



# Executive Summary

Lawrence Berkeley National Laboratory (Berkeley Lab) addresses the world's most urgent scientific challenges by advancing sustainable energy, protecting human health, creating new materials, and revealing the origin and fate of the universe. Founded in 1931, Berkeley Lab's scientific expertise has been recognized with 13 Nobel prizes.

Berkeley Lab is a U.S. Department of Energy (DOE) Office of Science laboratory that focuses research to address pressing and profound scientific problems facing humankind. Berkeley Lab's research includes many programs focused on sustainability problems, including the Sustainable Science and Carbon Cycle 2.0 initiatives. Berkeley Lab's Operations units also focus to advance sustainability, with the Facilities Division having a central role in building, modernizing and maintaining sustainable mission-ready facilities to support research.

This report is a compilation of narratives that tell the stories of a diverse group of sustainability projects finished by the Facilities Division. The projects range from the installation of energy efficient technologies in buildings to optimizing recycling opportunities at the Bevatron demolition site. These successes depend on Berkeley Lab's reliable, dedicated Facilities personnel — some of whom are featured throughout this report — who cost-effectively and smoothly carry out these sustainability projects. Berkeley Lab has implemented sustainability measures and accomplished goals, but if still has more to accomplish. With future collaboration among scientists, personnel from Operations divisions, and other Lab employees, Berkeley Lab will not only be world-renowned for science, but for sustainable science.

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## Letter from the Facilities Division Director

As Director of the Facilities Division, I am proud of the work that we do to support the phenomenal science at Berkeley Lab. Surrounded by world-class researchers and scientists, the standards are high to deliver facilities and grounds that do not impede, but rather enhance, the work occurring on site. Much of this research and development contributes solutions to the globe's current problems that impact human health and the environment.

The Facilities Division does its part to contribute to this effort with sustainability measures that reduce the environmental impact of Berkeley Lab facilities and operations. The process has been interesting and fulfilling. As a national laboratory, our first level of sustainability measures answers President Obama's Executive Orders and Department of Energy Secretary Chu's Departmental Orders. We have implemented policies and systems to ensure that we achieve, and surpass, the goals outlined in these orders, and our customers have responded positively.

The Berkeley Lab sustainability folks have achieved the sustainability goals in a time of limited budgets. The work occurs thanks to a team of sustainability conscious scientists and staff collaborating to design and implement programs, policies, and facilities to reduce resource use and pollution attributable to Berkeley Lab.

With sustainability becoming more and more entrenched in Facilities Division processes and work, we look forward to building and maintaining this Lab as a thoughtful, sustainable institute performing excellent science.

*Jennifer S. Ridgeway*

Goats annually graze Berkeley Lab's hillside grasses and shrubs with agility and ease. They are one of the many strategies of Berkeley Lab's vegetation management program, which also maintains a successional mosaic of plant communities and maintains safe tree stands. All of these strategies reduce the risk of intense, high-temperature wildland fires.

# Overview of Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory is supported by the U.S. Department of Energy (DOE), through the Office of Science, and is operated by the University of California. Berkeley Lab has a history of excellent science with 12 Nobel Laureates and 57 members of the National Academy of Sciences.

Berkeley Lab is guided by its mission: "Bringing science solutions to the world."<sup>1</sup> Director Paul Alivisatos, Ph.D., leads Berkeley Lab with a team of division directors who oversee the science and operations offices of the Lab. Fourteen science divisions devote public and private funds to solving global problems through excellent science, research and development. Eight divisions and departments, including the Facilities Division, Environmental Health and Safety Division, Human Resources Department, Information Technology Division, and more, complete Berkeley Lab's operations work.

Berkeley Lab is located in the San Francisco Bay Area in the hills above the UC Berkeley campus. It employs over 4,000 scientists, researchers, and staff and annually hosts over 5,000 visiting and guest scientists at six major national user facilities. Berkeley Lab influences the local economy through job creation and technology start-up successes.

## *Environmental Stewardship*

As part of the DOE, a federal agency, Berkeley Lab must comply with Executive Orders and Departmental Orders, goals, and policies. For example, DOE releases an annual Strategic Sustainability Performance Plan, which outlines the goals and strategies of the DOE to achieve aggressive goals to reduce resource use, emissions, and pollution in cost-effective ways while fulfilling the agency's mission. The Office of Science is taking a portfolio approach across its sites to achieve each of these goals, and Berkeley Lab is supporting that approach through its science, facilities, and operations.

As part of these efforts, Dr. Alivisatos implemented a Lab-wide science campaign called Carbon Cycle 2.0, which focuses research on the issues related to the natural carbon cycle. This research will help to answer the questions and solve the problems facing the globe related to Earth's carbon cycle and climate change. Simultaneously, Dr. Alivisatos encouraged the Sustainable Science Initiative, which ensures that the world-class science of Berkeley Lab is done in sustainable facilities and with the support of sustainability policies and programs.



The Facilities Division is the home for Berkeley Lab's energy manager/sustainability coordinator and plays a major role in the Sustainable Science Initiative. Not only do Facilities personnel build and maintain Berkeley Lab facilities and grounds, they also provide utilities and logistical support that allow the Lab to fulfill the Mission Readiness needs of researchers and staff.

In addition to the work of the Facilities' Division, Operations units are key to the success of Berkeley Lab sustainability. The Office of the Chief Financial Officer oversees the procurement of environmentally conscious products and services, called sustainable acquisition. The Environmental Health and Safety Division oversees the Environmental Management System, which tracks progress towards achieving compliance with various sustainability and environmental metrics. These metrics provide the backbone of the sustainability program, which continuously evaluates operations and services to reduce Berkeley Lab's environmental footprint. A coalescing group, called the Sustainability Transformation Team, allows scientists from Environmental and Energy Technologies and other research Divisions to come together with staff from Facilities and other Operations Divisions to discuss common interests and sustainability opportunities. The combination of these efforts from a variety of divisions allows Berkeley Lab to achieve ambitious sustainability goals.

<sup>1</sup>"Our Mission," Lawrence Berkeley National Laboratory, accessed September 19, 2011, <http://www.lbl.gov/LBL-Programs/>

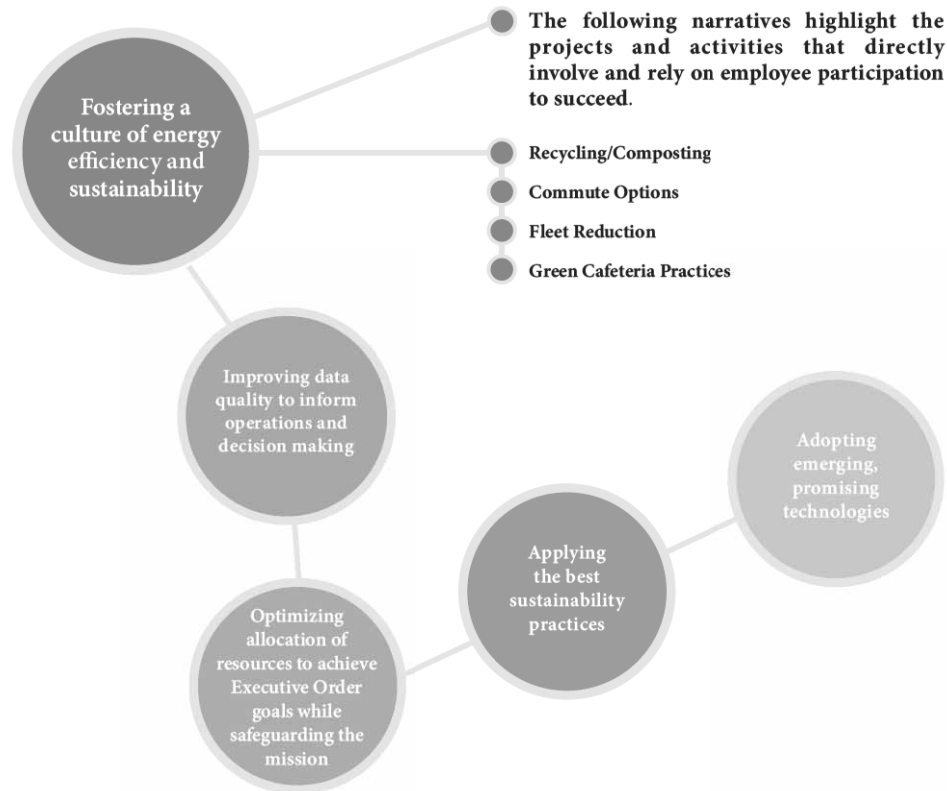


Berkeley Lab Director Paul Alivisatos

# Sustainability Success

The following sections show a cross-section of sustainability achievements at Berkeley Lab. They are categorized under the five objectives of the DOE's Strategic Sustainability Performance Plan (SSPP), the summary document that states the Department's sustainability goals and priorities and those of each of its sites. Throughout this document, Facilities Division employees are featured to provide a glimpse of the many personnel who help Berkeley Lab achieve sustainability goals.

The first objective of the DOE's SSPP is to ensure that DOE culture encourages energy efficiency and sustainability. Any organization must rely on its employees to take the responsibility and ownership of reducing their resource use and sustainability behavior. Regardless of the type of work, this entails daily thoughtfulness to conserve energy and minimize the fiscal, social, and environmental costs associated with work.



The cooperation of Berkeley Lab employees has been critical to the success of its recycling program. In buildings throughout the 200-acre campus and at satellite facilities, waste is routinely deposited in bins marked for recycling, composting, or trash. Procurement policies are also in place to encourage less landfill waste generation in packaging materials.

## Recycling/Composting

San Francisco Bay Area cities boast some of the highest recycling rates in the United States. As a member of that community, Berkeley Lab is not just playing a part in promoting diversion of solid waste from landfills; it is playing a leading role.

President Obama's Executive Order 13514 called for diverting 50 percent of non-hazardous, non-construction waste by 2015. Berkeley Lab has already met this goal. On a monthly basis, diversion rates range from 45 percent to 60 percent. Over a 12-month period ending in June 2011, approximately 1,150 tons of non-hazardous, non-construction waste

were generated, and 53 percent of it was diverted from landfills. More than 30 tons of it were composted; nearly 580 tons were recycled.

Berkeley Lab is not only successfully recycling waste, it is promoting the reuse of materials that might otherwise be thrown away. At the same time waste diversion rates were increasing, the total amount of waste generated fell by about one-third. Lab-wide efforts are underway to produce less waste. For example, the furniture reuse warehouse allows Lab organizations to "test-drive" furniture without financial risk. It salvages useful resources, reduces waste, and saves money.

