LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division NEWS

SUMMER 2014:
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FLEXLAB™ , the Facility for Low-Energy Experimentation in Buildings, is now open and its first users, Webcor and Genentech, are conducting research there. Read all about the opening ceremonies in this issue, and if you're interested in using FLEXLAB for your own project, go to their new website [http://flexlab.lbl.gov].

In this issue, you'll also read about EETD's research in the life-cycle analysis of biofuels and large-scale hydrogen production. EnergyIQ, the free, web-based, action-oriented benchmarking tool for non-residential buildings, has new features to make it easier to use. And you'll find an analysis of the costs and benefits of renewable portfolio standards.

To learn more about EETD's work, please visit eetd.lbl.gov .

Don't forget to like us on Facebook, https://www.facebook.com/eet.div.lbnl , and visit our Vimeo channel, https://vimeo.com/eetd .

If you are new to the free quarterly *EETD News*, please subscribe [http://eetd.lbl.gov/newsletter/sub/newsletter_signup.php].

—Allan Chen

EETD News reports on research conducted at Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division, whose mission is to perform research and development leading to better energy technologies that reduce adverse energy-related environmental impacts. The Division's staff of nearly 400 conducts research on energy efficiency in buildings, indoor environmental quality, U.S. and international energy issues, and advanced energy technologies. The newsletter is published online once a quarter. For more information, contact Allan Chen, (510) 486-4210.

The *Center for Building Science News* was published between 1993 and 1998. It covered news of the Division's research in energy efficiency and buildings, the indoor environment, and energy analysis. You'll find all back issues, from Winter 1993 through Summer 1998, available here [http://eetd.lbl.gov/newsletter/cbs_nl/cbsnews.html].

Summer Newsletter: Vol. 13, No. 1 [http://eetd.lbl.gov/newsletter/nl48/]
Environmental Energy Technologies Division News [http://eetd.lbl.gov/newsletter/]

Department of Energy's FLEXLAB™ Opens Test Beds to Drive Dramatic Increase in Building Efficiency

The world's most advanced energy efficiency test bed for buildings is open for business, launched today by U.S. Department of Energy (DOE) Deputy Secretary Daniel Poneman. DOE's FLEXLAB™ at Lawrence Berkeley National Laboratory (Berkeley Lab) is already signing up companies determined to reduce their energy use by testing and deploying the most energy efficient technologies as integrated systems under real-world conditions. The facility includes a rotating test bed to track and test sun exposure impacts, and other high-tech features.

From left to right, Carla Boragno, Senior Vice President, Site Services, Genentech; Laurie Giammona, Vice President, Customer Service, Pacific Gas and Electric Co.; Andrew McAllister, Commissioner, California Energy Commission; Paul Alivisatos, Director, Lawrence Berkeley National Laboratory; (behind Dir. Alivisatos) Jes Pedersen, CEO, Webcor Builders; (cutting ribbon) Daniel Poneman, U.S. Deputy Secretary of Energy; Janet Napolitano, University of California President; Nancy Skinner, Assemblywoman for California's 15th District; Aundra Richards, Site Manager, Berkeley Site Office, Department of Energy; Steven Chalk, Deputy Assistant Secretary for Renewable Energy; Ashok Gadgil, Director, Environmental Energy Technologies Division.

In addition to Deputy Secretary Poneman, University of California President Janet Napolitano, Genentech Vice President Carla Boragno, Webcor CEO Jes Pedersen, and PG&E Vice President Laurie Giammona joined event host Berkeley Lab Director Paul Alivisatos to speak about the power and potential of this facility to help California, the nation, and the world reduce energy use, curb greenhouse gas emissions, and save money.

"In the United States, nearly 40 percent of all energy and over two-thirds of all electricity consumed goes to operate commercial, industrial, and residential buildings," said Deputy Secretary Daniel Poneman. "To power these buildings, Americans spend more than $400 billion every year. By making buildings more energy efficient, we can save money by saving energy, and drive the nation to our low-carbon future."

"So far, Berkeley Lab's energy efficiency work has saved American families, businesses, and institutions many billions of dollars in energy bills. If all goes as planned, FLEXLAB—the first of its kind test bed designed to enable much more aggressive whole-building energy savings—will add to that impressive tab," said Berkeley Lab Director Paul Alivisatos.

"Berkeley Lab is already a global leader in smart-building innovations that are helping our nation cut greenhouse gas emissions," said Napolitano, president of the University of California, which manages Berkeley Lab for the U.S. Department of Energy. "FLEXLAB will allow us to cut building emissions even further, and lessons learned here will be instrumental in helping UC reach its carbon neutrality goal by 2025."

FLEXLAB is a testing ground for developing new, energy-efficient and low-carbon building technologies. Berkeley Lab and its utility and private sector partners will identify, test, and measure technologies of the future that will help California and the world move to a cleaner, more efficient energy future.

In the first test bed experiment, leading biotech company Genentech is leveraging FLEXLAB to test systems for a new building at their South San Francisco headquarters.

"At Genentech, we are constantly innovating and following the science, so we were excited to apply this approach to energy efficiency and building optimization," said Carla Boragno, Genentech Vice President for Site Services. "FLEXLAB represents a new type of experiment for us, and presents the opportunity to be first-in-class in another area of innovation. We are proud to be the leading client of FLEXLAB."

