the revised Guiding Principles for Sustainable Federal Buildings by FY 2021, with annual progress thereafter.	9% (60% towards goal of 15%) by building count of existing occupied buildings greater than 10,000 gsf have been High Performance Sustainable Building (HPSB) assessed and certified. Two new buildings completed in FY 2021 received LEED gold certification (B642 and B643).	Nine additional buildings are planned that will meet the Guiding Principles and/or LEED certification in the next 2 years. With these additional buildings it is estimated that 13.8% of LLNL's buildings (by building count) will be compliant with the Guiding Principles.	Medium

DOE Goal	Performance Status	Planned Actions & Contribution	Risk of Non-Attainment
ACQUISITION AND PROCUREMENT			
<p>Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in all applicable contracts.</p>	<p>Sustainable Acquisition or Environmental Affirmative Procurement Program (EPP) clauses have been incorporated into all eligible LLNs general provisions (GPs) for purchase orders and subcontracts. As a result, LLNS is 100% compliant with the requirement to include sustainable acquisition clauses in all eligible contract actions. LLNS had 11,359 contract actions with a sustainability clause.</p>	<p>LLNS will continue to include sustainable acquisition or EPP clauses as identified in the GPs in all eligible purchase orders and subcontracts. LLNS will continue to implement, review, and update Procurement Standard Practice 23.5, <i>Environmental Affirmative Procurement and Waste Reduction Requirements</i> as it applies to LLNS procurement activities.</p> <p>LLNS will conduct additional training to help technical release representatives (TRRs) meet sustainable acquisition purchases, and will investigate adding a mandatory entry in purchasing software to indicated sustainable purchases. Additionally, the sustainability program and the Project Management Office will coordinate to track materials selected for federal sustainable buildings.</p>	<p>Low</p>
MEASURES, FUNDING, AND TRAINING			
<p>Implement site set annual targets for sustainability investment with appropriated funds and/or financed contracts.</p>	<p>In FY 2016, LLNS evaluated the merits of the recommended four ECMs proposed in the IGA estimated at a cost of \$2 million, not including the third-party financing cost and LLNS support costs. No activity in FY 2021 due to manpower and resources. LLNS is working towards confirming life cycle cost effective ECMs that can be initiated by October 1, 2022.</p>		
TRAVEL AND COMMUTE			
<p>Year over year scope 3 GHG reduction from an FY 2008 baseline.</p>	<p>GHG emissions in this category decreased by 65% from FY 2008 and 43% from last year due to decreased travel activity due to the COVID-19 pandemic.</p>	<p>Scope 3 emissions are likely to increase slightly due to increased electricity use, more travel and employee commuting.</p>	<p>Medium</p>
FUGITIVES AND REFRIGERANTS			
<p>Year over year Scope 1 & 2 GHG reduction from an FY 2008 baseline.</p>	<p>GHG emissions in this category were reduced by 21% from FY 2008 and increased 24% from last year due to increased purchases of sulfur hexafluoride (SF₆). However, 50% of purchased SF₆ is being stored for future use.</p>	<p>Continue the aggressive management of SF₆ and better manage refrigerants. A GHG Emissions Reduction Action Plan is in place for FY 2022 focused on natural gas use reduction (e.g., replacing non-efficient boilers), gas insulated equipment (GIE) sulfur hexafluoride emissions management, and refrigerant management.</p>	<p>Medium</p>

DOE Goal	Performance Status	Planned Actions & Contribution	Risk of Non-Attainment
ELECTRONIC STEWARDSHIP			
100% of eligible (i.e., not classified) used electronics are reused or recycled using environmentally sound disposition options each year.	LLNS has a process to evaluate excess electronics for either reuse or recycling options.	Continue with program. Some challenges exist as recycling options continue to decrease and markets fluctuate (cost to recycle has increased).	Low
Establish a power usage effectiveness target for new data centers; discuss efforts to meet targets.	<p>Continue efforts in evaluating options to further optimize, consolidate or close remaining 16 LLNL unclassified data centers by:</p> <ul style="list-style-type: none"> • adoption of a Cloud Smart policy to the furthest extent practicable based on cost, security requirements, and application needs • migrating to available inter-agency co-located data centers • migrating to more optimized data centers within the LLNL inventory. 	<p>LLNS will continue to implement and measure progress toward meeting the goals set forth in the Federal Information Technology Acquisition Reform Act (FITARA) memorandum.</p> <p>Actions will include the following:</p> <ul style="list-style-type: none"> • Review and report quarterly data center inventory metrics utilizing DOE’s eDARS reporting system. • Freeze significant expansions of existing data centers. • Calculate Power Utilization Effectiveness (PUE) values utilizing DCPro metrics collected and reported into eDARS. To achieve a PUE value of less than 1.8 for existing data centers, significant investments in energy reducing infrastructure based on DCPro recommendations would have to be planned, budgeted and deployed at a future date to be determined. • Continue efforts, where feasible, to increase efficiencies by consolidation, closure, or re-purpose existing LLNL data centers and utilize cloud services. 	Medium
CLIMATE RESILIENCE			
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	Through LLNS’ existing environmental policy, commits to continuously improve environmental performance.	LLNS has identified existing resilient actions and areas for increasing effort to prepare for predicted climate threats through a baseline assessment. LLNS plans to identify—and update as needed—policies relating to changes in weather patterns and is currently developing a climate VARP.	Low

Performance Review and Plan Narrative

Energy Management

30% energy intensity reduction from an FY2003 baseline

Performance Status

The daily electrical and natural gas demand at Site 200 and Site 300 is significant. LLNL uses 60 or more megawatts of electricity during peak times, and 11,417 therms of natural gas each day. The average energy use intensity is 127 kBtu/ft², without the excluded areas.

At the end of FY 2021, the LLNL contribution to the DOE energy use intensity reduction goal was -29.11% (figure 1), relative to the FY 2003 baseline, normalized for weather. Without a correction for weather, the intensity would be at -30.23%. The Energy Usage and Cost Report are entered in the DOE Sustainability Dashboard. For FY 2021, the total site electricity use was 355,925 MWh while for FY 2020, the electricity use was 387,012 MWh or an 8.03% drop (see figure 1a). Natural gas use was only 0.44% less, as the weather was unseasonably colder in FY 2021 compared to FY 2020 (3157 heating degree days (HDD) in FY 2021 compared to 2810 HDDs in FY 2020).

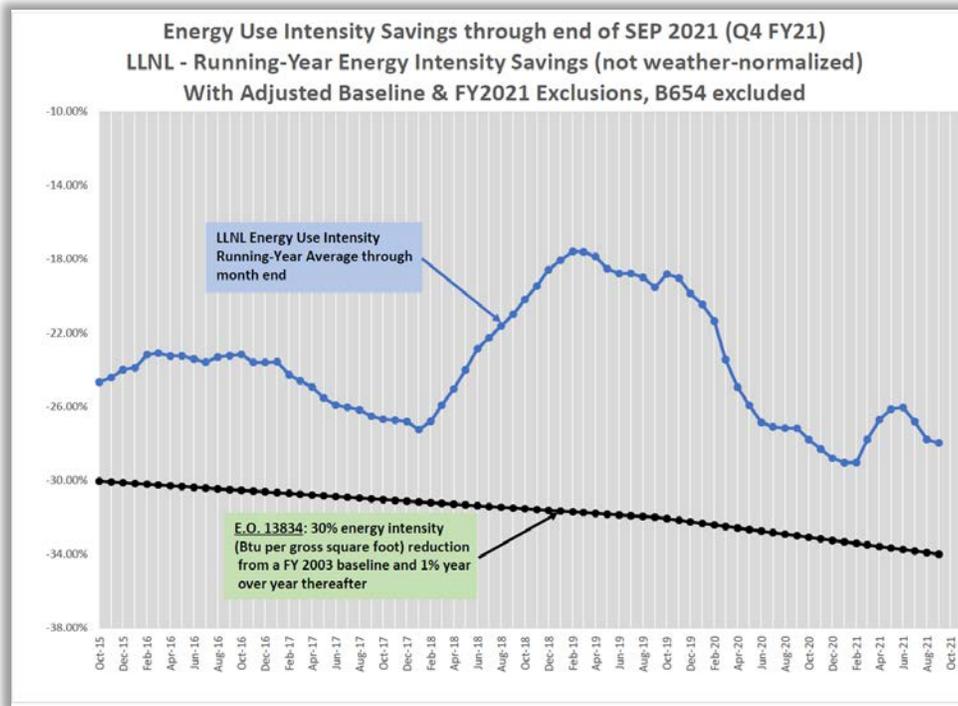


Figure 1. Energy-use intensity savings through end of FY 2021.

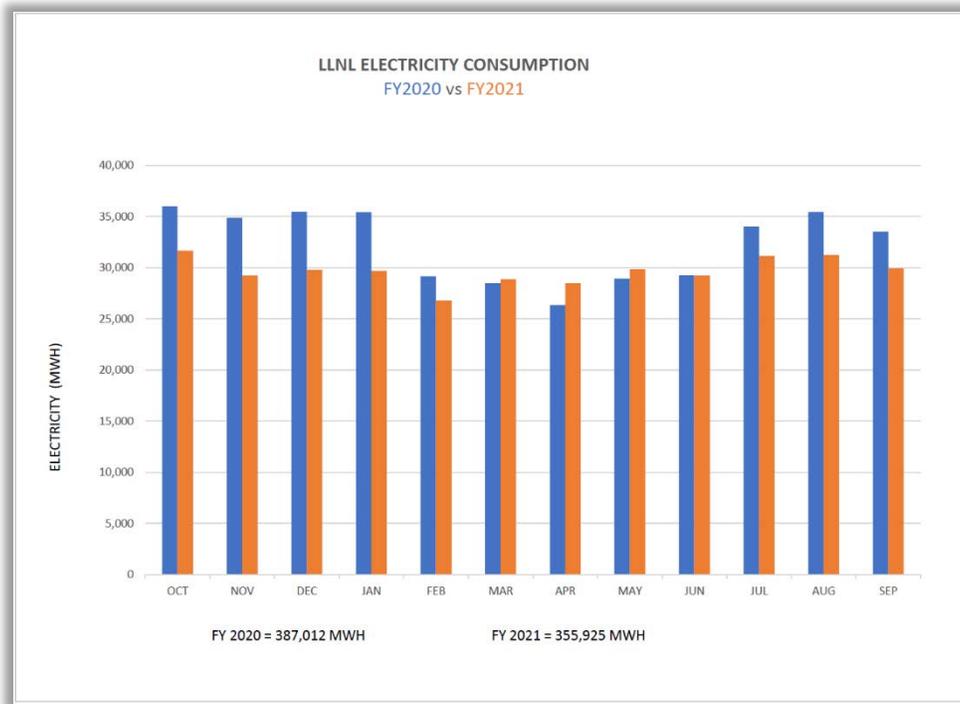


Figure 2. Total site electricity comparison.

For goal subject facilities, HVAC systems and lighting continue to be the two largest users of energy at LLNL, therefore this is where energy conservation efforts are focused.