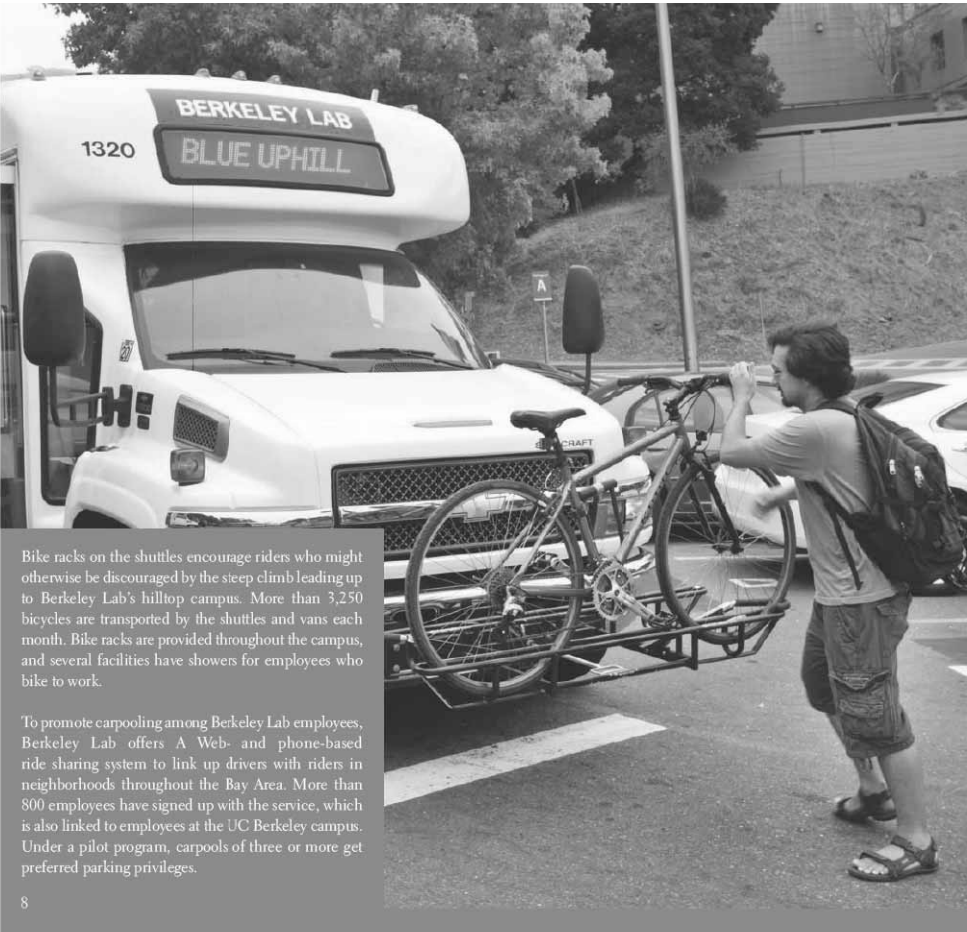
# Commute Options

For the 4,000 employees of Berkeley Lab, the journey to a sustainable energy future often begins early in the morning, on their commute to work. Almost half the employees at the Lab get to their jobs using mass transit, shuttle buses, carpools, bicycles, or a brisk walk — alternatives to driving to work alone.

Berkeley Lab has instituted several measures to add convenience for commuters who choose not to drive. A fleet of shuttle buses has long been at work taking scientists and support staffs to their labs and offices. The buses serve both the main Berkeley Lab campus and satellite facilities and make frequent and regular stops at transit hubs for train, bus, and BART service throughout the Bay Area. Lab employees

can pay for mass-transit using pre-tax dollars through a payroll deduction plan. A Web and phone-based GPS tracking system gives riders live updates on shuttle arrival and departure times. For employees who work late, a free taxi service is available for trips to mass transit sites and satellite facilities after the shuttle bus system shuts down.

Since 2010, an outside contractor has provided shuttle bus service. After bus stop waiting times were reduced to 10 minutes during the workday, ridership increased 15 percent, to approximately 58,500 rides per month. The new fleet of shuttles includes 13 buses powered by biodiesel and four vans powered by E-85 ethanol (85 percent ethanol), an alternative fuel.



Bike racks on the shuttles encourage riders who might otherwise be discouraged by the steep climb leading up to Berkeley Lab's hilly campus. More than 3,250 bicycles are transported by the shuttles and vans each month. Bike racks are provided throughout the campus, and several facilities have showers for employees who bike to work.

To promote carpooling among Berkeley Lab employees, Berkeley Lab offers a Web- and phone-based ride sharing system to link up drivers with riders in neighborhoods throughout the Bay Area. More than 800 employees have signed up with the service, which is also linked to employees at the UC Berkeley campus. Under a pilot program, carpools of three or more get preferred parking privileges.

# Fleet Reduction

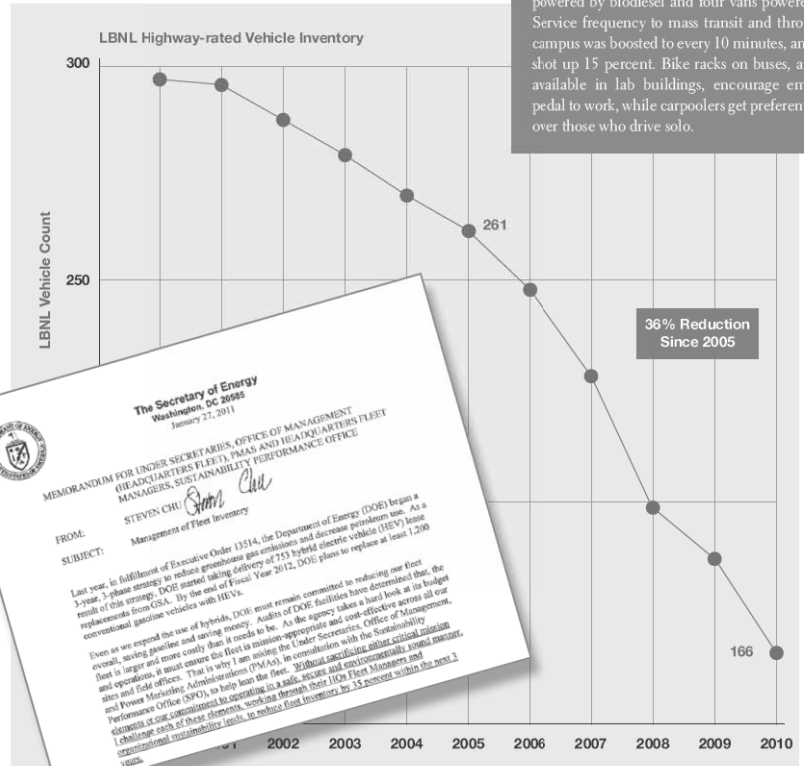
Here is a quick way to trim fuel costs for fleets of government vehicles: Reduce the size of the fleets. Berkeley Lab has done so, in short order, and is leading the nation in that effort.

By the end of 2010, the Lab operated only 166 highway-rated vehicles, down 36 percent from 2005. That was when Nobel Laureate Steven Chu, director of Berkeley Lab at the time, decided there were too many cars, trucks, and buses on site and ordered a systematic reduction.

After Chu was named Secretary of Energy by President Barack Obama, the fleet-reduction goal set at Berkeley Lab became policy for the Department of Energy (DOE). By 2014, all DOE facilities are required to trim their fleets by 35 percent from the baseline year 2005.

Fleet reduction was accomplished by returning cars and trucks to the General Services Administration and by tightening the rules for use of the Lab's vehicles. Staffers who wish to obtain a government vehicle must first ask permission of the fleet manager, with final approval required from the Chief Operating Officer. Those needing to travel offsite in lab vehicles are asked to carpool together.

Today, Berkeley Lab's fleet is not only smaller, but increasingly is powered by non-petroleum fuels. Sustainability plans at Berkeley Lab call for all Lab-owned vehicles to run on alternative fuels by 2020. Currently, one-in-four fleet vehicles is electric-powered. Half of the remaining vehicles run on E-85 (85-percent ethanol), supplied by an on-site ethanol pump.



Berkeley Lab is served by a fleet of 13 shuttle buses powered by biodiesel and four vans powered by E-85. Service frequency to mass transit and throughout the campus was boosted to every 10 minutes, and ridership shot up 15 percent. Bike racks on buses, and showers available in lab buildings, encourage employees to pedal to work, while carpools get preferential parking over those who drive solo.

## Green Cafeteria Practices

Every lunch hour at Berkeley Lab, as many as 1,200 employees and visiting scientists converge on the Bay View Café, a cafeteria where sustainability is valued just as much as the freshness of the vegetables in the salad bar.

Sustainability begins with the food itself: daily offerings of fresh, natural, and organic entrees purchased from local farms and prepared from scratch.

Back in the kitchen, every food preparation station features recycling and compost bins. There's also a trash can for items that can't be recycled or

composted, but it takes a long walk across the room to reach it — just another incentive to think green. Forty-five tons of cafeteria waste were composted during 2010.

Cafeteria compost isn't limited to food waste and paper napkins. The Lab's clear plastic cups, straws, lids, and flatware are made from corn and are 100 percent compostable. While most paper goes to compost, cardboard packing material is recycled, as are glass bottles and aluminum beverage containers.



On the Bay View Café loading dock is a 55 gallon drum that collects canola oil from the deep fat fryers as well as bacon fat and other kitchen grease. Once a month, the drum is shipped to a nearby East Bay biodiesel oil refinery, where it is made into biodiesel fuel — the same type of fuel that powers the Berkeley Lab fleet of shuttle buses.

Berkeley Lab was fortunate to find a sustainability-minded vendor to recently take over the cafeteria. Café operator, Epicurean Group, is "Green Certified" by the Association of Bay Area Government's Green Business Program, and is continuing and improving previous sustainable practices at the cafeteria.

## Meet Facilities Folks

### Sheree Swanson

#### Project Director

Aligned with the goals of the Facilities Division, Sheree Swanson does her part to "deliver buildings that are energy efficient, sustainable and aligned with the alternative energy research mission." Part of her work is to coordinate and oversee the demolition of Old Town buildings and the environmental remediation of the site. Berkeley Lab demolition projects, more appropriately called deconstruction projects, have a waste diversion goal of 75 percent for non-hazardous, non-contaminated waste. The Old Town project has met this goal with ease, thanks to both the project's focus and the industry's evolution that now includes an increased attention to sustainable building materials and conscientious waste diversion.

Sheree also oversees the design and upcoming construction of the Solar Energy Research Center (SERC), a future showcase that will incorporate several sustainability features such as sustainable materials, solar panels, a green roof, and regenerative elevators. On projects like these, she likes to collaborate with researchers from the Environmental Energy Technologies Division, who are good resources to share information about emerging technologies and processes that will make for showcase buildings.