PG&E is next in line to use the facility to test the next generation of technologies—those that focus on whole building systems—for emerging technologies incentive programs. PG&E is working with an advisory committee to identify system-scale efficiency improvements that make best sense for most businesses. It is testing alternatives in FLEXLAB, starting with innovations in building envelopes, lighting, and shading.

"Compared to the usual 'widget' approach of offering incentives for single pieces of equipment, utilities are finding the next generation of energy efficiency technology—which includes single or multiple integrated building systems—is an order of magnitude more complex. FLEXLAB will help them get a handle on this," said FLEXLAB Executive Manager Cindy Regnier. "And that opens the door to new and renovated buildings that are dramatically more energy efficient."

That's what Bay Area-based builder Webcor—Genentech's contractor—hopes to find. In FLEXLAB's pre-launch private-sector experiment, Webcor is using the rotating test bed to plan a 250,000-square-foot building, which includes a built-out space that mimics Genentech's interior office space, and will test for user comfort and utility.

"We are running tests and gathering data that will allow us to maximize the Genentech building's energy-efficiency potential," said Webcor CEO Jes Pedersen. "FLEXLAB could revolutionize the way we plan and build energy-efficient buildings."

Recognizing that building inefficiency is a critical obstacle to achieving U.S. clean energy and emissions goals, DOE issued a Request for Proposal in 2009 for a new kind of testing facility to address the challenges buildings face in achieving deeper levels of energy savings. Many buildings are designed to be energy efficient, but once they are up and running, can use a lot more energy than planned. To close that achievement gap and accelerate breakthrough technologies, Berkeley Lab competed for and won the $15.9 million contract to build FLEXLAB, a testament to the Lab's long history of energy efficiency innovations.

Opening day featured a series of panel discussions focused on energy efficiency from a business perspective. Speakers represented companies including Microsoft, Siemens, Oracle, Wells Fargo, Colliers International, and Schneider Electric.

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For FLEXLAB news and photos [http://flexlab.lbl.gov]

Berkeley Lab news release [http://newscenter.lbl.gov/2014/07/10/department-of-energys-flexlab-opens-testbeds-to-drive-dramatic-increase-in-building-efficiency/]

New Research Assesses Energy Balance of Large-Scale Photoelectrochemical Hydrogen Production

In the search for clean energy solutions to displace greenhouse gas-emitting fossil fuels, few technological options are as alluring as directly producing hydrogen from sunlight. If hydrogen, the most abundant element in the universe, could be produced on earth economically and with a minimum overall environmental impact, it could provide energy to both stationary and transportation applications with very low overall carbon footprint and climate impact. For example, hydrogen could be the fuel input in fuel cells to generate electricity, or feedstock for producing liquid transportation fuels.

Today, however, the most economical way to make hydrogen is by reforming fossil fuels such as natural gas—with the nearly same negative impact to the climate as direct combustion. Hydrogen production via electrolysis—splitting water into hydrogen and oxygen using electricity—can in principle use renewable electricity, but it is currently much more expensive.

Scientists are pursuing a promising pathway to generating large-scale amounts of hydrogen for clean energy production directly by splitting water using sunlight, a process called photoelectrochemical (PEC) production. Instead of splitting off the hydrogen from hydrocarbons and being left with carbon, which is typically oxidized and emitted into the atmosphere as carbon dioxide, photoelectrochemical production splits off hydrogen from water, leaving clean oxygen gas. Researchers have accomplished PEC on a small scale in laboratories, but scaling up the process into hydrogen generating plants capable of supplying enough to meet the needs of industrial societies requires considerably more research and technology development.

Many unanswered questions lie not just in the technology, but in the area of life-cycle impact—in particular, its net energy balance. An energy production facility such as one based on PEC technology should generate more energy over its lifetime than is used to manufacture and operate it. Scientists and funding agencies would like to understand what research directions they need to follow in order to make large-scale PEC-based hydrogen production a reality.

A new study from scientists at the Joint Center for Artificial Photosynthesis (JCAP) created a life-cycle assessment (LCA) model to provide some estimates that might help guide research directions to faster marketplace success. They constructed a model simulation of a large-scale PEC-based hydrogen production facility, using what is known currently about the technology as well as projections of future performance. JCAP scientists affiliated with the Materials, Physical Biosciences, Chemical Sciences, and Environmental Energy Technologies (EETD) Divisions of Lawrence Berkeley National Laboratory (Berkeley Lab) participated in the study.