Plans and Projected Performance

LLNS has developed a comprehensive list of energy-savings projects that includes the results from the IGA report, EISA audits, compliance issues, deferred maintenance projects—that have a significant energy savings—metering evaluations, and grassroots suggestions. The list continues to evolve and expand as new energy-efficiency opportunities are identified. The list is prioritized by the energy savings return on investment (ROI) compared to the project costs.

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 buildings 141, 111, 405, and 071 the efficiency jumps from old to new was in the order of 33% to 40%. 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 old. It can be said that all HVAC unit replacements at LLNL will help achieve the 30% energy reduction from the FY 2003 baseline. As standard practice, LLNS uses California Title 24 Energy Code to guide in the design and replacement of new HVAC equipment. Participation of a minimum LEED certification also supports the energy efficiency and sustainability effort.

A concerted effort is underway to identify high energy wasteful buildings. The goal is to develop a detailed, return on investment and feasibility report for targeted buildings and present to NNSA for funding. New HVAC replacement projects currently underway at B322, B170, and B492 are replacing large tonnage air conditioning (AC) equipment with more efficient ones. At B131 High Bay, a CHAMP (Cooling Heating Asset Management Program) project replaced the old and oversized dehumidification unit with a smaller more efficient unit. In addition, a new energy efficient centrifugal chiller with environmentally friendly new

refrigerant (R514A) replaced an older chiller with old ozone depleting refrigerant. This effort is estimated to reduce energy usage by over 60% in the building.

Old Barracks buildings 218, 316, and 217 had the HVAC system upgraded to more efficient heat pumps replacing old-fashioned cast-iron radiators fired by steam boilers. This is estimated to save over 30% in energy. This effort also helps with the Laboratory’s natural gas reduction initiative.

Building 391 West received a CHAMP-funded replacement of two older water-cooled chillers as well as new high-efficiency condensing boilers.

In addition, the preventive maintenance program included in the ESPC project has added several facilities to the WebCTRL system. The original ESPC project started with upgrades of HVAC controls on 24 facilities and over the years, LLNS has added 2-3 facilities per year on average to the original WebCTRL system.

Applying best practices continues to help reduce LLNL’s energy intensity. These best practices include alerting facility managers of excessive use in their facilities, updating and adapting equipment operating schedules to meet the changing requirements of occupants, providing staff with the training and tools they need, and tracking energy use and comparing against expected performance.

LLNL’s Site 200 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 941 high-speed, connected digital processors in 61 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 many of our buildings as summarized below in Figure 3 and detailed in Table 2. *Digital HVAC detailed additions.* LLNS considered implementing temporary set-backs in response to the shelter-in-place (SIP) order issued in March 2020 due to the COVID-19 pandemic, however, repopulation of the site happened relatively quickly (within a few weeks) and therefore set backs were not established.

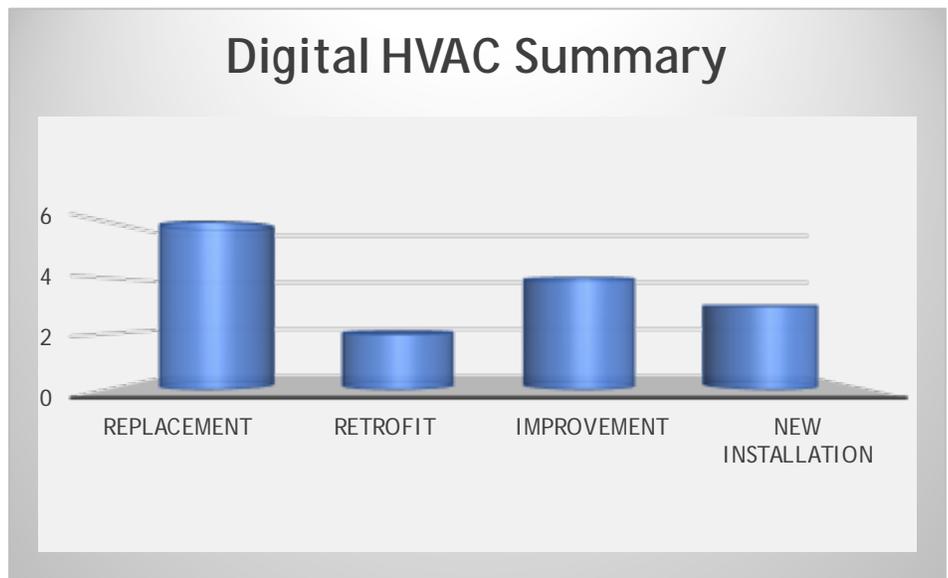


Figure 3. Overview of digital HVAC work.

Table 2. Digital HVAC detailed additions.

Building	Digital HVAC Controls Replaced, Expanded, or Added
B111	An in-house project was started to replace VFDs, controllers, air flow stations, damper actuators and various sensors on the ACUs in the building. This will provide much better occupant comfort and system efficiency.
B154	An in-house project was started to replace the unstable 1988 control system to regain control of ACU01. We expect the increased stability and advanced optimization algorithms to decrease electricity and gas usage by the unit and downstream terminal units.
B642, B643, B225, B365, B810	Added these buildings to the site-wide network to enable real-time monitoring and troubleshooting as well as remote alarming.

In addition to HVAC projects, tier 2 of a Site-wide utility valve replacement project (tier 1 replaced over 100 water valves in FY 2019) began in September 2021 and replaced over 50 city water valves. A second phase will replace 70 leaking compressed air valves.

A focused effort will also be placed on installing variable frequency drives (VFDs) on compressors and other equipment. In FY 2020, two new air compressors installed at Site 200 and two at Site 300 all have VFDs that are expected to result in significant energy savings. Where previously, three air compressors were required to sustain the site, only two are now required. Table 3. *Proposed projects in support of energy management* lists projects that, if funded and implemented, would assist LLNS in trying to meet its energy-intensity reduction goals.

Significant progress has been made on installing and replacing existing site-wide exterior lighting fixtures with LEDs. Approximately 800 LEDs have been installed including the entire site perimeter and high traffic areas at Site 200, and when re-lamping opportunities arise. In addition, exterior LEDs are installed for all new construction and major repairs. A light replacement project at B581 exchanged 260, 400-watt metal halide lamps for 164W LED lights. In this facility, the lights are on 24-hour hours a day seven days per week, which translates to a large potential energy savings. It is estimated that the new lights will save about 540 MWh per year. In addition, the metal halide bulbs had a life expectancy of 18000 hours whereas the LED lights have a life expectancy of 50,000 light hours.

Table 3. Proposed projects in support of energy management.

Project	Project Cost (\$M)	Annual Savings (\$M)	Simple Payback (Yrs)	FY22 (\$M)	FY23 (\$M)	FY24 (\$M)	FY25 (\$M)
Building Automation Systems/EMCS	5	0.9	5.6	1.5	2	1	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	3	0.4	7.5	1	1	0.5	0.5
Site-wide Lighting Improvements, Interior	5	3.8	1.3	1.5	1.5	1.5	0.5

Resources Required

Funding will be required for projects that have been identified, including the installation of more DDC systems or conversion of existing pneumatic control systems, additional programmable thermostats, interior and exterior lighting upgrade projects, and other energy conservation-related projects. LLNS is continuing to develop a strategy to justify energy conservation projects in comparison to its low cost of electricity.

Plans to reduce deferred maintenance, while at the same time increasing energy efficiency, will be implemented according to the prioritized project list for the site. When replacing aging equipment identified in the master deferred maintenance list, new equipment will be the latest, most energy-efficient type available.

Based on best estimate of available resources for FY 2022, LLNS will attempt to maintain its energy intensity savings at current levels considering the total goal-subject building area of 5.9 million ft².

Table 4 shows the site projected electricity consumption and Figure 4 shows the load forecast.

Table 4. Site projected electricity consumption with Exascale (x10⁶ kWh).

Fiscal Year	2022	2023	2024	2025	2026	2027
Forecast total electricity consumption (M kWh)	433	561	516	517	520	525
HEMSF facility 1 B453 - COMP (M kWh)	210	270	230	230	235	240
HEMSF facility 2 B581 - NIF (M kWh)	36	40	42	44	44	44
Estimated load after energy efficiencies (M kWh)	423	552	507	509	512	517

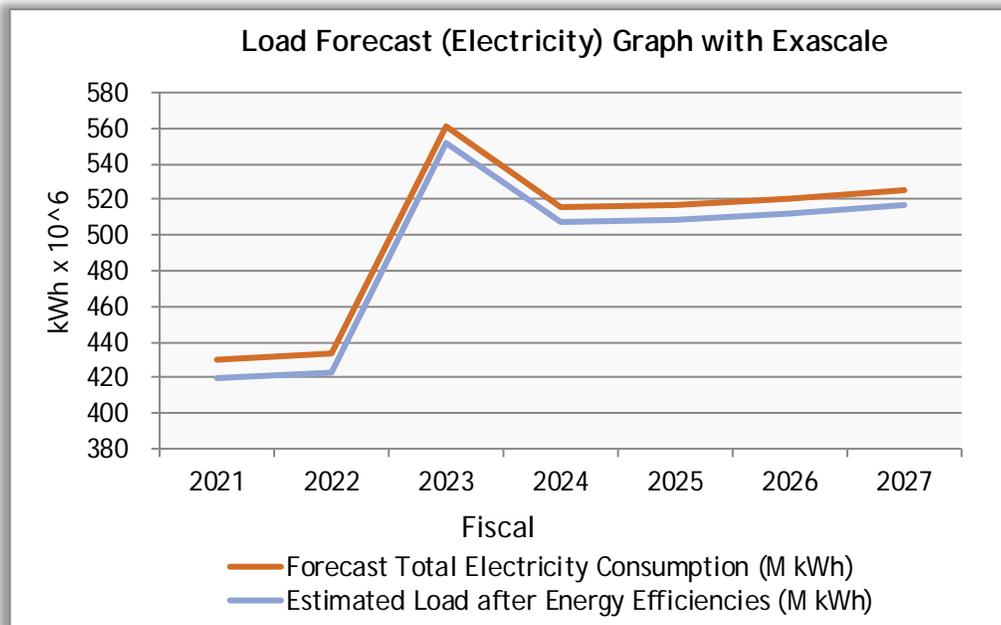


Figure 4. LLNL energy load forecast with Exascale.

EISA section 432 energy and water evaluations

In FY 2021, internal desk audits were performed on ten facilities, B453, B581, B490, U325, B131, B654, B133, B451, U291, and B391. 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 2021 made up the first 25% for the 2021-2024 round of audits.

Energy audits to meet EISA section 432 and efforts to increase efficiency (e.g., combining energy audits with condition assessment surveys) along with recommissioning/retro-commissioning, are continually being evaluated. Meetings with managers of facilities identified with an increase in electricity usage are being held to discuss the recent energy audit recommendations to plan a path forward beginning with those recommendations that offer the most energy savings opportunities.

There are two qualified certified energy managers (CEM) at LLNL, which is sufficient at this time. LLNS is working to identify facility managers or facility points of contact as candidates to enroll in the program in the future.

Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate

Performance Status

LLNS will continue to update the metering plan to align with the November 2014 Federal Building Metering Guidance document. LLNS' commitment to support the DOE SSPP and comply with the Energy Policy Act (EPACT) 2005 and EISA 2007 regulations is exemplified in this latest issue of the metering plan. LLNS is committed to monitoring and reducing its energy usage and finding innovative ways to lead the lab complex while at the same time meeting its mission goals. This updated metering plan not only outlines the strategy to continue repair of meters, but also highlights LLNS' new goal of upgrading existing legacy meters before they fail. The latest metering plan will be uploaded in the dashboard, as well as the completed site metering Excel workbook.

Plans and Projected Performance

Below is a summary of LLNS' performance compared to the SSPP goals.

SSPP Metering Stretch Goals	FY 2021 Performance Status	Planned Actions and Key Issues
Meter all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	90% achieved as of the end of FY 2012. Approx. 60% of highest users are metered, remaining 30% of facilities share one or more failed meter (these facilities include at least one meter where electrical usage is estimated).	Funding for a metering services project estimated at \$500K is needed to arrest the declining state of advanced electric meters. Additional funding will upgrade natural gas and water meters to meet the FY 2022 goal requirements.

In FY 2015, modem-based electricity meters were taken out of production. As a result, LLNS shifted its strategy from repairing existing modem-based meters to complete meter upgrades to maintain compliance with its metering goals. The site decided to only perform electricity meter upgrades at computation facilities during FY 2017. As a result, the remainder of the LLNL site continues to experience legacy electricity meter failures both in communication and overall function.

Resources Required

Table 5 lists projects that will ensure that appropriate LLNL facilities meet the metering goal for electricity, natural gas, and potable water metering. These projects are intended to help change behaviors and improve operations to achieve energy efficiencies.

Table 5. Proposed projects in support of metering.

Project	Project Cost (\$M)	Annual Savings (\$M)	Simple Payback (Yrs)	FY22 (\$M)	FY23 (\$M)	FY24 (\$M)	FY25 (\$M)	FY26 (\$M)
Electricity metering	4.2	N/A	N/A	1.0	1.0	1.0	0.7	0.5
Natural gas metering	3.6	0.065	54	0.8	1.0	0.75	0.6	0.5
Potable water metering	1.5	0.025	59	0.25	0.5	0.25	0.25	0.25

Water Management

20% potable water intensity (gal per gross square foot) reduction from an FY 2007 baseline

Performance Status

In FY 2021, LLNL’s contribution to the DOE potable water intensity savings goal was -2.56% (Figure 5). LLNL’s drop in potable water intensity savings from the previous year (-8.89% versus a target of -0.5%) was primarily due to the following factors:

- The switch back to the primary water supplier (Hetch Hetchy) in August 2020.
- Fewer employees on-site due to COVID safety protocols. This, however, did not reduce the domestic water usage despite the decrease in number of employees reporting on-site. It was noted that the water quality on-site was degrading due to long residence time and the domestic water distribution piping in the facilities had to be flushed weekly to comply with the water potability standards. In addition, Computing’s mission work continues, and the cooling requirements still must be met.

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

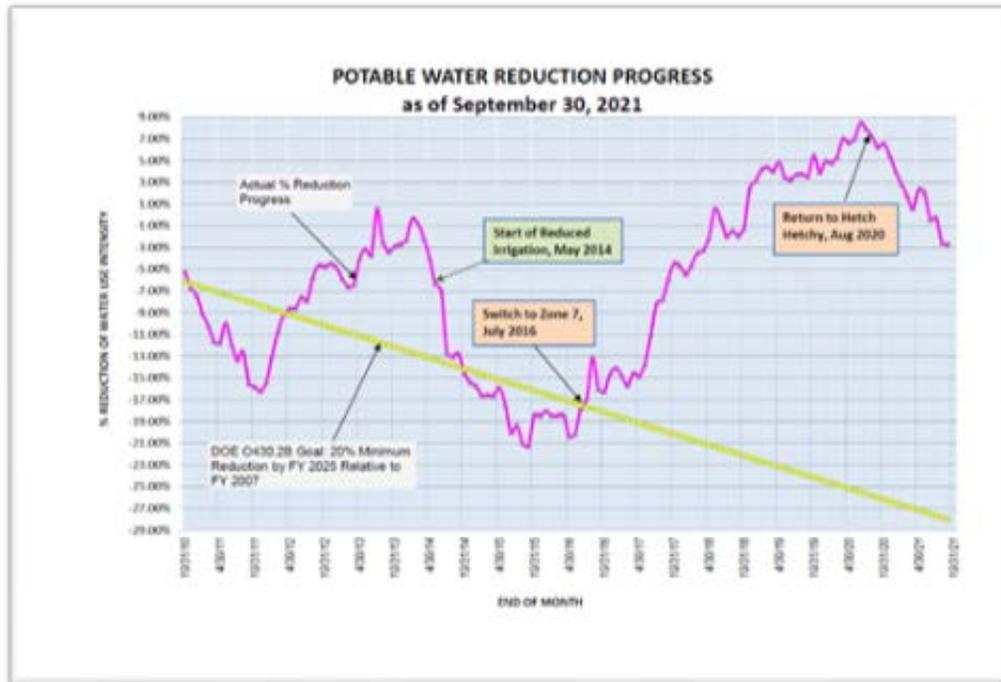


Figure 5. Potable water use intensity savings through end of FY 2021.

Potable water use at LLNL’s cooling towers decreased nearly 22 million gallons from FY 2020 due to switching back to the primary water supplier (Hetch Hetchy). This is due to the less mineral content in the source water which allows up to 20 cycles of concentration in the cooling towers before blowdown. Also, since the weather was seasonably colder, cooling was not a major demand in the buildings. The Laboratory applies various intensity levels of landscaping as appropriate to the contextual environment—ranging from special-use to transitional and natural settings. As stated in the 2011 Sustainable Landscape Concept Plan, one of the site landscaping goals is to reduce the amount of irrigation for water-intensive lawn. The use of turf would be limited to only certain special aesthetic and recreational applications. Other lawn areas with no specific functional requirements would be converted to drought tolerant/Livermore Valley-compatible planting.

LLNS will continue to perform incremental landscape and irrigation modifications to reduce water use as funding allows—reducing lawn areas and optimizing irrigation efficiency with alternate sustainable landscaping. A breakdown of LLNL potable water consumption is illustrated in Figure 5. The cooling tower make-up component is the highest user at 44.28%, with irrigation use second at 24.28% and facility process use third at 17.66%.

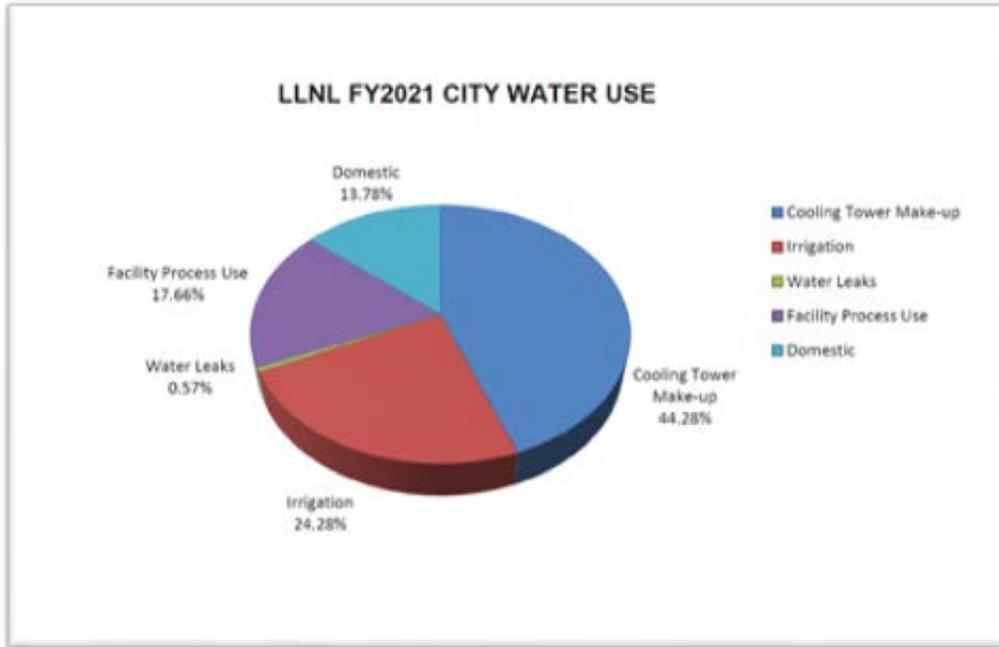


Figure 6. LLNL FY 2021 potable water use breakdown.

Current LLNS practice is to meter areas or zones of greatest water use—such as the cooling towers and irrigation zones—rather than at individual buildings as it would be prohibitively expensive. All five cooling tower make-up water systems at LLNL are furnished with standard water meters. LLNS plans to upgrade all water meters to advanced water meters, which is included in the metering project proposal and outlined in Table 5. This will allow a more timely and accurate accounting of the total cooling tower make-up water load.

Plans and Projected Performance

There are several factors that will make it difficult to reduce water use without additional resources to execute the needed water savings projects. The main challenges faced include continued Laboratory computing mission growth which requires additional cooling tower make-up (unlike energy-intensity calculations, there are no exclusions for mission growth for water reduction; and continued growth and activity will increase the domestic water demand at the site).

There are several water infrastructure projects underway (or being planned) that will assist the Laboratory in reducing water consumption (Table 6).

Table 6. Water infrastructure projects.

Location	Description
Site 200 Water Disinfectant Booster Plant Project	The construction of this project was completed in late August 2020 along with the approval of the water operating permit. The return to the use of Hetch Hetchy water supply has reduced the amount of make-up water at the cooling towers. This make-up water use is the biggest user of potable water at the site.
Site 300 Water Filtration Project	Construction complete and revised water permit received. This project will allow the use of Hetch Hetchy water instead of ground water, resulting in improved water quality. It is not certain whether this switch will also yield less potable water use. Insufficient data to determine whether potable water use is reduced.

Location	Description
Site 300 City Water Piping and Valve Replacement Project	Will re-size and re-route the main city water line and replace failed isolation valves to better serve the mission and efficiently mitigate line breaks. Project implementation is scheduled to start in December 2021.
Site 300 Tank Inspections	In past years, tank inspections were completed using a remotely-piloted underwater vehicle (ROV) with a high-definition camera and lighting system—requiring fewer personnel to complete the inspection. This new method resulted in 16 combined work hours to inspect each tank for a total completion time of approximately 160 work hours for all tanks. The total amount of potable water saved by using this method was approximately 1.116 million gallons.
B801 Cooling Tower	Noted to be using considerable amount of domestic water for its make-up needs. A chemical treatment consultant analyzed the make-up water and the blowdown water to compare the chemical concentrations between the two. The consultant advised on the optimum level of concentration so that blowdown water could be reduced. This saved thousands of gallons of water per day.
UESC Investment Grade Audit (IGA) (submitted 2015)	Included a proposal for three water ECMs: well water cooling tower make-up for U325, wastewater reclamation for cooling tower make-up at U291 and OS454 Livermore Computing (formerly the Terascale Facility), and xeriscaping at B170.

In keeping with its high standard of environmental stewardship and commitment to meeting DOE’s water intensity reduction goals, LLNS continues to evaluate ways to identify, monitor, and mitigate inefficiencies in its water-distribution systems. This will have an additional benefit of reducing electrical energy expended in water distribution across the site.