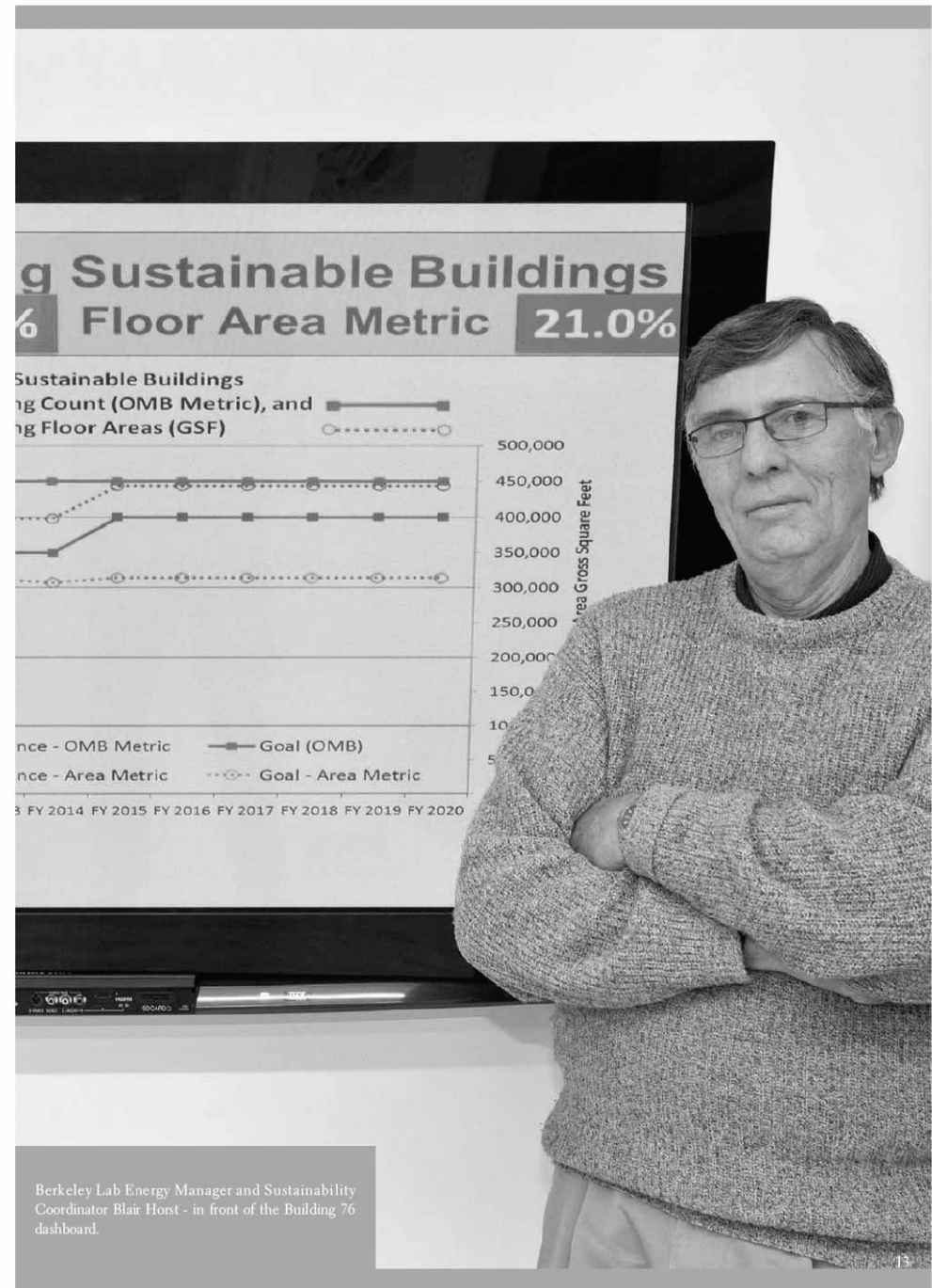
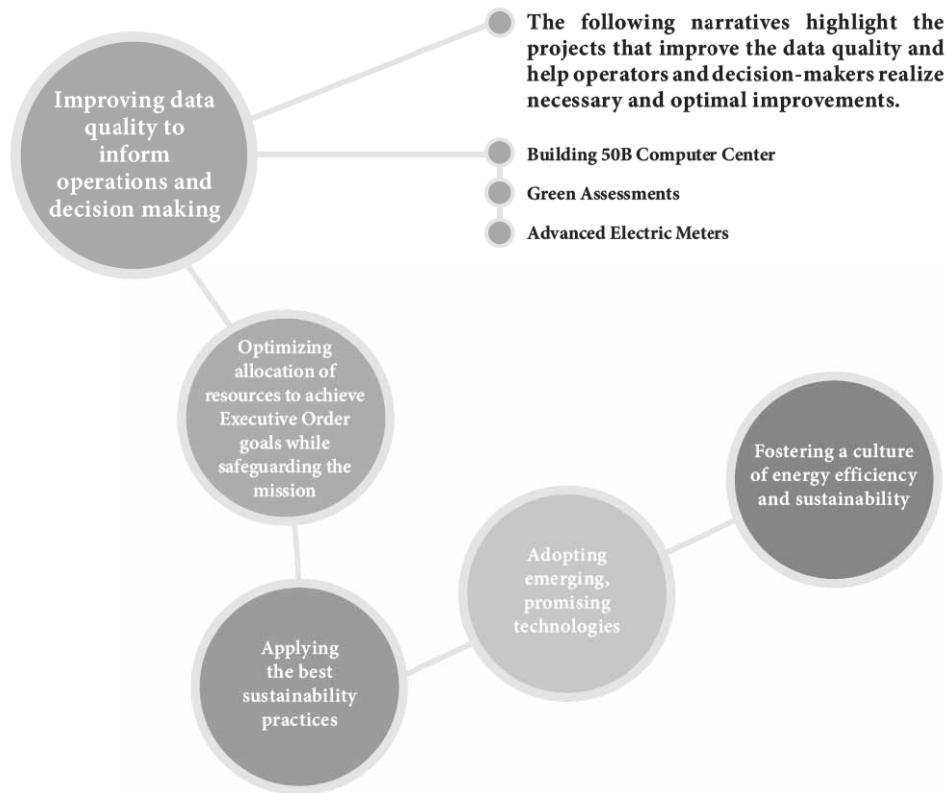
Not only does Sheree incorporate sustainability into her work, but she "does the right thing" at home by supporting organic farmers. She is an inspiration for personal and organizational sustainability. "I see sustainability as a critical issue also from an institutional perspective. We should strive to do our best and create a high performance culture to ensure our sustainability as an institution of world class science."

*"Communication is key for high performance cultures."*



# Sustainability Success

The second objective of the DOE's SSPP promotes a culture that seeks to quantify performance and integrate data into the decision-making process. Good, plentiful data inform building operators and decision-makers of the performance of buildings, policies, and programs. Where they perform poorly, the buildings, policies, and programs can then be improved to reduce the environmental impact of Berkeley Lab.



# Building 50B Computer Center

Data center energy costs can be 100-times higher than those of typical buildings. Inefficiencies can also erode competitiveness and waste precious energy resources. Major renovations completed in 2010 at Berkeley Lab's Building 50B data center are combating these inefficiencies, thereby saving energy and money and boosting the Information Technology (IT) Division's computing power.

The project trimmed energy use in the 5,000 square foot data center by an estimated 643,000 kWh/year, which increased cooling capacity by 21 percent. A key element of the new, sustainable design was the installation of more than 800 wireless sensors that feed valuable information on temperature, humidity, and energy usage to a real-time monitoring system. Informed by sensor data from server racks, under the floor, and in

the ceiling, Berkeley Lab engineers were able to raise the computer floor air temperature set-point, optimize coordination of multiple Computer Room Air Conditioning (CRAC) units, and eliminate humidification control systems.

Airflow patterns among the rows of racks were redesigned for efficient hot-aisle/cold-aisle isolation. A new system channels the room's hot air through the ceiling and back to the floor-mounted CRAC units, significantly reducing hot and cold air mixing throughout the data center. As before, the CRACs disperse the cool air through a pressurized, under-floor ventilation system; but perforated floor tiles, which release the cool air, were redesigned and relocated to eliminate hotspots and maximize efficiency.



The Wireless Sensor Network was installed in collaboration with the sensor vendor, the IT Division, and Environmental Energy Technology Division researchers. At the LBNL average power rate, annual savings are more than \$60,000. Among the energy savings realized in the redesign of the system were:

- 330,000 kWh/year saved by increasing server inlet air temperature set-point by about 10° F
- 165,000 kWh/year saved by turning off one CRAC unit
- 148,000 kWh/year saved by turning off humidification devices

# Green Assessments

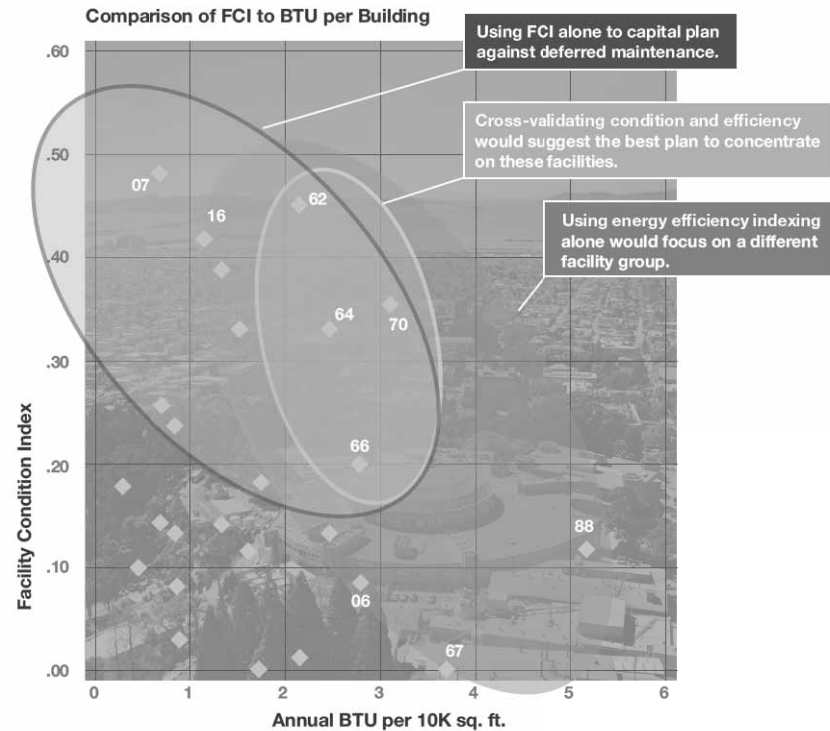
Mission success for Berkeley Lab — delivering scientific solutions to the world — relies on the readiness of its facilities to support it. Green Building Assessments, combined with more traditional Facility Condition Assessments, are important methods used to prioritize spending of maintenance and repair dollars.

Facility Condition Assessments (FCAs) are conducted on selected buildings each year to identify maintenance and repair needs. Green Building Assessments identify and evaluate retrofit projects using sustainability criteria, such as how much energy might be saved after the work is

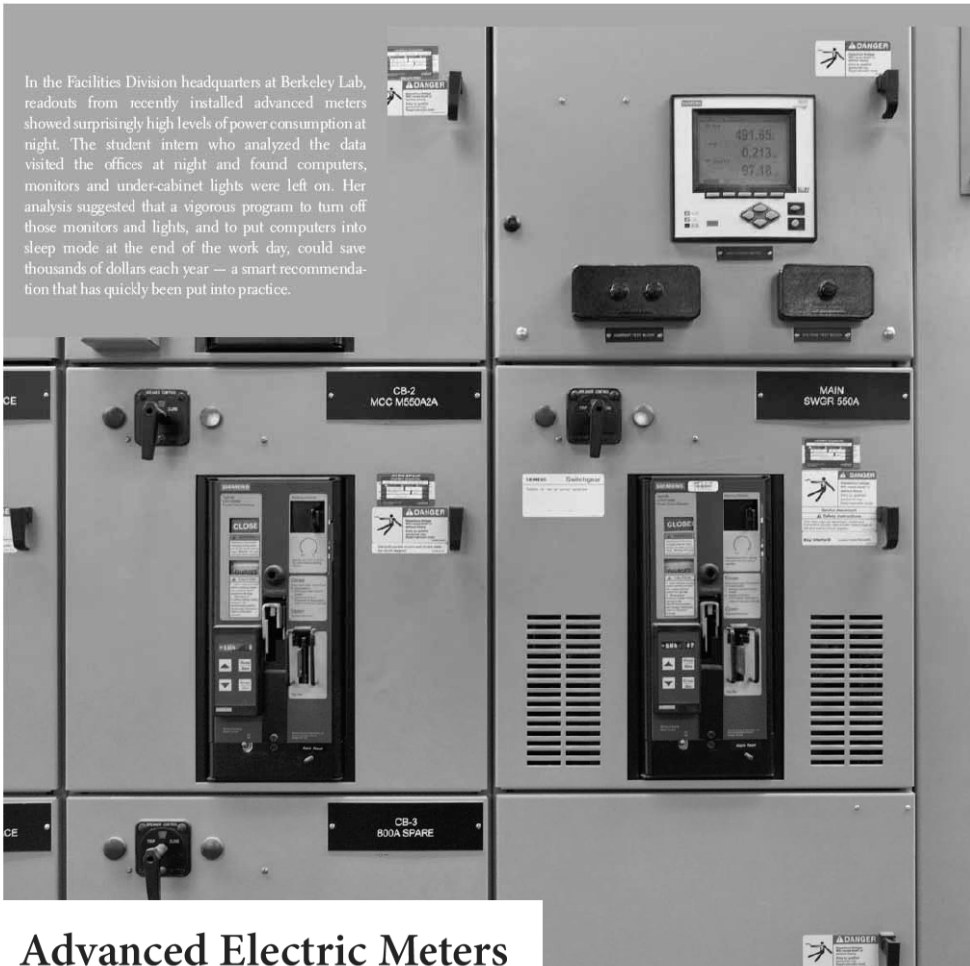
completed. It is now "standard operating procedure" at Berkeley Lab to carry out Green Building Assessments with FCAs.

Every step in the process involves choices. Scientists and Facilities engineers work collaboratively to identify mission critical systems and research priorities. Multiple factors are assembled and processed via pairwise computer analysis. The resulting lists of prioritized projects help Berkeley Lab managers make decisions to maximize the Lab's mission readiness, satisfy government requirements, budgetary considerations, and sustainability goals.

Berkeley Lab facilities engineers use software models to rank assets. Using building condition alone, for example, identifies one set of maintenance spending priorities; energy efficiency alone identifies another. Scientific mission needs are another. As is depicted on the graphic display, the software narrows the choices to those that score well on all counts.