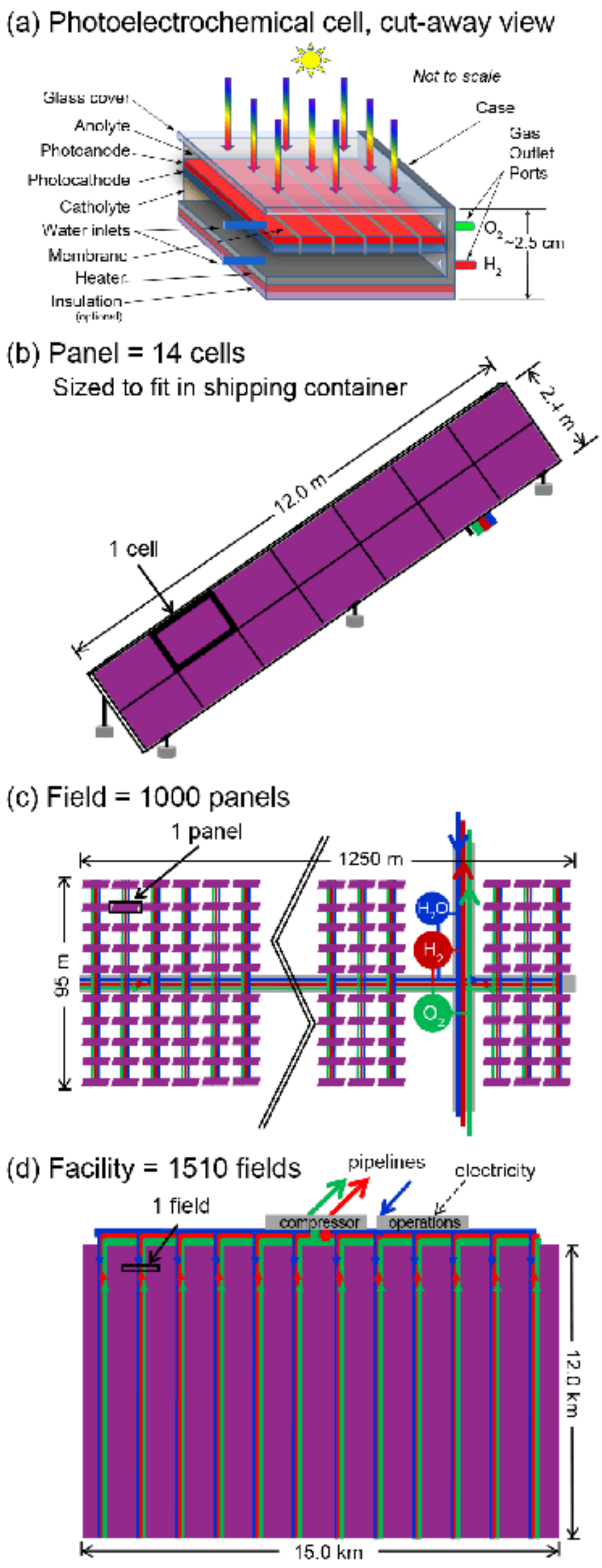
"The modeling of this solar-to-hydrogen technology provides insights into its potential competitiveness," says the study's lead author, Roger Sathre of the Environmental Energy Technologies Division. "It will help identify the key challenges and opportunities for improvement."

EETD researchers have had considerable experience performing life cycle assessments of technologies still in the laboratory, such as new infrared-blocking electrochromic window coatings, carbon sequestration technologies, and advanced biofuels. Their results are intended to help guide lab R&D to market success.

Thorough Description and Many Inputs

The development of the hydrogen production model required many components and considerable input from the researchers developing the technology. The research team modeled a facility capable of producing the hydrogen equivalent of 1 gigawatt (GW) of continuous output, or 610 tons of hydrogen per day. All U.S. light-duty vehicles could be powered by about 160 such plants.

"This study is the first to look at a large hydrogen generation system, and to make a thorough assessment of its balance of system (BOS) requirements—its energy and materials inputs and outputs," says Jeffery Greenblatt of EETD, one of the study's authors. A couple of prior studies have evaluated smaller-scale systems, about one-thousandth the size, focusing on their economics.



A photoelectrochemical (PEC) hydrogen production facility.

The Berkeley researchers prepared a preliminary engineering design of the plant and generated a model describing the system-wide energy flows associated with producing, using, and decommissioning the facility. This allowed them to calculate the facility's three primary energy metrics.

One is the life-cycle primary energy balance, or how much net energy the facility would provide over its lifetime. The second is the energy return on energy investment (EROEI), which describes how much usable energy the facility generates divided by its energy inputs—it must be greater than one by as much as possible for the technology to be viable. Finally, the energy payback time measures how long the facility must operate to deliver the hydrogen equivalent of the energy required for its manufacturing, construction, and decommissioning.

Creating the model required building the facility up from its components, as shown in the figure. The team modeled a large, two-square-meter photoelectrochemical cell, assembled in a truck-transportable structure called a panel containing 14 cells. Panels were arranged in fields consisting of 1,000 panels each, and the overall facility was made up of 1,510 fields.

The model required estimates of energy use to make all these components and the rest of the plant, such as pipes for water and gas, storage tanks, compressors, sensors, roads, and the like. Construction, operation, and decommissioning required estimates of the energy inputs, material inputs such as water and process gases, and transportation to bring in materials and cart out wastes. The plant was assumed to have a service life of 40 years.

Positive Energy Benefits Require Meeting System-level Goals

Under the model's base case conditions, the plant's payback time is 8.1 years. The energy return on energy invested, at 1.7, is positive. The life-cycle primary energy balance over the plant's 40-year life is more than 500 petajoules. "One petajoule is the energy required to power 50,000 hydrogen fuel-cell cars for a year," Greenblatt points out.