LLNS’s search for the most advanced and efficient leak detection technologies has created an opportunity to collaborate with industry leaders who employ the latest technological and environmentally sound methods to detect, locate, and correct leaks. Additional resources are required to pursue the currently available improved leak-detection strategies.

DOE’s FY 2022 water intensity reduction goal is 30%. Based on LLNS’ best estimate of available resources for FY 2022, LLNS will strive to maintain current savings.

Estimated water use over the next years is depicted in Table 7.

Table 7. Estimated water use.

Fiscal Year	2021A	2022	2023	2024	2025	2026	2027	2028
Total water consumption (Mgal)	256	261	287	263	264	266	267	320
B453-COMP (Cooling Tower)	25	40	100	60	70	80	80	200
B581-NIF (Cooling Tower)	16	17	17	18	18	20	20	22
Water efficiencies (Mgal)	242	247	267	249	252	254	257	310

Resources Required

LLNS has requested funding to complete water saving projects identified in previous audits that can assist in intensity-reduction measures and are shown in Table 8. Funding and implementing these projects would better allow LLNS to meet its water intensity reduction goal.

Table 8. Proposed projects in support of water management.

Project	Project Cost (\$M)	Annual Savings (\$M)	Simple Payback (Yrs)	FY22 (\$M)	FY23 (\$M)	FY24 (\$M)	FY25 (\$M)
Use RO treated well water at U325	4.9	0.23	21.6	0.5	0.5	1	2.9
Use RO treated well water at U291	3.5	0.17	20.2	0.5	1	1	1
Use RO treated well water at NIF	3.5	0.17	20.2	0.5	1	1	1
Use reclaimed wastewater at U291 and COMP (cost-share)	18	0.61	29.5	4	5	5	4

Year over year reduction of non-potable freshwater consumption (Gal) reduction of industrial, landscaping, and agricultural (ILA) water performance status

LLNL uses potable water for industrial (e.g., cooling tower make-up) and landscape irrigation at Site 200. At Site 300, potable well water is used for all purposes. The planned cutover from well water to Hetch Hetchy water was completed in October 2019.

The 30% water consumption reduction of ILA water goal does not strictly apply to LLNL since by definition ILA is non-potable water. However, LLNS is committed to reducing industrial use of potable water at the cooling towers and for landscape irrigation. As a subset of the water reduction savings, the portion attributable to ILA can also be tracked.

Related to water supply vulnerability and improving resilience at LLNL, NNSA funded an engineering study to determine the feasibility of reusing reclaimed wastewater as makeup to the cooling towers and irrigation. Cooling tower use is a rapidly increasing potable water demand related to Exascale computing. The preferred alternative is to extend the City of Livermore’s reclaimed water system (purple pipe system) to LLNL which would improve resilience and provide an additional water supply with the largest potable water offset for cooling and irrigation. Results of the study have been briefed to NNSA management and the City of Livermore, the NNSA share was estimated at ~\$18M for a city-led project to extend existing reclaimed water system (purple pipe) to LLNL. It is estimated that this option could provide 340 million gallons of treated water for cooling and irrigation.

Storm Water Management

The management and control of storm water runoff quantity, timing, and water quality are important considerations in low-impact development and sustainability. Storm water management is a component of LLNS’ EMS through various environmental aspects—including groundwater discharges, inadvertent releases, water use, and land resource use. LLNS also considers storm water management an element in water conservation and green building.

LLNS’ storm water program has been designed to address regulatory requirements and DOE orders. Storm water discharges at both Site 200 and Site 300 are regulated by the State of California under the authority of the Clean Water Act using industrial and construction storm water National Pollutant Discharge Elimination System (NPDES) permits. The state also regulates storm water discharges under the Porter-Cologne Water Quality Control Act using waste discharge requirements. LLNS’ storm water programs must also comply with DOE orders as specified in Contract DE-AC52-07NA27344. LLNS implements the storm water programs through procedures and Storm Water Pollution Prevention Plans (SWPPP).

Storm Water Management Performance Status

New construction at LLNL will include storm water controls consistent with EISA 438 and EPA Guidance—to the maximum extent technically feasible.

Storm-Water Management Planned Actions

Consistent with EISA 438 and low-impact development, LLNS is including water-balance considerations into designs for the East Campus Site Improvement project and Applied Materials and Engineering campus. These projects will include many low-impact development designs to meet or exceed a 95th percentile storm—consistent with the EPA guidance.

Waste Management

Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris and reduce year over year construction and demolition materials and debris sent to treatment and disposal facilities

LLNS' waste reduction and pollution prevention (P2) efforts have been guided by federal executive orders (EO) and are firmly entrenched in many of its management practices. Many of the goals have been in place at LLNL and continue to be exceeded. P2 is a key component of LLNS' EMS, which includes training for all employees.

Performance Status

Waste Minimization and Recycling

In FY 2021 LLNS continued to recycle scrap metal, cardboard, paper, landscaping waste, organics waste, sawdust/woodchips, cooking grease, and toner cartridges to divert over 75% of municipal waste from landfill. LLNS has consistently diverted over 70% of municipal waste from landfill since 2012. LLNS also diverted 75% of construction and demolition (C&D) debris from landfill in FY 2021. Due to the increasing number of construction and demolition projects LLNL has implemented measures to improve recycling efforts and tracking of the amount of recycling of C&D wastes. Municipal waste management plans where the amount and type of items recycled, as well as where they will be recycled, are required for most large construction and demolition projects. LLNS continues to make improvements to better streamline reporting of C&D recycling efforts between LLNS' sustainability team, construction team, and construction subcontractors.

Toxic Chemical Reduction

Using a priority-based approach, twenty-seven chemicals were selected as "priority" chemicals in 2008 and continue to be tracked and reported regularly (Figure 7). Purchases of priority chemicals was 26% greater than the 2008 baseline, but slightly less than FY 2020.

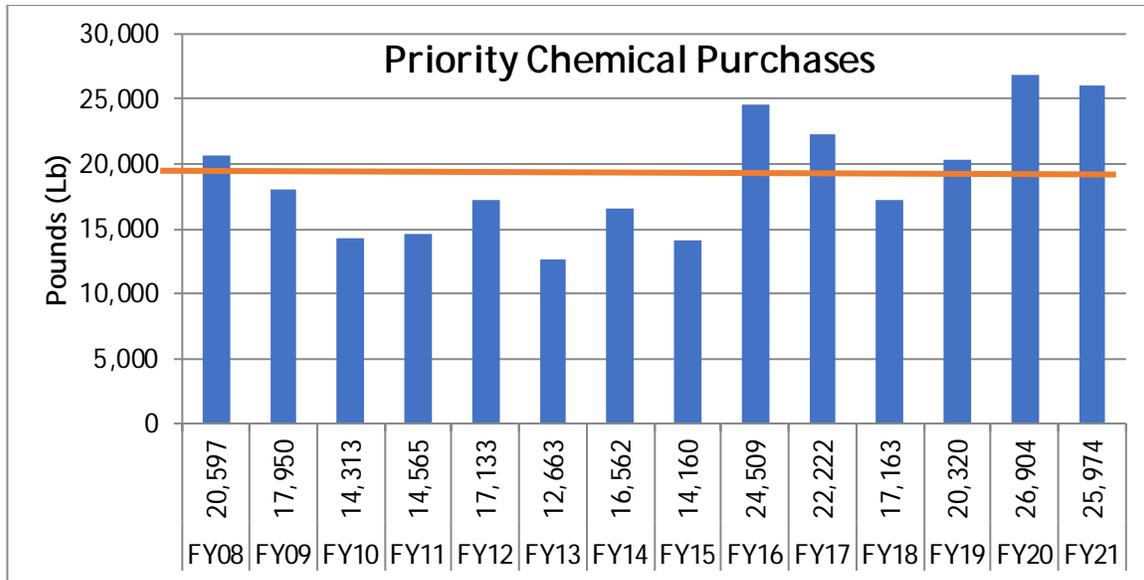


Figure 7. Priority chemical purchases.

Plans and Projected Performance

LLNS plans to continue to reduce pollution and increase recycling during FY 2022 by focusing on the following actions:

- Continuing to roll out the program to collect recyclable and compostable materials across selected buildings. This will include roadshow presentations at each building, training and cooperation with building champions, creation of an associated informational webpage, and continued waste tracking efforts. The roll out will be aligned with a return to normal working posture at the Laboratory based on COVID-19 precautions.
- Raising awareness through awards, outreach, and Laboratory events.
- Continuing to reduce high-risk chemical inventory for chemicals that do not have a foreseeable mission use.

Resources Required

Normal business processes are in place for LLNL to meet this goal.

Fleet Management

20% reduction in annual petroleum consumption by FY 2015 relative to an FY 2005 baseline; maintain 2% year over year reduction

Performance Status

In FY 2021, LLNL’s petroleum fuel consumption increased about 25% over FY 2020 (about 67% less relative to the FY 2005 baseline). Much of this increase is a result of additional onsite activity in FY 2021 VS FY 2020 and replacement of E-85 fueled Security vehicles with Unleaded fueled vehicles. LLNL will continue to replace petroleum-use vehicles with alternative fuel (AF) and electric vehicles (EVs) at site 200. The Laboratory will also continue to promote the reduction of petroleum fuel by utilizing electric vehicles and by advertising and leveraging taxi services. However, it should be noted that the fueling station at Site 300

does not have E85 fuel, and therefore must use regular unleaded fuel. Figure 8 shows the decrease of the overall petroleum consumption.

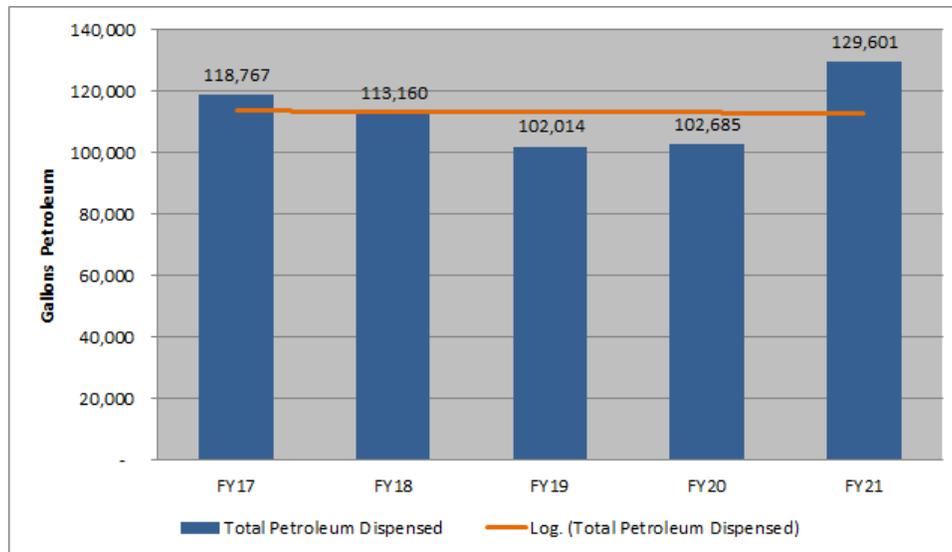


Figure 8. LLNL petroleum consumption reduction.