In the Facilities Division headquarters at Berkeley Lab, readouts from recently installed advanced meters showed surprisingly high levels of power consumption at night. The student intern who analyzed the data visited the offices at night and found computers, monitors and under-cabinet lights were left on. Her analysis suggested that a vigorous program to turn off those monitors and lights, and to put computers into sleep mode at the end of the work day, could save thousands of dollars each year — a smart recommendation that has quickly been put into practice.



## Advanced Electric Meters

To those striving for more sustainable electric power usage, information itself is power.

Berkeley Lab is installing across its 200-acre hilltop campus advanced electric power meters that not only allow remote monitoring of electricity use, but provide a wealth of data to help facility managers find ways to use less of it. By the end of FY 2011, conventional electromechanical meters had been swapped for advanced digital meters in 43 Berkeley Lab buildings, and plans were on the books to install at least 30 more during FY 2012.

Each advanced power meter is linked, through the Berkeley Lab Ethernet, to computers located at the on-site data center in building 50B. In addition to basic measurements, such as how many kilowatt hours of

energy has been consumed, the intelligent meters continually log data on power demand, voltage, current, and power quality.

Harmonics and power factor are two of the power quality metrics tracked by advanced electric meters. Harmonics describe interactions among waves of alternating current which can change depending on the type of devices being powered. Fluctuations in harmonics can raise or lower the amount of current flowing and contribute to excessive wear on equipment such as electric motors. The power factor is a ratio indicating how much of the power in an electrical system is being put to useful work. A low power factor can be corrected to improve the efficiency of that system. Power quality data can be tracked over time to reveal patterns and trends, which can help to identify corrective actions, avoiding disruptive equipment failures.

## Meet Facilities Folks

### George Rosas Custodial Services Supervisor

The Custodial Services Department employs an effective system of informal feedback to improve operations and decision-making. George Rosas relied on this system to help institute the use of non-toxic, environmentally-friendly, and/or Green Seal-certified cleaning and maintenance products at Berkeley Lab.

The process to switch to these products was not easy. It started with a DOE mandate that requires Green Seal-certified products to be used on DOE sites instead of conventional products that are sometimes toxic. Even though the market for "green" products was small at that time, George and his team purchased and tested samples of these products, which often resulted in disappointment. But they persisted, and through trial and error and open communication, they made collective decisions to identify and switch to green products that work. Currently, most of the cleaning and maintenance products are non-toxic, environmentally friendly, and/or Green Seal-certified, and Custodial Services is continuing to search for and try new green products.

Custodial Services also picks up solid waste from buildings, including landfill, recyclable, and compostable wastes. Another DOE-mandated goal is to divert 50 percent of non-hazardous and non-construction waste from landfills. Achieving this goal requires employee participation to place the appropriate items in appropriate solid waste bins. When emptying the recycling and composting bins, the custodians are noticing that the bins include items that don't belong. They are hoping to employ an informal feedback system to improve Berkeley Lab's waste diversion rate in the future.

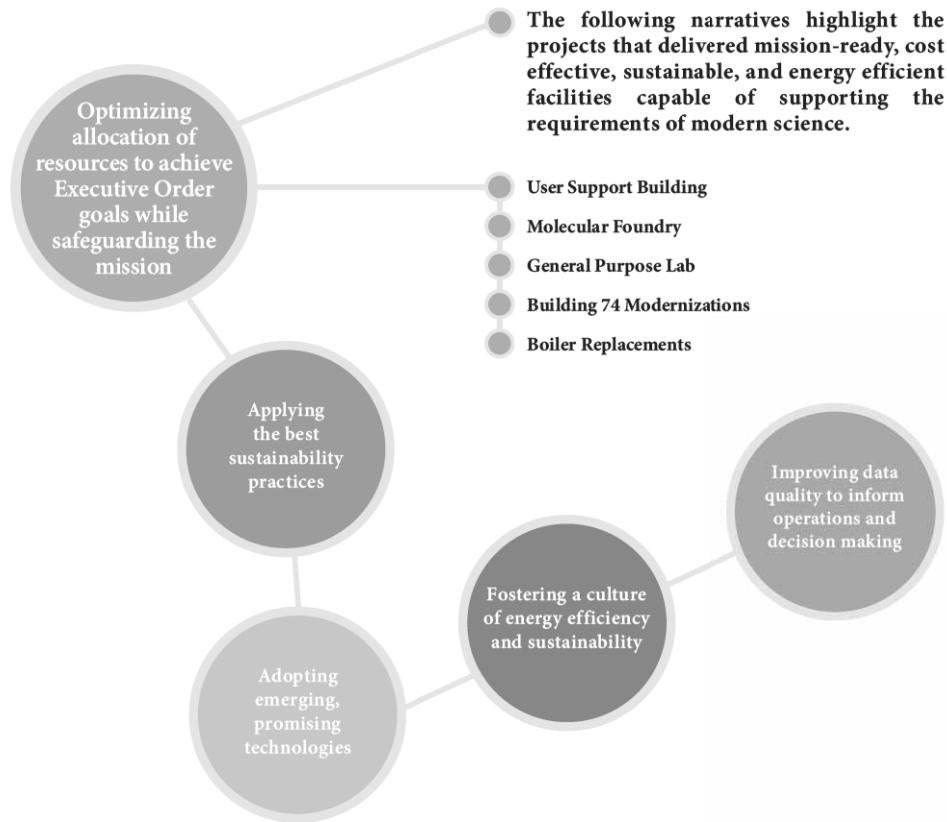
*“Everybody needs to do their part.”*



# Sustainability Success

The third objective of the DOE SSPP is to cost effectively achieve the President's sustainability goals of the Executive Order, which are to: track and reduce Scope 1, 2, and 3 greenhouse gas emissions; implement high performance, sustainable facilities in new construction and existing buildings; reduce water use; promote sustainable acquisition of products and services; minimize solid waste and pollutants generation; and maximize solid waste diversion from landfills.<sup>2</sup>

DOE's driving mission is to "ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions."<sup>3</sup> Achieving the extensive and ambitious Executive Order goals without sacrificing the DOE science mission requires the optimization of funding and personnel to implement sustainability measures and programs collaboratively and efficiently.



<sup>2</sup>"Executive Order 13514," Department of Energy, Energy Efficiency and Renewable Energy, Federal Energy Management Program, accessed September 19, 2011, <http://www1.eere.energy.gov/femp/regulations/eo13514.html>

<sup>3</sup>"Mission," Department of Energy, accessed September 19, 2011, <http://www.doe.gov/mission>



# User Support Building

The physics inside may be high-energy, but Berkeley Lab's new User Support Building (USB), adjacent to the domed Advanced Light Source (ALS), is loaded with state-of-the-art energy-saving features.

The User Support Building opened in September 2010. It was built to support staff and visiting scientists who conduct experiments at the ALS, which generates one of the world's brightest sources of X-ray beams for state-of-the-art research in materials science, biology, chemistry, physics, and the environmental sciences. Each year some 2,000 users from across

the nation and world conduct research using this unique facility, and their work conducted here has been well recognized including awards of Nobel prizes.

The User Support Building has been designed to use 47.1 percent less energy than American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1, the national standard for energy efficient buildings, would allow. An application for LEED Gold certification has been submitted.



## A User Support Facility Full of Green Features

- Siting of the User Support Building adjacent to a shuttle stop and the primary user destinations: the ALS, the Guest House lodging, the Lab Commons with its dining, banking, and meeting facilities
- Daylighting, High R-value insulation, a "cool roof," energy efficient lighting
- Taking advantage of our mild climate, all offices have operable windows; space heating and cooling systems respond to open windows and unoccupied offices to help maximize overall energy savings
- A heat-recovery system in the Computer Server Room that re-deploys waste heat for productive use elsewhere in the ALS-complex
- A Flexible 9,000 square foot assembly space designed to be quickly adapted to changing needs
- A low-water use design throughout the facility and landscaping
- Use of renewable materials and use of simple polished concrete for flooring
- Recycling of construction waste

# Molecular Foundry

Sited on a hillside between the National Center for Electron Microscopy and two multi-program research laboratory buildings, with stunning views of UC Berkeley and San Francisco Bay to the west, the Molecular Foundry is a landmark in sustainable energy design. In 2007 it became the first building in the City of Berkeley to earn the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Gold certification. The Molecular Foundry was also a pioneer as it was one of the first research laboratory buildings in the nation to receive a LEED Gold certification.

Designated as a U.S. Department of Energy National User Facility, the six-story, 96,000 square foot laboratory building serves as a hub for researchers around the globe pursuing the emerging science of nanotechnology — the study of the structure and behavior of materials at extraordinarily small scales.

The Molecular Foundry's LEED Gold rating was earned through its use of many green design features, including optimized electrical and HVAC (space heating and cooling) systems, an energy-efficient chiller and boiler plant, and innovative layouts of traditionally energy-intensive areas such as labs, a cleanroom, and a computer server room. The Molecular Foundry's extensive use of daylighting, operable windows, protection of indoor air quality through low volatile organic carbon emitting materials, and clean-construction practices all contribute to a great work environment.

The building was designed to consume 35 percent less energy than the national standard for energy efficient buildings, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1. As designed, it also produces 85 percent less greenhouse gas emissions than a conventional facility that meets that same standard.



## A Foundry Full of Green Features

- Extensive use of daylighting in labs, offices, and common spaces
- An electromagnetic cooling tower water treatment system that sanitizes and uses less water
- CO<sub>2</sub> monitoring and control of outside air for ventilation
- Flexible laboratories with large floorplans
- A notable low-water using landscape, designed by PWP Landscape Architecture of Berkeley
- Use of renewable materials, such as bamboo flooring in the lobby
- 85 percent of construction wastes were recycled
- Bike racks and showers for employees



## General Purpose Laboratory – 1 (Building 33)

Berkeley Lab is working with the Department of Energy to demolish legacy buildings with identified seismic safety issues. Related to these demolitions is a program to construct three replacement general-purpose research laboratory/office buildings in order to maintain Facilities mission readiness commitments. The first of these replacement buildings is the ~40,000 square foot General Purpose Laboratory-1 (GPL-1).

As its name implies, the GPL-1 facility is designed for flexibility. The modern research spaces are intended to accommodate the wet laboratory needs of any research program at Berkeley Lab. For decades to come, these new spaces will be assigned and re-assigned to respond nimbly to evolving science and mission requirements.

Berkeley Lab broke ground for the GPL-1 in September 2011 on the former site of a vacated World War II-era building determined to be unsafe for occupancy due to particularly serious structural seismic safety issues. Sustainability has been considered both in the design of the new building, and in the creation of the site for it – the demolition debris was recycled whenever possible, and, the existing Lab utility infrastructure will be adapted to serve the new building.

The GPL-1 Building has been designed to use 40 percent less energy than American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1, the national standard for energy efficient buildings, would allow. An application for LEED Gold certification will be submitted.



### A General Purpose Lab Facility Full of Green Features

- Siting of the GPL-1 Building, on a re-use site, adjacent to a shuttle bus stop and within easy walking distance of other research facilities and the Lab Commons with its dining, banking, and meeting facilities
- Solar water heating, daylighting, high R-value insulation, a "cool roof," energy efficient lighting
- A modern HVAC (space heating and cooling) and lighting control system that can automatically adjust to occupancy conditions, and includes a "fan wall" design element so overall energy savings can also be achieved when windows are open
- A "Dashboard" function that will display current and trending energy use data to interested occupants
- A Low-water use design throughout the facility and landscape
- Use of renewable materials, and use of 100 percent recycled steel for the buildings girders
- Recycling of construction waste



# Building 74—Modernized with the Earth in Mind

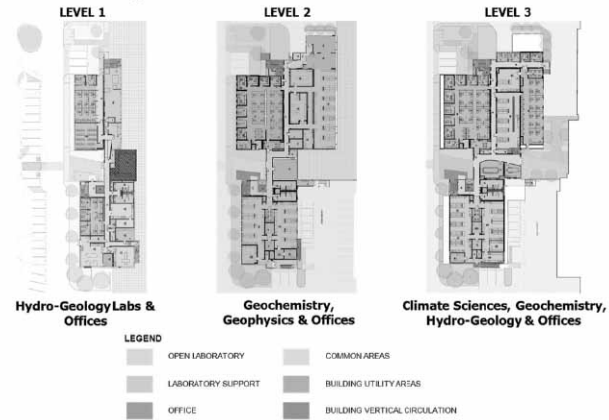
As part of its sustainability vision, Berkeley Lab works to renovate older facilities when they can be adapted to the requirements of modern science. Berkeley Lab is completing a major renovation of Building 74, a 45,000 square foot general-purpose research laboratory and office building which has served generations of scientists since it was constructed some 50 years ago and first occupied in 1962. Set for completion in July 2012, the remodeled facility will be outfitted with the latest in sustainable architectural and engineering features, while also providing an infrastructure capable of serving the requirements of modern research science.