"Our results show that hydrogen production based on photoelectrochemical technology has the potential to deliver significant amounts of energy," says Sathre. "There are a number of variables that influence how much energy, and these are variables that R&D in the field needs to focus on."

The most important factor is the overall efficiency of conversion from solar energy to hydrogen, termed the *solar-to-hydrogen (STH) efficiency ratio*. The higher the STH efficiency, the better the energy return (the base case assumed 10 percent conversion efficiency). The lifespan of the PEC cell, the energy used to manufacture the PEC cell, and the lifespan of the rest of the facility are the other most important factors. The report addresses a number of research directions that could lead to more efficient PEC cells.

The researchers estimate that if PEC cells have an STH efficiency of 20 percent (which they believe is possible eventually), and a cell life span of 20 years, the plant can have an energy payback time of just three years, and an EROEI of more than 3, almost double that of the base case.

"Our result validates the need for high efficiency PEC cells, something the research community already understands," says Frances Houle, Department Head for Science-Based Scale-Up at JCAP and another of the study's authors. "It also drives home the need for cell longevity—on the scale of years—well beyond what is currently measured in the lab, which is the scale of hours. Also, we found that the energy investment in the balance of system is smaller than that required to fabricate the PEC cells, so methods to make the cells with less energy will be impactful."

Greenblatt adds that "research is on the right track, because the analysis suggests that a plant built with PEC technology will be energy-positive, but future R&D should ensure that the variables most affecting net energy balance—efficiency, longevity, initial energy investment—are well-understood and optimized."

—Allan Chen

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Roger Sathre, Corinne D. Scown, William R. Morrow III, John C. Stevens, Ian D. Sharp, Joel W. Ager III, Karl Walczak, Frances A. Houle, and Jeffery B. Greenblatt. "Life-cycle net energy assessment of large-scale hydrogen production via photochemical water splitting," *Energy & Environmental Sciences,* DOI: 10.1039/c4ee01019a [http://dx.doi.org/10.1039/C4EE01019A].

This research was supported by JCAP, a DOE Energy Innovation Hub, supported through the Office of Science of the U.S. Department of Energy. Information about JCAP is available online.

LAWRENCE BERKELEY NATIONAL LABORATORY

Environmental Energy Technologies Division

NEWS

Lignin's Role in Reducing Life-Cycle Carbon Emissions Explored in New Research Paper

Cellulosic biofuels are the focus of intense research aimed at developing transportation fuels that are significantly lower in carbon intensity than those derived from petroleum. Biofuels have the potential to reduce the impact of the transportation sector on the climate—cellulosic ethanol, by some estimates, may reduce the carbon emissions relative to gasoline by up to 80 percent. While researchers have developed technologies capable of converting many components of wood and other plant material into liquid fuels, lignin, a chemical in plants that gives their cells rigidity, has proven difficult to break down.

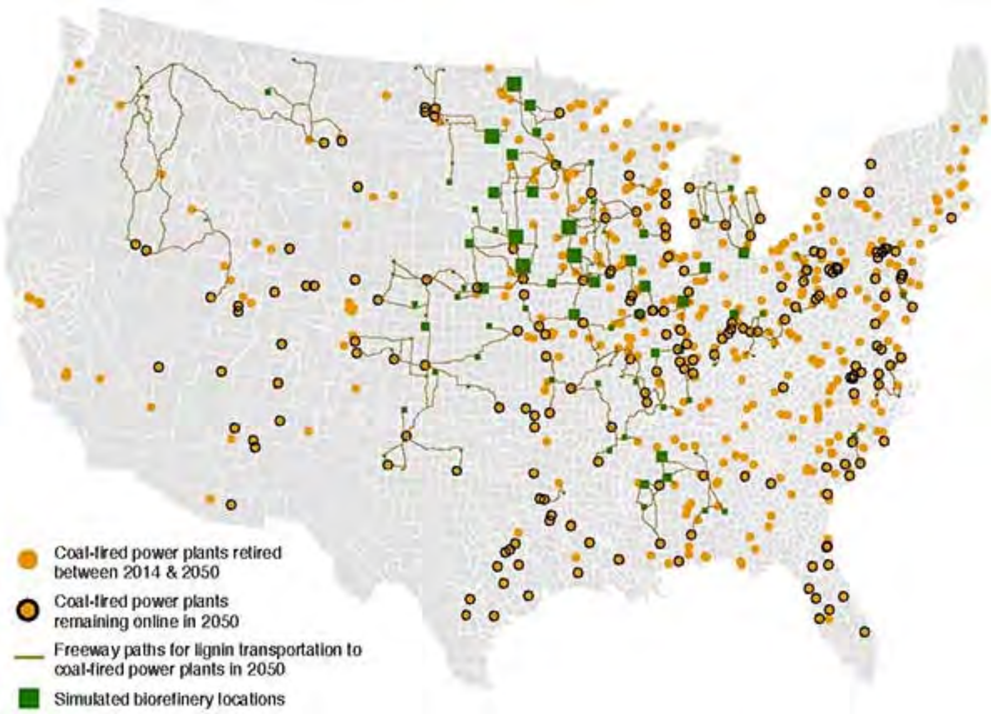
Current models of the refining process for biomass-to-transportation fuels assume that the lignin component is burned onsite to meet the plant's process heat and power needs. Onsite combustion offsets some of the plant's energy costs, and provides the plant with offset credits for greenhouse gas emissions.