Plans and Projected Performance

LLNL will continue to strengthen its AF infrastructure by replacing conventional fueled vehicles with AFVs and by promoting the use of AFs.

10% increase in annual alternative fuel consumption by FY 2015 relative to an FY 2005 baseline; maintain 10% increase thereafter

Performance Status

LLNS continues to focus its AF strategy primarily with the use of ethanol fuel (E85) as its fuel of choice. In 2007, LLNS built an ethanol fuel station with a 12,000-gallon underground tank at a cost of \$1.3 million. Subsequently, LLNS restructured its fleet strategy to be composed of E85-compatible vehicles. In FY 2021, LLNS' use of AF increased 13% relative to the previous year's consumption. This increase is attributed to increased onsite activity and mileage driven overall during FY 2021 due to many employees returning to the site since COVID safety protocols were implemented in March FY 2020. As shown in Figure 9, LLNL has entered the maturity stage on AF consumption and year-over-year increases are anticipated to level off. LLNS had 30 EVs (sedans) deployed and in use in FY 2020 and has supporting charging infrastructure in place.

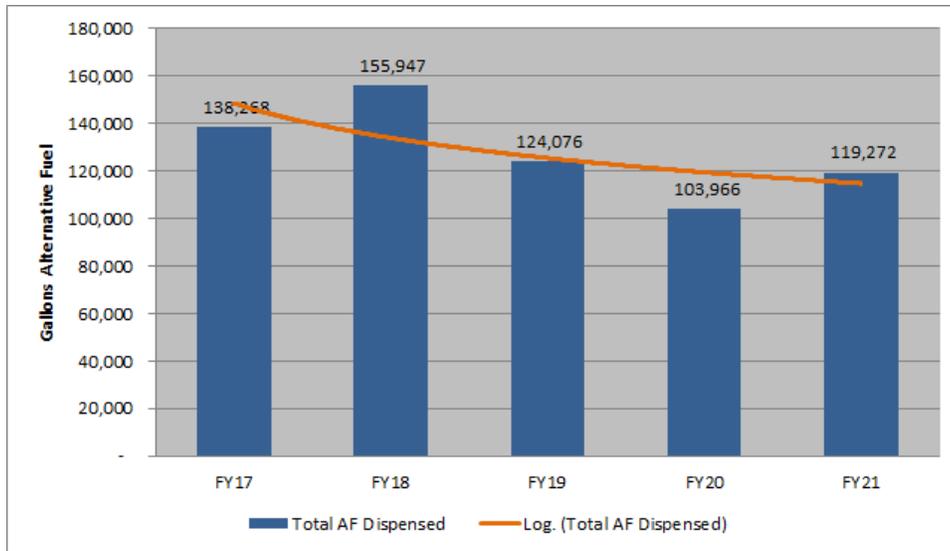


Figure 9. Total alternative fuel dispensed.

Plans and Projected Performance

Plans for FY 2022 are focused on electric vehicles and charging stations in lieu of AFVs.

75% of light-duty vehicle acquisitions must consist of alternative fuel vehicles (AFV)

Performance Status

In FY 2021, LLNS met the required 75% replacement of fossil-fuel, light-duty vehicles with AFVs. LLNS’ AF fleet accounts for over 80% of its total light-duty vehicles.

Plans and Projected Performance

LLNS will continue replacing its fleet with AFVs as manufacturers make them CARB-compliant for the state of California, and as they become available. LLNS will continue with its primary E85 AFV fleet strategy and explore different AFV options.

LLNS is promoting replacing conventional fueled vehicles with electric vehicles and adding more electric vehicle charging stations to support these vehicles. LLNS currently has 30 electric vehicle sedans and 22 level 2 charging stations. As summarized in Table 9, future building construction will add 19 additional charging stations (with the potential to expand to at least 15 additional stations - ‘EV ready’). In addition, approximately 18 locations have been identified where charging stations could be installed; this could result in 40 or more plugs. These sites have been prioritized from “easy wins” to more costly projects that will require trenching. Part of these 18 sites will be paid for from funding (\$280,000) allocated to LLNL by NNSA.

The Laboratory continues its personal vehicle charging program that was started in FY 2014. The program is designed to allow employees to charge their personal vehicles using existing Livermore site-designated charging locations for a monthly fee. Employees who choose to participate in the program are asked to sign an end-user agreement that provides details and terms of the program requirements. End-users pay a monthly fee that provides them with access to charging stations. This program is in response to employee requests and in support of NNSA/DOE and the Laboratory’s site sustainability efforts.

Table 9. Existing and planned electric vehicle charging stations.

Number of Government EVs:	30 sedans
Number of Level 2 charging cables (not including solar):	9 at B611 2 at B224 2 at B405 2 at B445 7 at B642
Number of Level 2 charging cables under construction:	2 at B870 4 at B445 2 at 405 4 at EOC 3 (+7-9 EV ready) at B144 2 (+6 EV ready) at B265 2 at 449

Renewable Energy

Renewable Electric Energy requires that renewable electric energy account for not less than 7.5% of a total agency electric consumption by FY 2013, and each year thereafter. Continue to increase non-thermal usage.

Performance Status

Due to the low cost of purchased power, installing renewable energy at LLNL has been a challenge. 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 Consortium initiated an effort with WAPA to solicit a 10-50 MW block of renewable power for a period of 20 years at a fixed price. The Consortium’s objective was to identify a renewable resource that fits within its current procurement strategy of contracting for long term purchases as a hedge against price volatility. The DOE Livermore Field Office (LFO) supported the request-for-proposal by WAPA for the 10-50 MW purchase of solar energy to provide power to the Consortium and will continue to support WAPA and contract negotiations for the 20 year power purchase agreement (PPA) with the recommended provider in FY 2022.

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 13% through the purchase of RECs and renewable electric energy in FY 2021. LLNS purchased 218 MWh of RECs, 46,126 MWh of renewable electric energy from incremental hydropower, plus 4,933 MWh of renewable electric energy from the onsite solar plant. The onsite solar plant is located at the northwest buffer zone and started commercial operations in February 2016. This renewable energy plant generated a total of 6,236 MWh in FY 2021.

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

For FY 2022, LLNS will purchase RECs to comply with the renewable energy requirement. The number of RECs purchased can decrease substantially due to the contribution of the P-V solar plant at LLNL. LLNS will continue to explore research opportunities for renewable power generation at Site 300. If these projects come to fruition, then LLNL will use that power as well. Additionally, the Site 200 renewable energy goals would contribute to DOE’s goals.

Even with a 3.3 MW P-V array, LLNS will still need to purchase additional RECs—renewable energy projects are capital-intensive. In general terms, a 6 MW solar array would be required to meet the renewable energy goals for LLNL—this would require a multi-million-dollar investment. A 6 MW solar array would also greatly contribute to LLNS’ energy reduction goals. The high cost of on-site renewable power indicates an ROI that would exceed the projected 20-year useful life of the equipment. When compared to WAPA rates, renewable energy only becomes economically feasible when the producer is a private entity eligible for tax credits, tax exemptions, depreciation, and other assorted incentives.

For the next fiscal year, LLNS will accomplish the following:

- Continue exploring scientific opportunities in renewable energy.
- Continue discussions with renewable energy providers on innovative opportunities in renewable energy for LLNL.
- Continue collaboration in the Northern California DOE Laboratory Consortium.

Sustainable Buildings

At least 15% (by building count) of existing buildings to be compliant with the revised Guiding Principles for HPSB by FY 2021

Performance Status

Four LEED building certifications (B142, B264, B451, and B453) were completed in 2008–2011, one LEED Gold certification (B655) was completed in 2019, two buildings are CalGreen compliant, six initial building assessments using the DOE HPSB assessment tool were completed in 2011–2012. In FY 2020, one facility (B642) greater than 5,000 square feet was newly constructed that is under review by the USGBC for LEED Gold certification (Table 10). B643 is also under review by USGBC for LEED Gold certification but is under 5,000 square feet.

Table 10. Compliant HPSB buildings.

Building Name	GSF	Notes
B142	20,306	LEED certified
B264	20,461	LEED certified
B276	8,487	CalGreen compliant
B451	51,398	LEED certified
B453	240,598	LEED certified
B655	13,277	LEED Gold certified
T1878	6,292	HPSB assessed
T1885	7,046	CalGreen compliant
T1888	11,520	HPSB assessed
T1889	16,821	HPSB assessed

T4727	9,951	HPSB assessed
T4729	10,018	HPSB assessed
T5627	8,470	HPSB Assessed
B223	13,821	LEED certified
B224	22,101	LEED Silver
B642	24,379	LEED Gold (under review)
B643	2,967 (<5000 sqft)*	LEED Gold (under review)
Total	484,902	

*Not included in total

The current number of occupied buildings over 5,000 square feet in the enduring inventory is 170 with a total square footage of 5,867,198. As of FY 2021, 16 buildings were assessed using the LEED system, HPSB, or CalGreen – with a total square footage of 484,902. Currently these assessments represent 9% of the total 172 buildings. An additional 10 assessments based on building count and approximately an additional 397,000 square feet based on square footage need to be assessed to achieve the 15% goal.

In FY 2021 the sustainable design facilities standard was updated to ensure that new construction and major renovations address the HPSB requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, implement the Guiding Principles for Sustainable Federal Buildings required in DOE Order 430.1C, *Real Property Asset Management*, and support DOE Order 436.1, *Departmental Sustainability*.

Plans and Projected Performance

New construction projects planned for adherence to the Guiding Principles and/or LEED certification in FY 2022 and FY 2023 are summarized in Table 11. These projects provide an additional 162,474 square feet to the assessed and/or certified totals.

Table 11. Summary of new construction FY 2022-2023.

Building	Rating	Square Feet	Status (anticipated completion date)
B041 Emergency Operations Center (EOC)	Guiding Principles/LEED Gold	20,550	2/2022
B321G	Guiding Principles/LEED Silver	11,257	2/2022
B310	Guiding Principles/LEED Silver	12,122	8/2022
B265	Guiding Principles	21,309	2022
B449	Guiding Principles	21,309	2022
B183	Guiding Principles	21,309	2022
B654 addition	Guiding Principles	12,000	2022
B144	Guiding Principles	21,309	2023
B266	Guiding Principles	21,309	2023

Agencies may qualify as sustainable buildings, including existing buildings, new construction, and major renovations, using one of the following:

1. The Guiding Principles for Sustainable Federal Buildings and Associated Instructions (*Guiding Principles*), developed in 2020; or
2. Third-party building certifications systems or standards identified by GSA's Office of High-Performance Buildings.

All buildings and ancillary facilities are located within the established Laboratory site boundaries; with approximately 6,900 gsf of leased facility in the local vicinity. Site planning for new facilities is coordinated with architectural and civil design for orientation, energy efficiency, and incorporation of environmental management system considerations including bioswale soft shoulder for roadways and sustainable landscaping for open grounds.

Sustainable site development encompasses an integrated approach to the planning of future on-site facilities and infrastructure consistent with the LLNL Ten Year Site Plan (TYSP), striving to enhance site stewardship in coordination with the surrounding community. The Laboratory encourages walking and bicycling as a means of travel within the site; long-range site development envisions continuous improvement of a bicycle- and pedestrian-friendly environment.