The renovation will provide modern research space and is expected to achieve the U.S. Green Building Council's LEED Gold certification. The facility will perform at least 30 percent better than the national standard for energy efficient buildings, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1.

Key elements of the new design include a trio of high-efficiency rooftop air conditioning units that will replace an assortment of old and lower efficiency equipment. The roof itself is a "cool roof" made of sun-reflecting "Berkeley Gray" materials atop a heavily insulated ceiling. Solar hot water heating panels serving restrooms and kitchens will also be placed on the roof. Two independent heating and plumbing networks serving the old building were swapped for a modern centralized system, and computer-controlled heating, cooling and ventilation will adjust the flow of fresh air from outdoors. A bank of high-efficiency windows has been cut into the previously windowless middle floor of the east wing to provide daylighting, and the entire building is to be equipped with high-efficiency lighting using LED and the latest fluorescent lighting systems. The lighting system will be fitted with sensors and programmable switches to dim lights in lab spaces and in response to occupancy and available daylighting when appropriate.



## Building 74 Floor Plans



A finishing touch of green for this two-year renovation project: landscaping with selected drought-tolerant native plants that will flourish in our natural Mediterranean climate with a little help from a supplementary drip irrigation system.

## Boiler Replacements

At Berkeley Lab, the path to a sustainable energy future often runs deep into the basements of its largest facilities, which house the boiler rooms.

Whenever possible, large conventional boilers are being replaced by a new generation of highly efficient combustion systems. Known as modulating condensing boilers, they take up a third of the space, and use considerably less energy because they recover almost all the heat available from the burning fuel. The second feature, modulation, allows them to perform more efficiently on those frequent winter days when temperatures are cool, but not cold enough to require the boilers to operate continually at full capacity.

Berkeley Lab has installed four new top-of-the-line modulating condensing boilers, each rated at 2 million BTU, to serve the Advanced Light Source and the complex of building surrounding it. Such boilers can cost \$40,000 more than their conventional counterparts, but make up the difference with higher efficiency, longevity, and lower fuel consumption. Berkeley Lab has to date installed 13 of these new boilers in five facilities, and they are projected to save more than \$100,000 in fuel costs annually.



The secret of condensing boilers is their ability to extract almost every bit of available heat from the burning fuel. Condensing boilers have much lower flue temperatures; this allows water, a product of combustion, to condense within their flues. This condensate is corrosive. In conventional boilers, flue temperatures are kept high in order to prevent condensation. Condensing boilers employ noncorrosive materials, especially in the flues, to accommodate condensate, which is collected, neutralized and drained safely to the sanitary sewer.

Conventional boilers typically burn their fuel at full throttle, turning on and off according to the demand of room thermostats. Modulating boilers carefully track the temperature of water returning from the heating system, and in warmer weather can dial down the firing level to as low as five percent of maximum, using less energy to reheat it for the new cycle. As a result, the boilers perform at high thermal efficiency not just on the coldest days, but throughout the long heating season.

## Meet Facilities Folks

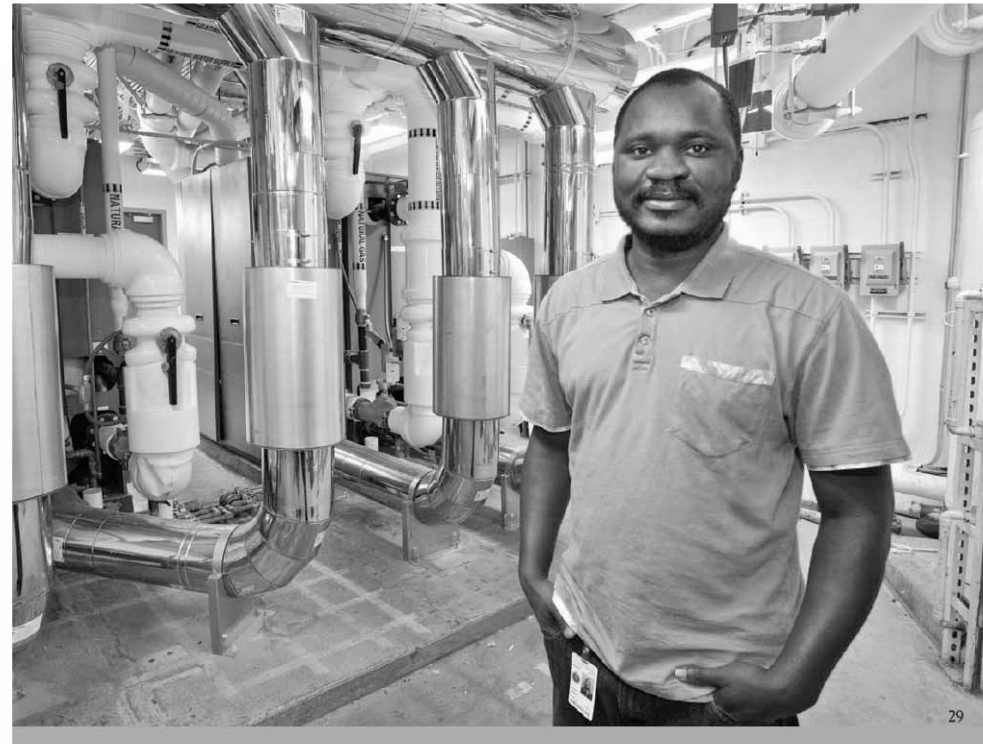
### John Kpaka Mechanical Engineer

As a mechanical engineer for the Facilities Division, John is a vital player in the effort to ensure that energy efficient facilities support Berkeley Lab's science. His work focuses on maintaining and updating the plumbing, utilities, and Heating, Ventilation, and Air Conditioning (HVAC) systems in buildings. A highlight of this work has been his contribution to the design, coordination and installation of high-efficiency boilers in four Berkeley Lab buildings. And more of these exemplary boilers are planned for installation in the near future.

John also assists Berkeley Lab's Sustainability Coordinator, Blair Horst, with the monthly collection of energy data from meters around the site. He then analyzes that data, which feeds the Building 76 dashboard and the annual energy reports that are submitted to DOE. This work not only engages building occupants, but it helps show DOE decision-makers that Berkeley Lab is achieving the sustainability goals of Executive and Department Orders.

John's energy conservation and sustainability actions extend to his personal life too. He likes to take advantage of public transportation, run errands without driving, and eat healthfully. John is yet another great example of Lab personnel doing the right thing at work and at home.

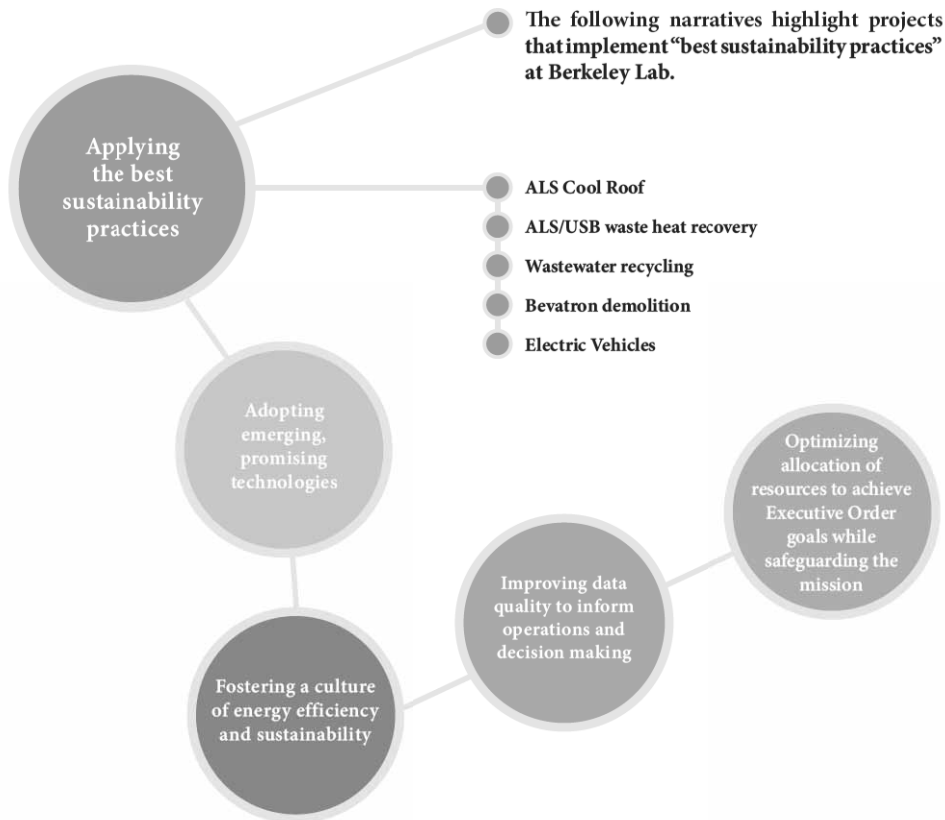
*"Don't forget to turn off the lights when you leave."*



# Sustainability Success

The fourth objective of the DOE SSPP is to build, operate, and maintain DOE sites with practices that minimize Berkeley Lab's environmental, financial, and social impacts. Sustainability practices address many categories of the facilities and operations of an organization, including, but not limited to, energy and water use; procurement policies and practices; commuting and transportation options; and solid waste and pollutant generation. Berkeley Lab is

fortunate, as a national laboratory, to have access to many federal networks with many experts to guide the implementation of cutting edge policies and practices. Some of these best practices originated at Berkeley Lab and have developed through the years to become widely adopted measures that help organizations, in both private and public sector, achieve their sustainability goals.



Demolition waste sorted into piles of metal and wood allow for higher recycling rates.



In 2010, Director Paul Alivisatos began Berkeley Lab's Sustainable Science Initiative, which encourages lab facilities to use Lab-developed technology and/or methods to optimize energy efficiency. Applying a cool roof product to the ALS dome is one example of a sustainable Berkeley Lab innovation in action.

## A Cool Roof for LBNL's Iconic Dome

The iconic dome of Berkeley Lab has a new roof — a cool roof made of shingles that look much the same but reflect nearly twice as much sunlight as the last roof installed two decades ago.

Researchers at Berkeley Lab have shown that reflective "cool roof" materials help combat climate change in two ways: by saving energy on air conditioning and by mitigating the "heat-island effect," which occurs when acres of dark roofs absorb heat, causing surrounding air temperatures to rise. Our researchers estimate that if about three quarters of our nation's commercial buildings switched to cool roofs, the U.S. would save enough energy on air-conditioning each year to reduce CO<sub>2</sub> emissions by about 6 million metric tons, the equivalent of taking more than a million cars off the road. Berkeley Lab researchers have collaborated with roofing manufacturers for over a decade to develop attractive cool roofing materials in a wide range of colors.

The 110-foot dome, made of steel girders covered by thick wooden planking, shelters the Advanced Light Source, a third-generation synchrotron that produces X-ray beams a billion times brighter than the sun. In 2011, afflicted by spots of dry rot and prone to leaks, the roof needed replacement. The new roof shingles have a solar reflectance index (SRI) rating of 30, one point better than the 29 specified by Secretary of Energy Steven Chu, who in 2010 directed all Department of Energy facilities to install cool roofs, if economically feasible, when constructing new roofs or replacing old ones.