Other options exist, including shipping the lignin to nearby coal-fired power plants. Offsetting some of the coal burned in these plants with lignin from biorefining reduces their carbon footprint. What is the most effective way to use lignin such that the positive impacts of reducing energy demand and emissions can be achieved at the lowest capital cost and water demand? The answer to this question interests parties across the energy industry, from policymakers to utilities and operators of generating plants, to the biofuels research and development community. For the first time, research conducted at the Lawrence Berkeley National Laboratory (Berkeley Lab) addresses this question at a national production scale.

A new study, published in the journal *Environmental Science & Technology* and led by Corinne Scown, uses life cycle analysis modeling (LCA) to answer this question. Scown is in Berkeley Lab's Environmental Energy Technologies Division (EETD). Scown and her colleagues conducted a life-cycle assessment of four options for using lignin: (1) onsite combustion for heat and power; (2) onsite combustion plus the use of additional gas-fired power generation; (3) export lignin to coal-fired power plants, use natural gas to meet the biorefinery's heat requirements and a portion of electricity use; and (4) export lignin to coal-fired plants, use natural gas to meet all of the biorefinery's heat and power needs.

In cases 1 and 2, biogas produced at the refinery and a solids boiler for the lignin produce electricity and process heat used in the manufacturing of the biofuels. Cases 3 and 4 eliminate the need for a solids boiler at the refinery site.

U.S. national cellulosic biofuels scenario including biomass production by county, simulated biorefinery locations and optimal rail paths for feedstocks.



Closest facility analysis for biorefineries exporting lignin to coal-fired power plants.

The team evaluated these four cases under a U.S.-based cellulosic biofuel production scenario in which corn stover (leaves, stalks, husks and cobs of corn), wheat straw, and the fast-growing tall grasses of the genus Miscanthus are converted to 160 billion liters of ethanol annually. The results are applicable to any biofuel process that cannot breakdown lignin. "As far as we know, this is the first evaluation of lignin use options at the scale of a national biofuels production scenario," says Scown. "We also know of no other study that has explored the life-cycle water use tradeoffs of such a scenario."

Using a computer model of an ethanol biorefinery, the research team calculated that the life-cycle greenhouse gas emissions ranges from 4.7 to 61 grams of carbon dioxide per megajoule (g CO_{2e}/MJ). This compares to 95 g CO_{2e}/MJ for gasoline.

Scown adds, "Overall, we found that exporting lignin to coal-fired power plants can reduce GHG emissions at a magnitude comparable to using lignin onsite to provide power in some cases. Export of lignin can reduce life-cycle water consumption by up to 40 percent, and reduce capital costs by up to 63 percent, in part, by eliminating the need for an onsite solids boiler."

The study also found that nearly half of U.S. coal-fired power plant capacity is expected to be retired by 2050, which will limit the capacity for co-firing with lignin, and double the transportation distances between biorefineries and coal power plants.

—Allan Chen

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The article "The role of lignin in reducing life-cycle carbon emissions, water use, and cost for U.S. cellulosic biofuels [http://pubs.acs.org/doi/abs/10.1021/es5012753]," was authored by Corinne D. Scown, Amit A. Gokhale, Paul A. Willems, Arpad Horvath, and Thomas E. McKone.

The research was funded by the Energy Biosciences Institute.

Ashok Gadgil Inducted into National Inventor's Hall of Fame

Ashok Gadgil, inventor of UV Waterworks, the Darfur stove, and other low-cost, energy-efficient technologies for the developing world, has been inducted into the class of 2014 National Inventor's Hall of Fame (NIHF) in Washington D.C. The induction ceremony took place at the U.S. Patent and Trademark Office (USPTO) on May 21, in presence of many prior inductees, several industry sponsors, and senior staff from USPTO, the U.S. Department of Commerce, and the White House Office of Science and Technology Policy.

Ashok Gadgil at the National Inventor's Hall of Fame Induction 2014

Ashok Gadgil's tile at the National Inventor's Hall of Fame

Gadgil is one of five living inventors inducted in this class of 15 inductees. The five include the inventors of 3-D printing, new methods of synthesizing biologically useful proteins, and carbon nanomaterials. Gadgil is the Director of the Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory (Berkeley Lab). He is also the Andrew and Virginia Rudd Family Foundation Professor of Safe Water and Sanitation in the Department of Civil and Environmental Engineering at the University of California, Berkeley. The National Inventor's Hall of Fame is part of the USPTO.

Gadgil was recognized by the Hall for work that "has helped 100 million people across four continents by making water safe to drink and by increasing the energy efficiency of stoves."

"What is unique about my inclusion in this remarkable group of inventors is the recognition of value in humanitarian aspects and impacts of my inventions," says Gadgil, "which apply science, technology, and creativity for scalable solutions to some problems of the poorest three billion people on the planet. I am pleased that USPTO signaled that they consider this purpose of inventing as important as the purely corporate or scientific ones."