Resources Required

New construction meets the guiding principles; however, funding limitations make it difficult to implement this approach for major renovations. There are significant additional costs to meeting net zero status for new construction and major renovations and therefore it is not currently achievable or practicable.

Acquisitions and Procurement

Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring biopreferred and biobased provisions and clauses are included in all applicable contracts

LLNS ensures all applicable contract actions—including task orders under new contracts and existing contracts—require to the extent possible, the supply or use of products and services that are energy-efficient (ENERGY STAR or Federal Energy Management Program [FEMP]-designated), water-efficient, bio-based environmentally preferable (including Electronic Product Environmental Assessment Tool [EPEAT]-registered products), non-ozone depleting, contain recycled content, or are non-toxic or less toxic alternatives. LLNL maintains affirmative procurement plans—also known as green purchasing plans or environmentally preferable purchasing plans—policies, and programs to ensure that all federally mandated designated products and services are included in all relevant acquisitions.

Performance Status

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' GPs 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) in order 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.). Based on these data, biobased contract actions in FY 2020 totaled 12, all attributed to compostable cafeteria products. It is anticipated that the biobased contract actions will be higher in FY 2021 depending on the full reopening of the two cafeterias and results of purchases for sustainable buildings.

Sustainable Acquisition Highlights

- EPEAT: 93% of all computers, monitors, imaging equipment, televisions, mobile phones, and servers purchased during FY 2021 successfully met the EPEAT bronze, silver, or gold criteria.
- LLNS continues to utilize sustainable integrated contractor purchasing team (ICPT) agreements. In FY2021 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 out of 15% recycled content material. During FY 2021, 3 purchase orders were awarded to Skolnik Industries totaling \$3,720.
- 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.
- 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 GPs are included in all purchase orders and subcontracts.

LLNS will conduct additional training to instruct TRRs on required sustainable acquisition purchases and investigate adding a mandatory entry in LINCS to indicated sustainable purchases.

LLNS will also continue to revise Standard Practice (SP) 23.5 as required and have each revision reviewed by an appropriate member of EFA. This will ensure all regulatory revisions, updates, and changes have been

incorporated and that the standard practice complies with LLNS' prime contract requirements. A representative from EFA reviews and updates the SP to ensure all appropriate regulations are cited. The revision to the SP will be processed and forwarded to the LLNS' contracting officer for their review and approval.

Resources Required

Business processes are in place for LLNL to meet this goal. Resources from the Supply Chain Management (SCM) department are required to ensure green-related clauses/articles are incorporated into purchase order and subcontract pro-forma documents and to update standard practices, as required.

Measures, Funding, and Training

Annual targets for sustainability investment with appropriated funds and/or financed contracts to be implemented in FY 2019 and annually thereafter

LLNS has engaged in energy performance contracts—most recently an ESPC—wherein new HVAC controls and WebCTRL software were installed in 24 facilities as part of ECM3.1, and 79 advanced electric meters and energy management software (EEM Suite) was installed as part of ECM3.2.

As stated in the energy management category, DDC HVAC controls were added to or expanded in 3 additional buildings to control temperatures, pressures, and humidity. 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 minimize discomfort and energy usage. In reviewing the building energy usage, a 4% reduction in electricity consumption was realized when comparing the usage to before the controllers were added.

The 3.3 MWP-V solar plant project on 10 acres in the northwest buffer zone started generating renewable electricity in February 2016. This is a PPA between PSEG Solar and WAPA. LLNL uses most of the produced renewable power with LBNL using 20% and SLAC using 7%. The plant is estimated to generate about 6M kWh of renewable electricity for LLNL annually and removes the equivalent GHG emissions of about 890 automobiles a year.

Challenges to Use of Energy Performance Contracts

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 and will be applied as appropriate.

Fugitives and Refrigerants

LLNL's Scope 1 emissions are the result of direct emissions associated with fuel combustion or fugitive emissions. LLNL's Scope 2 emissions are a result of indirect emissions associated with consumption of purchased or acquired electricity. All other potential Scope 2 emissions are not applicable to LLNL. Scope 1 and Scope 2 GHG emissions are offset by the estimated annual GHG emissions avoided by renewable energy produced on-site and reduced by purchased RECs.

LLNL's Scope 1 and Scope 2 emissions include:

- Natural gas fuel combustion for the generation of electricity, heat, cooling, or steam (e.g., boilers and furnaces).
- Fuel combustion (e.g., gasoline; E85, a blend of 85% ethanol and 15% gasoline; and diesel) in mobile sources including LLNS' GSA-leased vehicles, commercially leased, and agency-owned vehicles.

- Fugitive emissions from fluorinated gases and refrigerants including mixed refrigerants used in refrigeration and air conditioning equipment.
- Operation of the sewage lagoon at Site 300.
- Indirect emissions associated with electricity consumption.
- Estimated indirect emissions avoided by on-site clean renewable energy production (solar) and reduced by purchased RECs (emissions offset).

LLNS continues to assist DOE in working to achieve GHG reductions. LLNL's Site 200 and Site 300 major sources of Scope 1 and Scope 2 GHGs are influenced primarily by the management of electricity, natural gas, fossil fuels, and fugitive emissions—i.e., SF₆ and other fluorinated gases including refrigerants.

Factors influencing Scope 1 and Scope 2 emissions are addressed in the various activities and accomplishments described throughout this document, which include:

- Energy intensity reduction
- Renewable energy consumption
- Reducing fleet fuel use
- Metering
- Cool roofs
- Pollution prevention and waste reduction
- Sustainable acquisition and electronic stewardship

Performance Status

Fugitive GHG emissions contributed to 21% of LLNL's reported Scope 1 and Scope 2 GHG emissions for FY 2021. The largest contributor of fugitive GHG emissions is SF₆ primarily because of its extremely high global warming potential of 23,900 times that of carbon dioxide. Other fluorinated gases, including octafluorocyclobutane and refrigerants, are also significant contributors to LLNL's fugitive GHG emissions. Since 2010, LLNS has significantly raised the awareness on environmental issues with the continued use of SF₆. The *LLNL SF₆ Management and Capture Plan* (September 2015) documents ongoing SF₆ use, describes current and future efforts to minimize emissions to the extent practicable, and provides the basic framework for how LLNS plans and manages SF₆ operations with reduction goals in mind. As a result, FY 2021 fugitive GHG emissions have been reduced 21% from baseline 2008 fugitive GHG emissions. However, the year over year increase was 24% from FY 2020 due to purchases of SF₆, octafluorocyclobutanem (C318) and refrigerants R-134a and R-410A. SF₆ and C318 are primarily used as a dielectric material in high voltage equipment and accounted for 88% and 7%, respectively of FY 2021 reported fugitive emissions. Refrigerants are used in chillers and air conditioning units and accounted for 4% of FY 2021 reported fugitive emissions.

It is noteworthy that over 50% of the SF₆ purchased during FY 2021 is being stored for future use in the B190 accelerators and was not emitted during FY 2021. The estimate of actual SF₆ emission from the B190 accelerators is approximately 115 lbs over the past nine years. This is an annual SF₆ emission rate of approximately 13 pounds per year. This is an extremely low emission rate considering the accelerators' large full charge capacity of 13,600 lbs. The annual emission rate is less than 0.1% of the full charge capacity of the accelerators. The very low SF₆ emission rate can be attributed to the tight construction of the accelerators and the accelerator program's efforts to minimize SF₆ emissions. Efforts include the following:

- Using a hand-held leak detector to identify leaks. Leaks are typically very small requiring occasional tightening of flange bolts.
- During maintenance or repair operations requiring opening the small accelerators. Most of the SF₆ is recycled to a large outside storage tank that is used to charge the large accelerator when needed. The remaining SF₆ in the small accelerators is then recovered by a DILO SF₆ recovery cart.

- During maintenance or repair operations requiring opening the large accelerator. The SF₆ is transferred to the large outside storage tank through a system of piping, valves, vacuum pumps and compressors. The recovered SF₆ in the outside storage tank is then used to charge the large accelerator after the maintenance or repairs are completed.

The B190 accelerator program has also evaluated alternatives to SF₆ but there are no suitable alternatives to SF₆ at this time because of the very high voltages in the accelerators and their unique characteristics.

Also, over 95% of the octafluorocyclobutane purchased during CY 2021 is used as an insulating gas in experiments in B490 and B581. The octafluorocyclobutane used in B490 is recovered after each experiment using a DIL0 gas recover cart and very little if any of the gas is emitted. The octafluorocyclobutane used in B581 is not recovered and the gas is vented to the atmosphere after each shot. The actual octafluorocyclobutane emissions during FY 2021 were much less than the amount purchased.

The most significant contributors to the actual SF₆ emissions during FY 2021 were due to significant leaks originally identified during FY 2020 associated with two newly installed compressors at the Building 801 FXR (flash x-ray) system. Modifications to the SF₆ compressors to reduce the release of SF₆ to the atmosphere were completed in April 2021. The modifications included routing SF₆ released on the "high" pressure side of the compressors back into the low-pressure side of the compressors. The modifications were not successful and B801 FXR operations ceased on June 10, 2021. The program is currently in contract negotiations with the manufacturer to repair the compressors.

Regarding refrigerants, LLNS technicians who maintain, service, repair, and dispose of equipment containing refrigerants are certified as required by EPA regulations found in Code of Federal Regulation Title 40, Part 82, Subpart F. The purpose of these regulations is to minimize refrigerant emissions. The regulation was amended in November 2016 and placed greater emphasis on leak inspection, repair, and recordkeeping that began January 1, 2019, aiming to further minimize refrigerant emissions. GHG emissions from refrigerants decreased 9% year over year from FY 2020.

Plans and Projected Performance

LLNS has successfully reduced GHG emissions through aggressive reduction and management of fugitive emissions from equipment using SF₆. Personnel associated with the Building 801 FXR system are in contact with the compressor manufacturer to repair the leaks. Furthermore, efforts are underway to replace and upgrade fittings, manifolds, regulators, and distribution lines with the hope of reducing the current leak rate by 50% or more. LLNS is also in the process of reanalyzing its SF₆ inventory and its operations that use SF₆ with the goal of finding additional opportunities for SF₆ emission reductions.

Implementation of the amended federal refrigerant management regulation effective January 1, 2019 puts more emphasis on leak inspection and leak repair, which should help lower fugitive refrigerant emissions. Scope 1 and Scope 2 GHG reductions for FY 2021 and beyond will largely be dependent on Laboratory management of electrical energy because this is LLNL's largest contributor to Scope 1 and Scope 2 GHG emissions (Table 12).

An EMS GHG Emissions Reduction Action Plan is in place for FY 2022 focused on natural gas use reduction (e.g., replacing non-efficient boilers), gas insulated equipment (GIE) sulfur hexafluoride emissions management, and refrigerant management.

Table 12. Scope 1 and Scope 2 GHG emissions (MtCO₂e) by source.