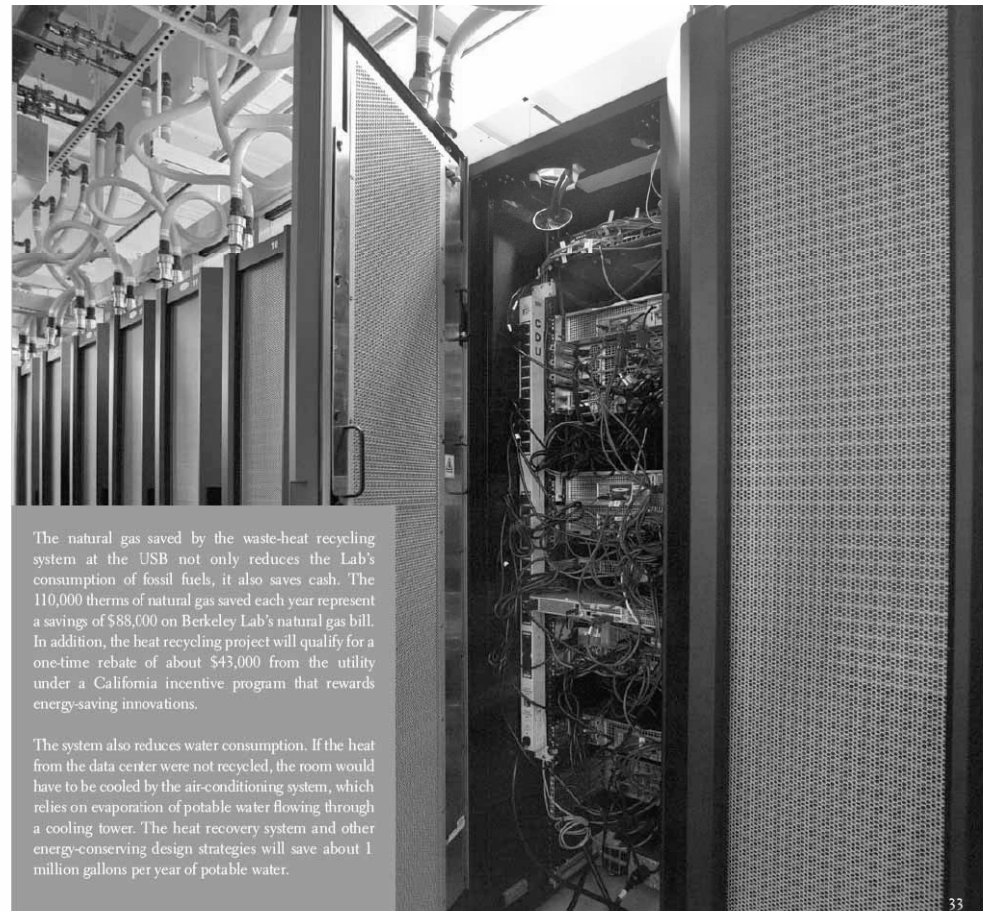
Throughout Berkeley Lab, 48 facilities have cool roofs, covering a total of 519,000 square feet, or 44 percent of the total roof area. Most are flat roofs covered in "Berkeley Gray," a color developed by the lab for the benefit of uphill neighbors who objected to the bright reflections off all-white roofs from below.

## Waste heat recycling in the ALS/USB complex

Each year more than 2,000 visiting researchers rely on computers at Berkeley Lab's new User Support Building to handle the flood of data from their X-ray beam experiments at the adjacent Advanced Light Source. These same machines also play a less obvious role: They help to keep the visitors warm.

In a model of sustainable design, Berkeley Lab has built a system that traps the waste heat from the racks of computer servers inside the User Support Building (USB) and pipes it to the heating plant that serves the entire complex of Advanced Light Source (ALS) facilities. The USB computers can generate up to 921,000 BTU of heat every hour, which will save a significant amount of natural gas fuel annually.

Eighteen water-cooled door panels installed on the rear of the data center racks capture the exhaust heat blown from fans at the back of each server. The heated water is pumped across the street to the ALS Utility Plant, which houses the chiller system, and to the ALS boiler plant, where four highly efficient boilers are located. These facilities provide heating and air-conditioning to the ALS building complex. Water comes into the data center cooling panels at about 65° F. It exits at about 73° F, is "amplified" to about 123° F by a heat pump, and is added to the heating system to reduce the burden on the boilers. The amount of waste heat captured by the system is enough to serve the heating needs of the entire, three-story USB while reducing the amount of natural gas need to fire the boilers.



The natural gas saved by the waste-heat recycling system at the USB not only reduces the Lab's consumption of fossil fuels, it also saves cash. The 110,000 therms of natural gas saved each year represent a savings of \$88,000 on Berkeley Lab's natural gas bill. In addition, the heat recycling project will qualify for a one-time rebate of about \$43,000 from the utility under a California incentive program that rewards energy-saving innovations.

The system also reduces water consumption. If the heat from the data center were not recycled, the room would have to be cooled by the air-conditioning system, which relies on evaporation of potable water flowing through a cooling tower. The heat recovery system and other energy-conserving design strategies will save about 1 million gallons per year of potable water.



In just two years, this model wastewater recycling system will more than pay for itself. Berkeley Lab designed and built the water-saving system using in-house resources. Each year, the reduction of approximately 500,000 gallons in purchased water and related sanitary wastewater discharge costs will save at least \$2,700.

## Building 70A Wastewater Recycling

At the giant W.M. Keck Observatory atop Mauna Kea in Hawaii, the deepest reaches of the universe are probed with advanced charged-couple devices (CCDs), state-of-the-science digital imaging sensors developed and produced at Berkeley Lab. The THEMIS satellite now orbiting the moon uses solid state devices developed at the same research facility.

This unique national research facility and staff have also played a part in the success of other pioneering projects. Similarly, creative Berkeley Lab EH&S staff and engineers have found an elegantly simple way to harness the CCD research and fabrication processes to cut the national laboratory's potable water consumption by approximately half a million gallons a year.

Building 70A is a large, multipurpose facility that houses a wide variety of chemistry labs, including the MicroSystems Laboratory, where unique CCDs have been created since 1996. Each month, the research and

fabrication processes generate 67,000 gallons of waste rinse water from an acid-etching process. That water is subsequently neutralized, and until recently was discharged safely into the municipal sewer system.

In January 2011, however, a new recycling system was completed. It directs the neutralized rinse water to the Building 70A cooling tower, which is part of the air-conditioning system for the entire facility. Tests show that no harmful chemicals are released when this recycled wastewater is evaporated from the cooling tower. Because this safe and neutralized water is added to the cooling system, approximately 500,000 gallons of potable water that would otherwise have been used is saved annually.

In a facility that contributes to our deep understanding of the cosmos and our world, Berkeley Lab has found another path to a sustainable future on our home planet.

## Bevatron Demolition Waste Reduction

It's no small thing to take down a Bevatron.

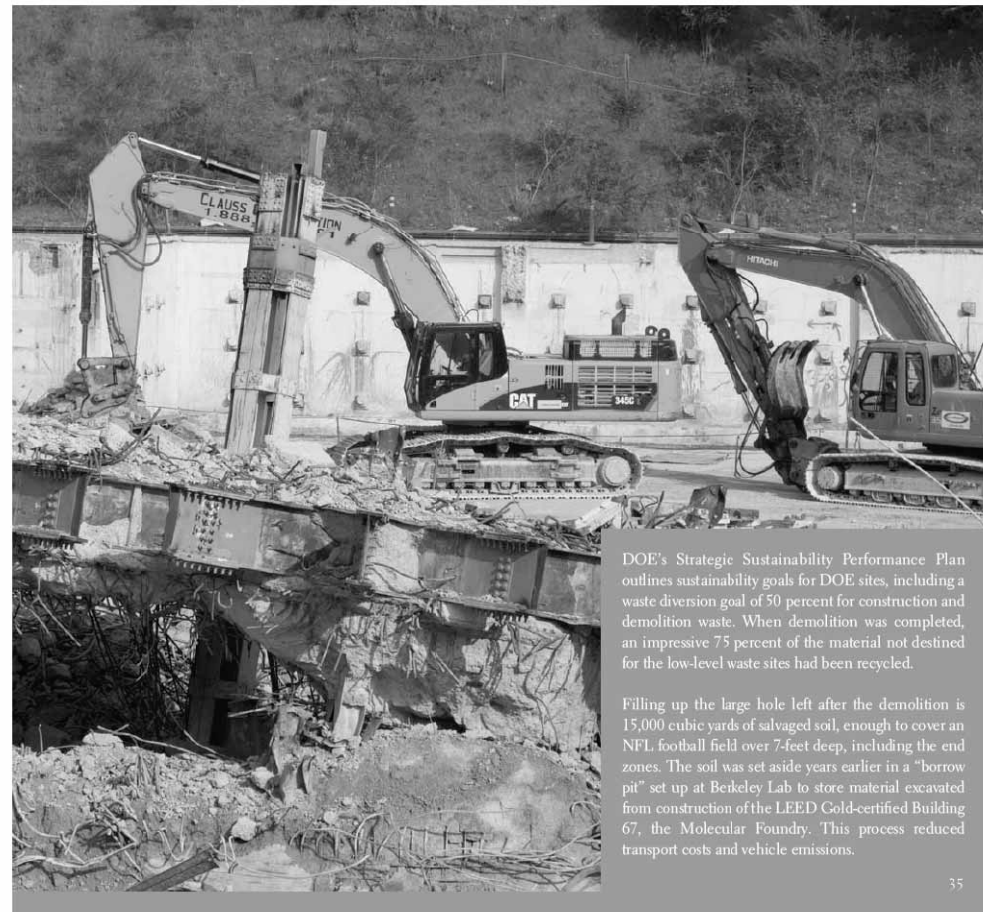
Berkeley Lab's cavernous Building 51 housed the Bevatron, a 6-billion electron volt atom-smasher (brighter than the sun) that was the workhorse of U.S. particle physics research from 1954 until it shut down in 1993.

Four Nobel Prizes were awarded to Berkeley Lab scientists for discoveries made there. However, the aging giant had become obsolete, superseded by more powerful particle accelerators already in use or on the drawing boards. The \$50 million demolition project began in August 2009.

Berkeley Lab set out to make the project a model for safe and sustainable demolition practices. Major efforts were undertaken to separate and safely

store low-level radioactive waste and asbestos-containing siding. Some 3,000 tons of concrete exposed to radiation from experiments at the Bevatron were carted to low-level radiation waste storage in Nevada.

Non-hazardous waste was separated and sent to recycling and reuse facilities. All of Building 51's structural steel girders and electric cables were hauled away for recycling. Reusable (non-radioactive) concrete shielding was transported to other DOE labs where it is being redeployed for the same use. More than 2,000 truckloads of concrete found free of radiation and chemical residue was sent to Bay Area recyclers for crushing, and much of that material will be used for roadbeds and foundations. Some of it may even find its way back to the old Bevatron site, which is being readied for new labs and a new era of scientific discovery.



DOE's Strategic Sustainability Performance Plan outlines sustainability goals for DOE sites, including a waste diversion goal of 50 percent for construction and demolition waste. When demolition was completed, an impressive 75 percent of the material not destined for the low-level waste sites had been recycled.

Filling up the large hole left after the demolition is 15,000 cubic yards of salvaged soil, enough to cover an NFL football field over 7-feet deep, including the end zones. The soil was set aside years earlier in a "borrow pit" set up at Berkeley Lab to store material excavated from construction of the LEED Gold-certified Building 67, the Molecular Foundry. This process reduced transport costs and vehicle emissions.