Of the more than eight million total patents issued by the U.S. Patent and Trademark Office, inventors of only 10 to 12 patents are annually elected to the NIHF. About 500 individuals (living and dead) have become inductees in the NIHF over the past 42 years of selection. Earlier NIHF inductees who worked at the Berkeley Lab include Charles Towns, Louis Alvarez, and Ernest Orlando Lawrence.

UV Waterworks Improves Drinking Water Sanitation

In 1993, Gadgil began working on the invention that was eventually named *UV Waterworks* after learning about a cholera epidemic in India that killed tens of thousands. According to the World Health Organization, 1.2 billion people lack access to safe drinking water, and more than 2 million people—mostly children under 5—die annually from waterborne diseases.

A Water Health Center in India

Using ultraviolet light to kill bacteria, such as the organisms that cause cholera, in water, a UV Waterworks device can provide safe drinking water for a village of 2,000, disinfecting four gallons per minute. Using only 60 watts of electricity, which could be obtained by a solar panel, the cost of disinfection is 4 cents per metric ton. With no moving parts, the device is simple, robust and designed to be fail-safe.

Gadgil decided to patent the device on the advice of Berkeley Lab's Technology Transfer Office, in order to combat the proliferation of technically inferior copies, and allow for a small start up to take the risk of commercializing the technology. A California start up, WaterHealth International (WHI), obtained an exclusive license from Berkeley Lab to manufacture and sell the device in the developing world. WHI maintains quality control of the technology and sets up water disinfection installations in villages on a turnkey basis. They train local technicians to maintain the equipment, and the local installation manager sells the water a price of 0.2 cents per liter (prices can vary somewhat, depending on local salaries and other costs). Sale of the water pays for the cost and maintenance of the installation, salaries of two part-time local employees, public health outreach and education in the community, and the operation of WHI, including its business margins.


By 2012, more than five million people were being served affordable, safe water in India, Bangladesh, Ghana, Liberia, Nigeria, and the Philippines. Clean water from these stations is estimated to save about 1,000 lives per year. The technology, together with a system of distribution that ensures the proper manufacture, distribution, and operation of the system, helps provide not only affordable clean water critical to good community health, but also employment and local economic stimulus.

Energy-efficient Cookstoves for Darfur and Beyond

About three billion people throughout the world cook their meals using solid fuels, on low-efficiency polluting stoves. The collection of wood imposes a large burden of labor and time—mostly on women and girls—and the exposure to the smoke from cooking is now recognized to be the single largest environmental threat to human health, prematurely killing four million people annually.

In 2005 Gadgil's attention was drawn by the U.S. Agency for International Development (USAID) to the plight of women in camps for internally displaced people, in Darfur, Sudan. At that time, women would walk, on average, seven hours a trip, every other day, foraging for fuelwood to cook their families' meals, and be at risk for assault while outside of these camps. Based on his analysis of the situation, Gadgil determined that a robust, user-friendly, affordable, and fuel-efficient wood-burning stove could offer substantial relief to the women from their hardship, and from the risk of violence and extreme humiliation.

Darfur woman cooks with the Berkeley Darfur stove

Visiting the conflict-torn region several times over a period of years, Gadgil and his team studied local conditions and the needs of the families in Darfur, and developed and field-tested a design for an energy-efficient stove made of sheet metal that could be assembled locally. The design evolved with carefully collected input from women cooks—stove users in the Darfur camps. The stove currently costs about $20, while saving $345 per year in fuelwood costs. (A large fraction of the camp population in North Darfur has stopped trying to collect wood, since the nearest supply is now mostly farther than a day's walk. Instead, they spend their precious family income to purchase fuelwood from middlemen). Lasting more than five years, each stove saves $1,725 in fuelwood costs over its lifetime, reduces the household expenditure on fuelwood from 30% to 15%, and incidentally reduces the emissions of greenhouse gases by two metric tons annually.

As with the development of the UV Waterworks device, development of the Darfur stove technology by itself was not end of the process—distributing and proliferating the technology to those who needed it required additional ingenuity. Working with non-governmental organization (NGO) partners in Darfur, the stoves team set up a supply, manufacturing, and distribution chain. Sheet metal parts are precision-cut at a factory in India and shipped as flat kits to Darfur, where they are assembled into stoves by trained local displaced persons—which means jobs for the local community, the creation of skills, and a local light manufacturing economy. The distribution chain is optimized to make the manufacturing of stoves as low-cost as possible without requiring the high start-up costs of building stoves from scratch in Darfur or nearby regions.

While stoves continue to be given free of cost to households in the displaced persons' camps, families outside the camps are now offered the stoves at the affordable $20 price it takes to manufacture one. The savings in fuelwood costs both lightens their economic burden and reduces women's exposure to danger from gathering fuelwood outside the camps' borders. As of early 2014, 37,500 stoves were in households in the hands of women in Darfur—saving $60 million in reduced fuel wood costs and helping 200,000 internally displaced people in these households.