Scope 1&2 GHG Emissions Breakdown			% Change From		
Categories	Baseline (FY2008)	FY 2020	FY 2021	Baseline	Last year
Facility energy	156,687.7	109,453.6	102,520.0	-34.6	-6.3
Non-fleet V&E fuel	0.0	0.0	0.0	N/A	N/A
Fleet fuel	1,773.0	1,124.6	1,124.6	-36.6	0.0
Fugitive emissions	34,946.7	22,428.2	27,788.7	-20.5	23.9
On-site landfills	0.0	0.0	0.0	N/A	N/A
On-site WWT	7.2	10.4	15.5	115.3	49.0
Renewables ^a (avoided)	0.0	0.0	0.0	N/A	N/A
RECs (subtracted)	0.0	(730.8)	(125.2)	N/A	-89.2
Total (MtCO₂e)	193,414.6	132,286.0	131,323.6	-32.1	-0.7

Note: Scope 1 and Scope 2 GHG emissions presented in this document are estimates. Actual Scope 1 and Scope 2 GHG emissions will be published in the final DOE Sustainability Dashboard.

The measures described in this document all have the potential to assist in GHG emission reductions, and they will be carried out if deemed economically feasible and supportive of mission. Future growth of LLNL continues to be centered on energy-intensive facilities and research including the NIF, HPC, and other program-related areas—all of which will increase LLNL’s GHG emissions. It should be noted that though LLNS has been successful with minimizing SF₆ emissions, this is only part of the picture and does not necessarily translate into overall GHG reductions.

LLNS will continue to maintain the SF₆ management and capture plan for managing SF₆ purchase, usage, and storage. Ongoing efforts to support SF₆ regulatory reporting include maintaining documentation on R&D uses and reporting emission data from electrical utility usage.

Resources Required

Most resources required to reduce LLNL’s overall Scope 1 and Scope 2 emissions are related to activities addressed under other goals, especially those related to energy intensity reduction and renewable energy use. LLNL can achieve additional emissions reductions by decreasing electrical energy consumption.

LLNS will continue to work on documenting and tracking SF₆ uses on-site. As the LLNL SF₆ management program becomes more developed, the number of projects where alternatives to SF₆ can be used becomes smaller. However, the remaining uses—specifically those in the high-voltage applications and accelerators—are typically characterized by robust containment and transfer systems that can detect significant releases fairly quickly. While the major users of SF₆ may not be able to eliminate the use of SF₆ in the near future, program management and researchers need to continue to ensure that the gas is used in a manner that minimizes the amount released.

Travel and Commute

Scope 3 includes all indirect emissions not included in Scopes 1 and 2. Employee commuting and business air travel—along with transmission and distribution (T&D) losses associated with electricity use—continue to account for most Scope 3 emissions. LLNL’s Scope 3 emissions are offset by the estimated annual GHG emissions associated with T&D losses that were avoided by purchased RECs.

LLNL Scope 3 GHG emissions include:

- Employee commuting
- Employee business travel
 - Air travel
 - Rental or privately-owned vehicle mileage
- Off-site (contracted) domestic wastewater treatment
- Off-site municipal solid waste disposal
- Electrical T&D losses
- Estimated avoided T&D losses associated with purchased RECs (emissions offset)

Performance Status

In FY 2021, the Laboratory maintained an overall reduction of 65% in Scope 3 GHG emissions from the FY 2008 baseline and reduced Scope 3 GHG emissions by 43% year over year from FY 2020 (Table 13). Contributing factors to this year’s emissions reduction relative to FY 2008 include a reduction in all Scope 3 categories primarily due to the reduced on-site work force and activities due to the COVID-19 pandemic. Similarly, the 43% decrease from FY 2020 is largely due to the reduced on-site work force and activities due to the COVID-19 pandemic.

Table 13. Scope 3 GHG emissions (MtCO2e) by source.

Scope 3 GHG Emissions Breakdown			% Change From		
Categories	Baseline (2008)	FY 2020	FY 2021	Baseline	Last Year
T&D Losses	8,624.1	4,416.8	4,118.9	-52.2	-6.7
T&D RECs Credit	0.0	2,280.3	1,276.9	N/A	-44.0
Air Travel	9,709.0	4,425.0	1,362.7	-86.0	-69.2
Ground Travel	1,217.7	821.2	1,466.2	20.4	78.5
Commute	25,708.0	15,610.3	7,103.9	-72.4	-54.5
Off-site MSW	729.8	732.1	675.4	-7.5	-7.7
Off-Site WWT	19.6	11.5	5.2	-73.5	-54.8
Total (MtCO2e)	46,008.2	28,297.2	16,009.2	-65.2	-43.4

Note: Scope 3 GHG emissions presented in this document are estimates. Actual Scope 3 GHG emissions will be published in the final DOE Sustainability Dashboard.

Plans and Projected Performance

For Scope 3 emissions reductions LLNS will continue to focus on opportunities to reduce employee commuting and business travel. Efforts related to Scope 3 emissions reductions will also be impacted by electrical energy use. Annual GHG emissions due to T&D losses associated with electrical energy use are a significant contributor to Scope 3 emissions. LLNS will continue the employee electric vehicle program and add additional charging stations as funding allows.

LLNS implemented a new hybrid telecommuting policy where many employees work more at home and less onsite than prior to the pandemic. This will result in lower GHG emissions due to commuting as LLNL returns to a new normal posture.

Resources Required

Normal business processes are in place for this goal.

Electronic Stewardship

Acquisition Strategies Performance Status

Performance Status

Each fiscal year, LLNL is tasked with purchasing EPEAT-registered products. To monitor success against this goal, LLNL's SCM department requires the major suppliers of desktops, laptops, computer monitors, imaging equipment, and televisions to issue EPEAT reports on a quarterly basis directly to the EFA representative and the contract analyst. Receipt of these detailed reports assists EFA in analyzing and projecting the total EPEAT buys throughout the fiscal year.

During FY 2021, the overall percentage of EPEAT (gold, silver, or bronze) desktop electronics, imaging equipment, mobile phones, television, and server buys was 93% for the year. Specific data are included in the dashboard.

Plans and Projected Performance

LLNL will continue to review requisitions to see where EPEAT-related products can be substituted for non-EPEAT requirements. LLNL will also continue to mandate that blanket agreement suppliers Holman's, The Office City, and Perfect Output submit quarterly reports that identify all EPEAT equipment acquisitions placed under these agreements. This data will be used to monitor performance and allow LLNL to adjust where necessary to assist in meeting the goal.

Operations Strategies - Power Management

Performance Status

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.

Plans and Projected Performance

LLNS 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.

Operations Strategies - Automatic Duplexing

Performance Status

At the beginning of Q2 FY 2021, LLNS implemented a new MPS contract, with all eight Directorates participating in the MPS program. LLNS' MPS Blanket Agreement states that at a minimum, all multifunction devices and printers purchased under the agreement must possess duplex printing capabilities. The MPS vendor does not install all devices; however, when they do the installation, they are directed to configure devices to default to duplex printing.

The new Agreement also supports additional sustainability and environment stewardship efforts such as sustainable offerings (bio-based cartridges, remanufactured toner/containing recycled content); and new EPEAT requirements and Energy Star Qualified products.

During FY 2021, LLNS continued various initiatives to reduce paper usage and streamline process workflows. Some initiatives include, working with the Weapons and Complex Integration Directorate to test new software which will enable users to track all multifunction devices and printers, secure print release, and control and report usage; and identifying devices which do not have duplex capabilities and setting capable devices to duplex/monochrome printing. LLNS continues to work with the new Print Management Services supplier to evaluate different business solutions in an effort to eliminate process steps associated with scanning and printing.

Plans and Projected Performance

Baseline data for *open* network devices were collected throughout FY 2021 to evaluate the impact on duplex rates resulting from machine refresh printing. Data will continue to be collected in the pilot area(s) and contrasted to existing machine data and results will be used to develop awareness, training, and configuration initiatives.

Future and ongoing plans include collaboration efforts to phase out single-function printers; drive printing toward duplex/monochrome printing; evaluation of new software for enhanced consumption data collection and reporting; low toner alerts and thresholds; and other innovative solutions to help optimize and streamline document-intensive business processes throughout the Laboratory.

End of Life Strategies

Performance Status

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.

LLNS continually looks for new opportunities to reuse or recycle electronics. DUS 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 5,900 items with an estimated value of \$464,500 were reused through the STARS during FY2021.

Plans and Projected Performance

The electronics recycling market has seen significant changes over the last few years and LLNS has had to adjust to this changing market. In the past, LLNS received money for recyclable electronic assets but paid for recycling during the last two years. For FY2021-2022 LLNS negotiated a zero funds arrangement with a new vendor who can offset their costs by selling the metals, etc. from the items the lab sends to them. The lab anticipates a savings of approximately \$75k annually based upon the last two years average expense under the previous vendor. LLNS will continue to track reuse and recycle electronic devices and encourage reuse through online mechanisms and the Laboratory's STARS.

Data Center Strategies

Performance Status

DOE Data Center Optimization Initiative (DCOI)

In 2016, the DOE established a Data Center Working Group to review data center facilities across the complex. This working group has amended the definition of a data center for reporting purposes and established reporting metrics. LLNS has since completed a comprehensive data center inventory based on these new criteria. LLNS is currently evaluating options for the consolidation or closure of 16 existing unclassified data centers by adoption of a cloud smart policy or migrating hardware to more optimized data centers within the LLNL inventory.

Energy Performance

LLNS uses the Power Usage Effectiveness (PUE) metric to measure HPC data center energy performance. The power is monitored using utility meters at each secondary main circuit breaker downstream of high voltage transformers. This data is logged and trended in a program called PI Vision by OSIsoft. Knowing the loads of these transformers, the PUE of the facilities is calculated using this program.

Specifications for new electrical distribution switchboards include submetering equipment enabling LLNS to gather additional data, and better track the efficiency of systems under varying conditions.

The energy usage is reported quarterly to DOE using the eDARS system.

Plans and Projected Performance

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).

LLNS will continue to optimize the efficiency of HPC with the Sierra and Lassen platforms. A combination of liquid-cooling and air-cooling techniques will be used for cooling with higher temperature American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) W3 water being used to improve energy efficiency without the use of chillers. In addition to Sierra and Lassen, LLNS continues to optimize the efficiency of HPC with other platforms that are also liquid cooled. This is being accomplished through the CTS-2 procurement slated for delivery of machines in FY 2022.

LLNS is heavily involved in the Energy Efficiency HPC working group (EEHPCWG), which participates in many HPC events and LLNS co-leads the group. 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.

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. LLNL is involved in a number of 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.

Optimization Efforts

To meet the demands of supercomputing, LLNS developed a road map to expand the missions of the Laboratory to be able to remove uncertainty with more computer horsepower over time. The strategic vision ensured that codes, system architecture and facilities were equally considered to ensure a successful outcome for future HPC systems. A HPC facility master plan was created in 2008 to evaluate facility endurance level across all HPC facilities. A recent example of optimization and consolidation efforts were realized at B439. This facility was determined to be a candidate for revitalization to provide secondary computing. Its infrastructure was over 40 years old and antiquated for future systems. With the power and cooling improvements provided through the B439 Upgrade for Computing Consolidation project, the facility provides for 1.5 MW of HPC with the ability to scale to 3 MW, 270 tons of cooling for air cooled systems and 650 tons of cooling for liquid cooling systems. This project will allow computing to continue to expand mission for the next several generations of supercomputing.