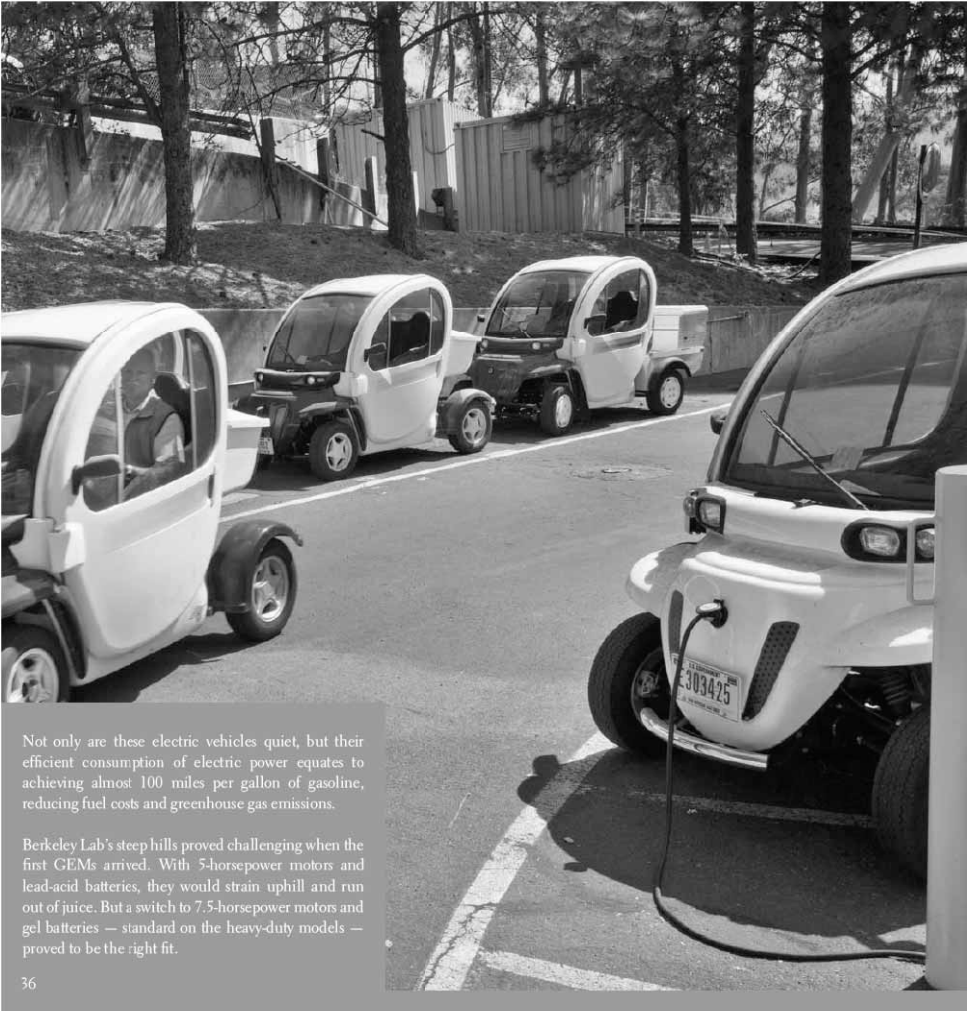
## Electric Vehicles

Lawrence Berkeley National Laboratory is alive with electric vehicles.

Humming about on its hilltop campus are more than 60 colorful GEMs — battery-electric vehicles representing one-in-four of Berkeley Lab's entire fleet of cars, trucks, and other wheeled vehicles. Drawing power from plug-in stations at their parking spots, the GEMs (Global Electric Motorcars) replace gasoline-powered sedans and also light duty pickup trucks used by the plumbers, carpenters, electricians, and other maintenance personnel who keep the Lab's many facilities mission-ready and running smoothly.

With a top speed of 25 mph and a range of 30 miles, the GEMs are proving to be both versatile and convenient, efficiently transporting people and hauling equipment across the campus' 5.6 miles of winding hillside roads. Some GEMs are outfitted with four seats; others are two-seaters with utility boxes or flat beds in the rear.

Compact and easy to park in tiny spaces, the GEMs are popular with facilities staff whose work spans the entire 200-acre campus and involves many trips from one job to the next during a typical day.



Not only are these electric vehicles quiet, but their efficient consumption of electric power equates to achieving almost 100 miles per gallon of gasoline, reducing fuel costs and greenhouse gas emissions.

Berkeley Lab's steep hills proved challenging when the first GEMs arrived. With 5-horsepower motors and lead-acid batteries, they would strain uphill and run out of juice. But a switch to 7.5-horsepower motors and gel batteries — standard on the heavy-duty models — proved to be the right fit.

## Meet Facilities Partner Folks

**Sarah Eary**

**Construction and Institutional Support  
Subcontracts Manager**

The Office of the Chief Financial Officer provides procurement support to Facilities. The Operations-wide commitment to sustainability is evident in this liaison role. Sarah sets up and oversees the design and construction contracts with Architecture and Engineering firms and Construction firms. At Berkeley Lab, these contracts include provisions that require 1) the design for and use of EPA-designated, recycled content building materials and 2) 75 percent waste diversion. Fulfilling these contract provisions requires diligent coordination and communication with the vendors, which Sarah pulls off.

Fortunately, this extra work is not a complete hindrance for design and construction firms because the industry is evolving to adopt more sustainable practices. Especially with larger construction projects, such as the LEED Gold certified Molecular Foundry, contractors are eager to contribute to a showcase green building. But even for smaller projects, Sarah encourages these good building methods because "it's about making people more aware" of the opportunities to build better buildings.

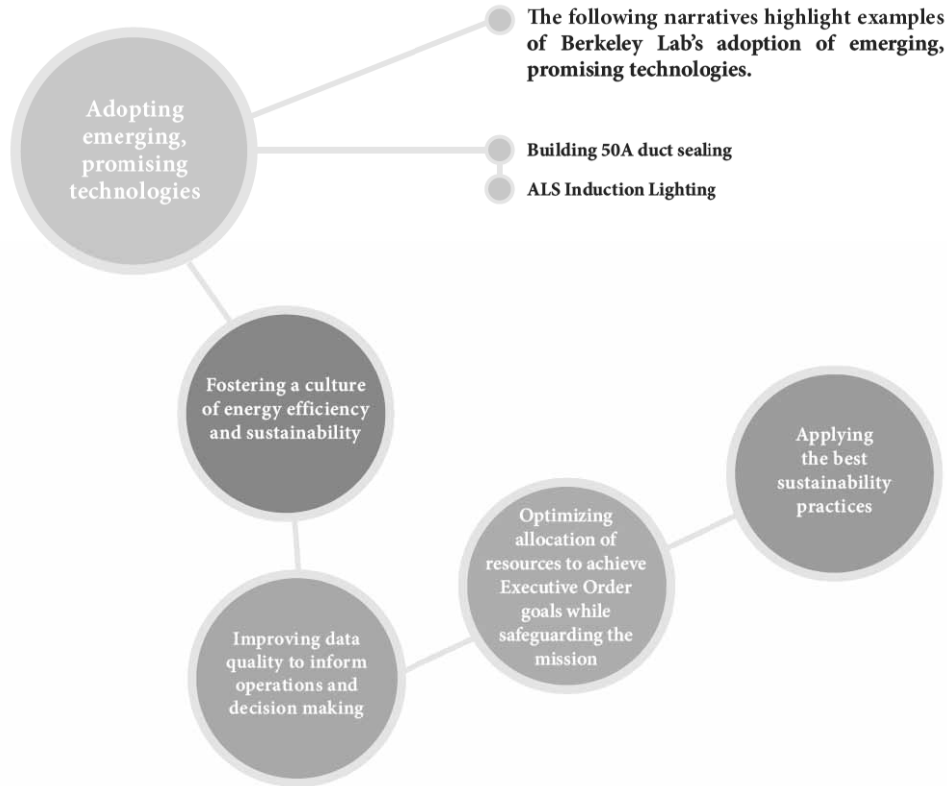
*"Recycle!"*



# Sustainability Success

The fifth objective of the DOE SSPP helps promising new technologies gain market traction through the federal sector. Berkeley Lab has a history of developing technologies that reduce energy use and environmental impacts and integrating them into the marketplace. For example, Berkeley Lab scientists developed the concept of “cool roofs” (see ALS Cool Roof, page 34) and collaborated with private industry to manufacture cool roof products for the mainstream market. Not only does the adoption of emerging, promising technology fulfill a departmental objective, it also supports home-grown research and development.

In addition, Berkeley Lab has released a Request for Proposal to install a 1-MW (MegaWatt) photovoltaic system across the hillside campus. With this system, Berkeley Lab expects to increase its renewable energy use by 1.2 GWh per year and reduce greenhouse gas emissions by almost 2,900 metric tons of CO<sub>2</sub>-equivalent per year.



Electrochromic and spectrally-selective low-e windows on the Environmental Energy Technology Division's windows testing facility.

California's building code has been amended to set standards for new and replacement duct systems. Berkeley Lab researchers estimate that by 2020 more than half of the new homes built in the U.S. will incorporate an improved duct design that minimizes leakage. Ducts sealed over the years from 2000 to 2020 will save billions of dollars in energy bills annually.



## Building 50A Plugging Leaks, Saving Energy

Leaky heating and cooling ductwork allows as much as 30 percent of heated or cooled air passing through them to escape, wasting astonishingly large amounts of energy. To deliver air through leaky ductwork, fans must work harder and longer, requiring more energy. Berkeley Lab scientists addressed the problem by developing an aerosolized duct sealant that can close off the leaks, much as a self-sealing tire can plug a puncture. This homegrown process, which has been licensed to private industry, has been put to the test at Berkeley Lab itself, resulting in a nearly 60 percent reduction in the energy needed to power associated heating and air conditioning fans in Building 50A.

Finely divided particles of sealant are blown into ductwork after supply and return air diffusers and registers have been temporarily plugged. As the particles escape through leaks in the ducts, the change in pressure and direction causes them to clump into a paste that quickly blocks the leak. The process was invented by Berkeley Lab scientist Mark Modera,

who formed his own company in 1998 to market it for residential home duct sealing. His firm was eventually acquired by a world-leading air conditioner manufacturer, which four years later also licensed additional Berkeley Lab technology that made the process suitable for large commercial structures.

The HVAC duct system of Building 50A, which houses computer scientists, theoretical physicists, and the offices of the Lab Directorate, was sealed in 2006. The system was designed to circulate 63,000 cubic feet of air per minute — about 60 times the size of a home heating and cooling system. The aerosolized particles sealed 89 percent of the measured leakage. That boost in efficiency reduced the fan flow by 30 percent, cutting by an estimated 58 percent the power required to run those fans. Among the other sites that have undergone duct sealing are two additional wings of the Building 50 complex, Berkeley Lab's largest facility, laboratory building 70; and Building 90, where the technique was developed.

Photo: Aerosol, LLC

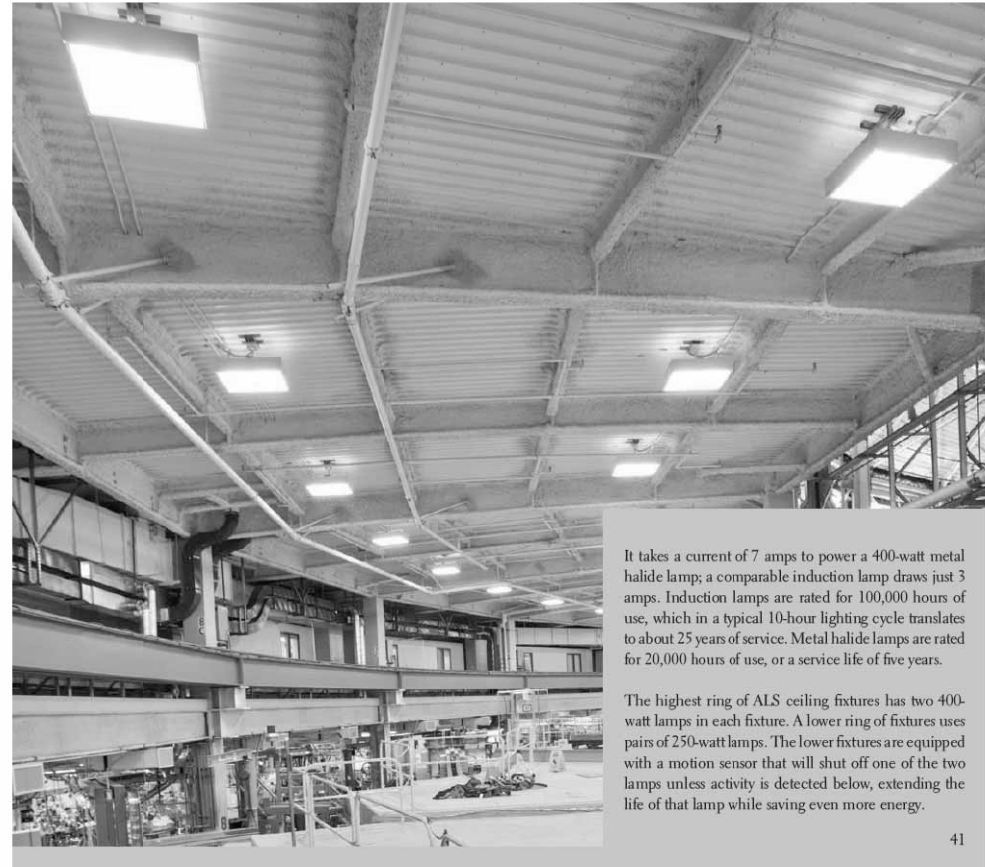
At Berkeley Lab's Advanced Light Source — where researchers operate some of the brightest X-ray and ultraviolet light beams in the world — changing an ordinary light bulb can be an ordeal. It cost nearly \$30,000 just to erect scaffolding for the delicate task of servicing only five fixtures at a critical location in the ring of lights within the facility's 110-foot tall dome.