The effort to manage the supply chain and deliver the tens of thousands of energy-efficient stoves moved into a non-profit organization called Potential Energy, co-founded by Gadgil in 2008. With funding from USAID, this non-profit is now testing a fuel-efficient stove for Ethiopia, earlier developed at Berkeley Lab with funding support from the U.S. Department of Energy. Ethiopia's forest cover has declined from 50 percent of the country's area in 1960 to less than five percent today, and yet 80 percent of households there still cook using wood fires.

Other Projects From Gadgil's Laboratory

Gadgil and his team invented, and now are field-testing a technology to remove naturally occurring arsenic from drinking water. Bangladesh, parts of India, and other areas of the world get drinking water from wells contaminated with high levels of arsenic from the local geology. Over time, drinking this contaminated water poisons inhabitants, causing arsenicosis, cancer, and other deadly maladies. More than 70 million Bangladeshis get their drinking water from arsenic-contaminated wells—the largest mass poisoning in human history.

Gadgil's research team has developed a simple, robust, and inexpensive technology for removing arsenic from water that uses a small amount of low-voltage electricity and iron electrodes to effectively remove arsenic from water. ECAR (ElectroChemical Arsenic Remediation) removes arsenic and purifies water to better than World Health Organization (WHO) standards at a cost (including capital and consumable supplies) of about 0.08 cents per liter. It is a low-maintenance device that produces very little waste. In 2012, ECAR was tested successfully in the field in West Bengal, India. An Indian water company licensed it from Berkeley Lab in late 2013. With funding support from the Development Impact Lab at the University of California, Berkeley, part of the USAID's Higher Education Solutions Network, Gadgil's team is now working with the licensee company, Jadavpur University (Kolkata, India), and local governments and NGOs in India, to further develop the technology through a large-scale field installation to be operated over several months. They hope that a distribution system along the lines of UV Waterworks could disseminate affordable arsenic-safe water in the region, using ECAR technology.

"It is quite amazing," says Gadgil, "that with the extraordinary science and technology at our fingertips at Berkeley, we are able to develop locally affordable and highly effective solutions to some of the desperate problems of large numbers of poorest people on the planet." He adds, "It is also deeply satisfying to see the impact achievable by keeping in mind the need of a scalable business model, and respectful accommodation with local social norms and cultural preferences."

—Allan Chen

Additional information:

Ashok Gadgil page at National Inventor's Hall of Fame [http://invent.org/inductees/gadgil-ashok/]

From the Lab to the Marketplace: UV Waterworks [http://eetd.lbl.gov/l2m2/waterworks.html]

WaterHealth International [http://www.waterhealth.com/]

From the Lab to the Marketplace: Darfur Stove [http://eetd.lbl.gov/l2m2/stoves.html]

Potential Energy [http://www.potentialenergy.org/]

A Mission to Darfur [http://www2.lbl.gov/Science-Articles/Archive/sabl/2006/Mar/01-Darfur.html]

Ashok Gadgil's Berkeley Lab page [http://energy.lbl.gov/staff/gadgil/agadgil.html]

Ashok Gadgil's UC Berkeley page [http://gadgillab.berkeley.edu/]

Adam Weber: Presidential Award Winner Continues to Hone Fuel-Cell Technology

On April 14, Adam Weber, a staff scientist in Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division (Berkeley Lab), stepped up in the East Room of the White House to shake hands with President Obama. Weber was one of 102 young scientists this year receiving the Presidential Early Career Award for Scientists and Engineers, the highest honor bestowed by the United States Government on science and engineering professionals in the early stages of their independent research careers. Weber was honored for his work on fuel-cell diagnostics and modeling activities, as well as for his leadership in coordinating scientific collaborations in these areas.

Adam Weber (center) holds his Presidential Early Career award, with Energy Secretary Ernest Moniz to his right, and Sunita Satyapal, head of the Fuel Cell Technologies Office.

A graduate of Tufts University and the University of California, Berkeley, Weber is familiar with prestigious awards—he has also been the recipient of a Fulbright scholarship to Australia, the 2008 Oronzio and Niccolò De Nora Foundation Prize on Applied Electrochemistry of the International Society of Electrochemistry, and the 2012 Supramaniam Srinivasan Young Investigator Award of the Energy Technology Division of the Electrochemical Society.

Though Weber is honored by the recognition, and he enjoyed meeting the other recipients and taking his family to Washington, D.C., for the awards ceremony, he maintains a steady focus on his day-to-day work in the laboratory. His current research revolves around three main topics: understanding and optimizing fuel-cell performance and lifetime; examining redox-flow batteries for grid-scale energy storage; and analysis of solar-fuel generators at the Joint Center for Artificial Photosynthesis.

Scientists like Weber believe that the proton-exchange-membrane (PEM) fuel cells being studied at Berkeley Lab and improved by Berkeley Lab industry partners are becoming an important part of our energy future—fueling cars and fleets, industry, appliances, and buildings.

Unlike batteries, fuel cells do not store electricity, they convert it from primary fuels like hydrogen—a plentiful and renewable resource. The main by-product of the chemical conversion is water.

Working to make these fuel cells more durable, efficient, and effective, Weber uses mathematical computer models to provide an approximate idea of the distribution of heat, fuel, and water within different parts of the cell and to understand how these distributions affect the cell's power output. Through these simulations, Weber can identify exactly what goes on inside the fuel cell with the aim of optimizing its performance.