LLNS also continues to install Tier III systems that allow higher temperatures of water to the HPC systems eliminating the need for chillers and pumps. LLNSL deployed Tier III water at B654 through the LCW project, and at B453 through various projects and will soon commission an 18,000-ton cooling tower as well.

Resources Required

Normal business processes are in place for LLNS to continue server consolidation efforts. Funding will be requested for optimization efforts required to bring enduring data centers to performance targets.

Organizational Adaptation and Resilience

Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols

Overview

LLNL is committed to be a leader in responsible environmental stewardship and so incorporates pollution prevention, resource conservation, and sustainable acquisitions into planning and decision-making processes. The Laboratory complies with all applicable environmental requirements, and ensures that interactions with regulators, DOE, and the community are based upon integrity, openness, and adherence to national security requirements. Through LLNS' existing environmental policy, the Laboratory commits to continuously improve environmental performance.

There were no changes specifically to site resilience measures due to the COVID-19 pandemic, however the pandemic did continue to affect site operations during FY2021. In response to this impact, LLNS maintained and improved many of the tools developed in FY 2020 and created new tools to support employees while staying all-in on mission commitment. The Return to New Normal (RTNN) approach was developed to make flexible, hybrid work a sustainable part of LLNL's future. Telecommuting principles and individualized telecommuting agreements were developed, frequently asked questions were addressed on an ongoing basis, and the Laboratory Director kept employees updated on all relevant issues. A website was created as a go-to place for employees to access RTNN-related news, updates, information, and resources as the Laboratory increased the on-site population and created a "new normal" hybrid work environment.



Photo 1. Wildfire damage at Site 300.

Wildfire risk is an annual reality for LLNL's Site 300, which sits in the California grassland's fire-prone ecosystem. A 2017 wildfire scorched grass and trees but did not impact facilities due to the capable response from emergency management and fire crews. In accordance with integrated safety management system (ISMS) practices, LLNS takes an integrated approach to continuous improvement procedures and policies—ensuring the Lab's resiliency to the impacts of climate change. (Photo Credit: Lisa Paterson/LLNS)

Performance Status

The Laboratory is actively considering the impacts on mission, workers, and physical property projected to result from sea-level rise, increased precipitation, extreme temperatures, flooding, drought, and extreme storm events. According to the National Climate Assessment, the Southwest region is projected to experience an increase in the number of extreme heat days, a reduction in snowpack, and an increase in wildfire risks as a result of climate change. These risks in particular continue to have an apparent and immediate potential to impact LLNL operations and mission (Photo 1).

The number of extreme heat days and the number of cooling degree days experienced at LLNL are also anticipated to increase due to climate change. While this has not yet had a substantial or lasting impact on operations, increases in the number of extreme heat days and changes in the number of cooling days would likely—over the long-term—increase cooling needs in facilities at both sites. Increases in cooling needs would result in increasing costs on-site and create a greater potential for blackouts or brownouts of the electrical grid. LLNS continues to maintain and replace HVAC systems as practicable—thus improving energy usage and system reliability. See Category 1, Energy Management, for a list of recent DDC and HVAC upgrades. LLNS' emergency preparedness actions include practicing for the potential for extreme heat to impact workers. LLNS conducts training for workers that includes strategies for the prevention of heat illness with work-rest regimens.

Climate change impacts are anticipated to include more frequent and severe droughts, and a reduction in snowpack. Current plans for maintenance and upgrades to the aging LLNL utility system would support reducing unnecessary water consumption that results from leaks and breaks and increase the reliability of the water supply for both sites. Modifications planned for Site 300 and the Site 200 drinking-water systems

would also increase the reliability of LLNL's supply. LLNS continues to explore ways to adapt to long-term water shortages including using treated wastewater for make-up water at certain cooling towers, treated-ground water for cooling tower make-up, and strategically replacing turf-grass with drought tolerant and native landscaping.

Plans and Projected Performance

LLNS' existing emergency management and response-planning considers a breadth of situations including those that may result from near-term climate impacts. A comprehensive approach to considering the long-term risks from climate change as they relate to physical property, mission, and workers may be taken as funding and resources allow. In accordance with underlying ISMS procedures for continual improvement, LLNS will continue to identify existing resilient actions and areas for increasing actions to build resilience against predicted climate threats.

As required by the DOE Climate Assessment and Resilience Plan (CARP) LLNS has identified a team of subject matter experts to develop a Vulnerability Assessment and Resilience Plan (VARP). LLNS will also continue to identify and update policies as they relate to climate change.

LLNS also has volunteered to pilot test the Technical Resilience Navigator (TRN) tool and has established a team, begun to engage stakeholders, collect and review relevant information, define priorities and scope and boundaries, and identify critical functions. The TRN team plans to meet routinely and use the data collected using the TRN to support the Laboratory's development of the VARP over the next year.

Update emergency response procedures and protocols to account for projected change, including extreme weather events

LLNL currently incorporates into its emergency response program a broad range of hazards and environmental aspects, potential consequences, and lessons learned from simulated and actual emergencies. Simulated emergencies are practiced under varying conditions at both the Livermore site and Site 300 to address the broad range of hazards. Additionally, through the general security policy and the security-risk management policy, LLNL will follow DOE directives and federal law to protect DOE/NNSA interests against a wide range of threats.

Performance Status

In some cases, proactive ongoing activities at LLNL already serve to address risks from potential climate hazards. For example, the Site 300 annual prescribed burn minimizes risks to assets from wildfires. As climate models predict more extreme droughts that persist for longer than normal periods of time, the risks from wildfires to Site 300 and Site 200 assets may increase beyond those experienced in previous years.

Since 2019, due to increased wildfire risk, PG&E, the main electric power provider for Site 300, began the Public Safety Power Shutoff (PSPS) program to proactively shut down power during extreme weather and/or wildfire danger. Power shutdowns may occur for as long as 96 hours, affecting Laboratory operations. Although Site 200 is not served exclusively by PG&E, it increases vulnerability when redundant PG&E power is unavailable. LLNS has developed plans to ensure critical systems at the Laboratory remain operational during outages and is implementing measures to reduce electricity use during periods of extreme heat.

Plans and Projected Performance

Changes in the earth's climate patterns promise lasting, impactful alterations to LLNL operations. While the Laboratory is in the process of completing a full vulnerability assessment, LLNS has identified that any projected climate hazard could impact circumstances surrounding emergency situations, the way the Laboratory responds to emergencies, or the extent of the emergency. The frequency with which the

Laboratory may need to address emergency situations that are associated with droughts and heat waves may increase as the impacts from climate hazards increase.

Ensure workforce protocols and policies reflect projected human health and safety impacts

LLNS' existing workforce protocols and policies reflect the value of each worker returning home daily at end of shift in the same or better condition than when they arrived at work (Photo 2). This sweeping approach to health and safety allows for adaptation for the impacts of climate change, such as heat stress or other environmental factors.



Photo 2. Workers review project requirements before starting work.

(Photo Credit Paul Hara/LLNL, photo taken prior to FY 2020 and COVID-19 control requirements)

Performance Status

LLNS has committed to protecting workers and the public through the occupational health and safety management system (OHSMS). The Laboratory's ES&H requirements and safe work practices maintain compliance with federal, state, and local regulations. LLNS is dedicated to improving health and safety performance and to creating a workplace that is safe, healthy, and injury-free. Though not initiated with the intent of addressing climate change impacts, the Laboratory's existing protocols and policies fully support addressing projected human health and safety impacts of climate change.

Plans and Projected Performance

LLNS continues to consider impacts on worker safety and health from climate change related risks. As these events become more likely and new climate patterns emerge, LLNS may need to consider short-term impacts, as well as the long-term projections and implications of climate change on worker health at work and outside of work, and to enhance protocols and policies to protect LLNS' workforce. Higher temperatures associated with climate change could lead to increases of heat stress for outdoor workers and cause raised levels of ground-level ozone that leads to worsened air quality. Greater risk of wildfires will continue to affect air quality at the Site 200 and Site 300. Exposure to wildfire smoke is linked to increased

incidences of respiratory illnesses (Reid et al. 2016)¹, which has led to yearly outdoor work restrictions since 2017², and the first ever closure of LLNL for non-essential personnel in 2019 for several days.

Ensure site/Lab management demonstrate commitment to adaptation efforts through internal communications and policies

The Laboratory has demonstrated its commitment to environmental stewardship and to protecting workers and the public through both its existing environmental policy and its existing health and safety policy, respectively. Through EMS and OHSMS, LLNS management demonstrates a strong commitment to the policies, and consistently communicates internally to the Laboratory personnel.

Performance Status

Existing LLNS policies were not initiated due to climate-change hazards and impacts, but have established a culture of demonstrating management’s commitment to environment, health, and safety. The LLNL director introduces the annual ES&H briefing for all employees. All ES&H action plans are reviewed and approved by the LLNL deputy director.

Plans and Projected Performance

LLNS management will continue to demonstrate commitment to environmental stewardship and worker safety and health (Photo 3). As needed, LLNL management may consider issuing internal communications or updating policies relating to adaptation efforts.



Photo 3. The LLNL Site 300 work release meeting enables management and workers to discuss activities each morning and ensures safe work conditions.

(Photo Credit Paul Hara/LLNL, photo taken prior to FY 2020 and COVID-19 control requirements)

¹<https://ehp.niehs.nih.gov/doi/10.1289/ehp.1409277>

²<https://bit.ly/2QzTMcu>

Ensure that site/Laboratory climate adaptation and resilience policies and programs reflect best available current science, updated as necessary

LLNS works to anticipate, innovate, and deliver solutions for the nation's most challenging security problems, including those that relate to energy and environmental security. LLNS scientists and engineers comprise those working on the front lines to advance climate science (Photo 4).



Photo 4. An LLNL worker sets up equipment as part of research on carbon capture.

(Photo credit: Jackie McBride/LLNL, photo taken prior to FY 2020 and COVID-19 control requirements)

Performance Status

LLNL applies the best available science in all decision making. LLNL's Program for Climate Model Diagnosis and Intercomparison (PCMDI) develops improved methods and tools for the diagnosis and comparison of general circulation models that simulate the global climate. PCMDI also supports modeling studies initiated by the World Climate Research Programme (WCRP). PCMDI contributed to the work for which the Intergovernmental Panel on Climate Change (IPCC)—who reports on scientific conclusions from climate-change modeling—was awarded the Nobel Peace Prize in 2007.

Plans and Projected Performance

Climate adaptation and mitigation is an LLNL mission focus area that is directly related to our current and future sustainability performance. Significant institutional resources, including both internal investments and competitive awards, focus on furthering the scientific, engineering, and multi-disciplinary understanding of climate change, its impacts to the human and built environments in which we live, and the mitigations and adaptations necessary to ensure national security. LLNL's deep subject matter expertise in this area ranges from climate and carbon science to infrastructure resilience and technology scale-up. Combining this deep expertise with broad multi-disciplinary analysis capability enables application of cutting-edge climate, energy, and infrastructure expertise to LLNL's national security mission and operations. Future years' planning includes deepening integration of our climate adaptation and mitigation mission area with our operational function and enabling real world deployment of cutting-edge science and engineering throughout the LLNL site.