To illuminate the workspace, and to save thousands of dollars in maintenance costs, the ALS now uses an advanced lighting system of its own: magnetic-induction fluorescent lamps with a service life of up to 25 years. The old metal halide lamps needed changing five times as often. Nearly 200 of these new fixtures have been installed.

Induction lights are engineered for longevity. They have no glowing filaments to break; no electrodes penetrating the lamp. Instead, the gases

permanently sealed inside the glass tube are excited to luminescence by electromagnets. The technology is similar to that in induction kitchen stoves, which use electromagnetic pulses, instead of electric coils or flame, to heat pots and pans. That magnetic field excites only iron or steel, so that a finger placed next to a pot of boiling water would feel no heat from the stove itself. Similarly, induction magnets excite only the sealed phosphor. There is less waste heat; no weak point to wear out.

The new ceiling lights consume far less energy than the metal halide lamps they have replaced — saving almost \$12,000 per year in electricity costs, while operating at a much cooler temperature and producing a more pleasing light spectrum for the work environment.



It takes a current of 7 amps to power a 400-watt metal halide lamp; a comparable induction lamp draws just 3 amps. Induction lamps are rated for 100,000 hours of use, which in a typical 10-hour lighting cycle translates to about 25 years of service. Metal halide lamps are rated for 20,000 hours of use, or a service life of five years.

The highest ring of ALS ceiling fixtures has two 400-watt lamps in each fixture. A lower ring of fixtures uses pairs of 250-watt lamps. The lower fixtures are equipped with a motion sensor that will shut off one of the two lamps unless activity is detected below, extending the life of that lamp while saving even more energy.

## Meet Facilities Folks

### Bill Kenney

#### Electrician and Electricity Enthusiast

When you talk to Bill Kenney, you know that electricity is cool. With a diverse history that has included working with the Electric Power Research Institute (EPRI) to standardize charging for plug-in hybrids, owning an EV1, and becoming an expert in PV (photovoltaic) installation, today he is an electrician highly qualified to safely and intelligently update the Lab's lighting, wiring, and metering. His contributions have ranged from encouraging and installing LED lights in the Environmental Energy Technologies Division Office in Building 90 to helping support the codes and standards for PV installation around Berkeley Lab. By day, Bill's charisma and positive attitude contribute to the great science and energy efficiency occurring at Berkeley Lab.

By night and weekend day, Bill is a charismatic and upbeat teacher who trains union journey-persons and apprentice electricians to size, orient, anchor, and install all types of PV systems safely and correctly. Over the past 10 years, Bill has trained 300-400 electricians. Additionally, he

installs PV systems on Habitat for Humanity homes, helping the homeowners to save money and reduce carbon emissions. Bill is a prime example of someone who applies sustainability skills and interests to benefit not only his work, but also to his community.

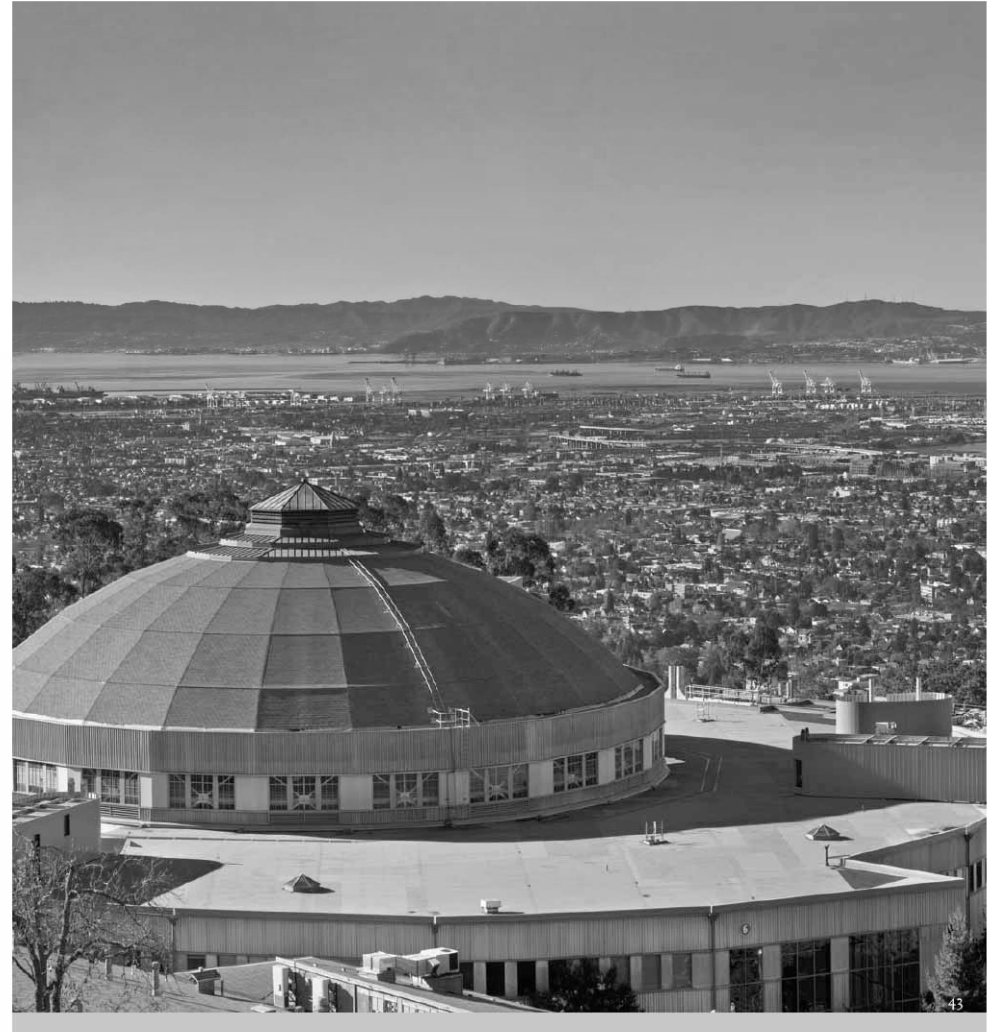
*"Smile and  
be happy."*

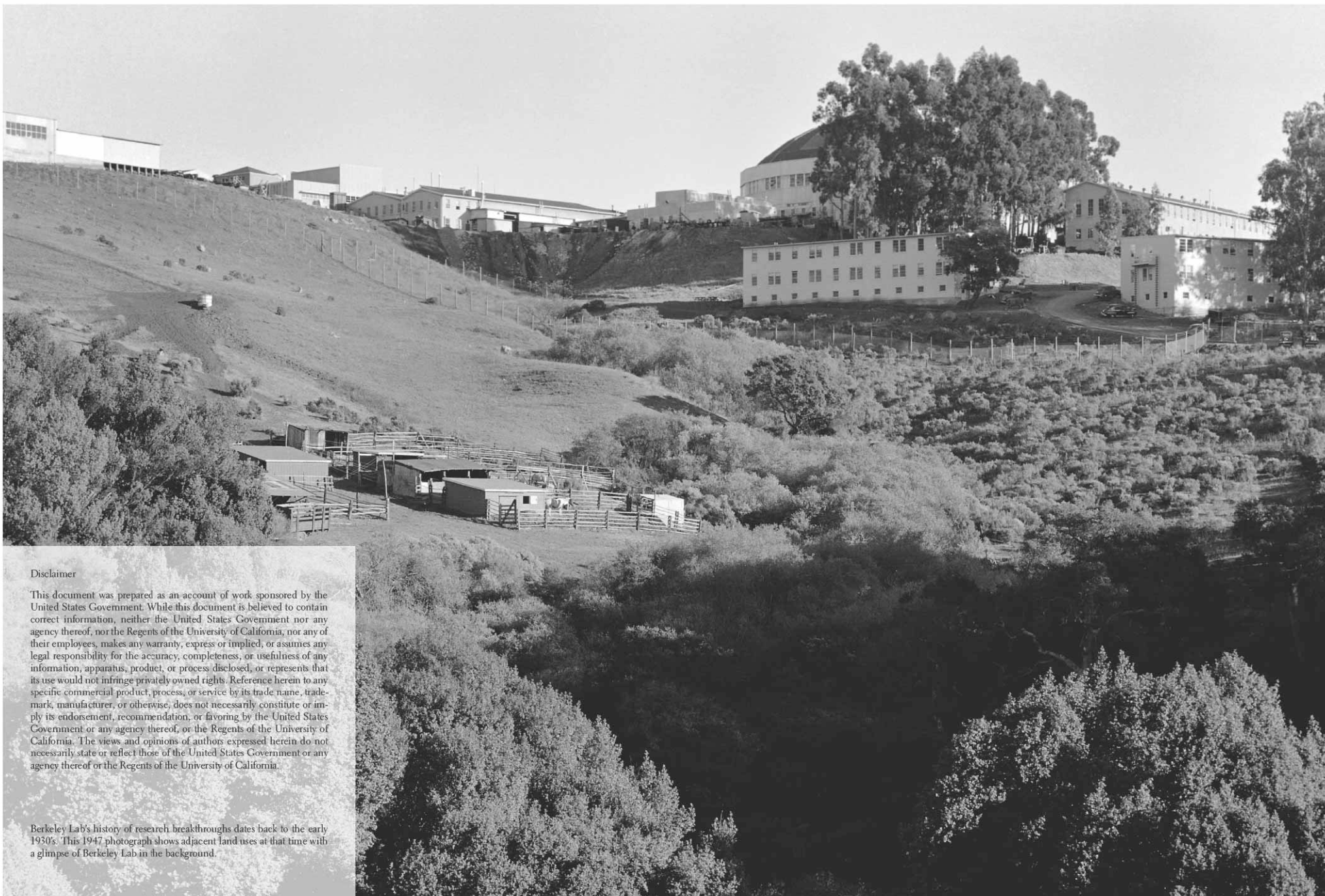


## Closing Words

Berkeley Lab's Facilities Division is committed to providing exemplary facilities and grounds to support the world-renowned science happening on site. As part of that work, Facilities folks implement sustainability measures that contribute to the accomplishment of the aggressive sustainability goals mandated by the DOE. Moreover, the Laboratory is actively supporting the DOE Office of Science to achieve each goal using a portfolio approach across all its sites. The

successes highlighted in this report show the commitment of the Facilities Division, but surpassing the sustainability goals requires the participation and contribution of all Berkeley Lab employees. Future steps will build on these successes with communications and outreach to engage and inspire Berkeley Lab employees to recognize and support environmental considerations whenever possible.





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Berkeley Lab's history of research breakthroughs dates back to the early 1930s. This 1947 photograph shows adjacent land uses at that time with a glimpse of Berkeley Lab in the background.