"A lot of our core competence is on the physics-based mathematical modeling of the complex phenomena," Weber said. "On the computer we can look at each of the components in the process and understand exactly how it works—where the water goes, where the hydrogen and oxygen go—and we can ask how we can make it better," he said.

Right now he's working on next-generation fuel-cell designs and materials, finding less expensive options to improve the technology and overcome stumbling blocks, such as improving the ability of fuel cells to operate at below-zero temperatures, making fuel cells more durable, and examining how to reduce cost without decreasing performance.

"Advancing fuel cells is important and it's happening right now," Weber said. "Hyundai is releasing a fuel-cell car this year, and Toyota will next year. But on the engineering and material side, there is still work need to be done for the Generation 2 designs," he said.

Improving the Ion-Conducting Membranes in Fuel Cells

Fuel cells work by generating protons and electrons from a fuel (such as hydrogen) and moving the protons through an ion-conducting, polymer membrane while the electrons flow through an external circuit as electricity (See Figure 1). The understanding and improvement of fuel-cell membranes is a major focus of what Weber and his colleagues are doing.

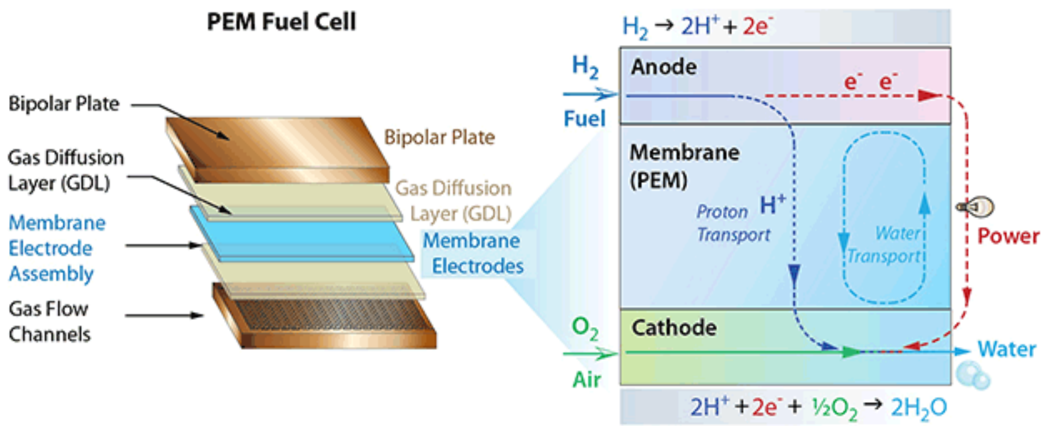

Figure 1: Layers of a PEM fuel cell (Source: Ahmet Kusoglu).

"We want to understand the processes; find the bottlenecks and ways to overcome them," Weber said. "We're looking for a viable way to have a carbon-neutral power source," he said.

One of his projects is to understand how cell membranes function when used in the electrodes as a binder. The small thicknesses-as thin as tens of nanometers of polymer-demonstrate different performance that may be key to allowing fuel cells to reduce their precious metal catalyst amount. These studies require his team to develop new analysis techniques.

Their research is the basis of recommendations they make to industry and laboratory partners for improving the membranes.

"We can tell them, 'if you double the amount of the flow of this gas, or change the size of the device, or use a material with these properties, these are the results you could obtain,'" he said. "Our results allow them to prioritize the research they are doing."

Weber's team has also been working with Los Alamos National Laboratory on durability issues in fuel cells and with the National Renewable Energy Laboratory on detecting and understanding manufacturing defects of membranes and electrodes. In this latter work, Weber said, the joint team has developed new infrared-based techniques to determine thickness variations and have begun to model how such defects impact performance.

Improving Fuel-Cell Operation at Low Temperatures

Weber's work to improve the ability of fuel cells to work effectively at low temperatures—something critical to starting a fuel-cell-powered car in wintertime in a cold climate—was one of the specific reasons he was granted the Presidential Early Career Award. This research is the subject of a journal article Weber recently co-authored in the *Journal of the Electrochemical Society*. In the paper, Weber and his co-authors report findings about research studying the nucleation and growth of ice crystals forming in the catalyst layer of the fuel cells.

It's all about removing the water produced in the conversion process fast enough, Weber said. Otherwise, it freezes at low temperatures and stops the fuel cell from producing electricity.

"Right now manufacturers have a lot of engineering solutions for this—they dry out the systems to keep the water from flooding the system," Weber said. "If we understand what's happening, we can find a passive solution rather than an active solution, like a blower, that is inefficient," he said.

Weber said that they started with experimental lab work, and then used the results in their computer simulation.

"For example, we filled the backing layer of the cell up with water and put it in a machine to measure the heat flow in the layer," he said. "When things freeze, they give off a lot of heat. We set the temperature down to -10 degrees Celsius, and then we waited for the heat release when the water changes from liquid to solid. We did this a lot of times," he said.

Weber and his team have taken the results of these experiments, and put them into models. Results have shown that, depending on how much below zero the temperature goes, it takes a long time for the water to freeze—longer than other models (which rely on a thermodynamic-based approach) have used. Put another way, cell-failure time increases with increasing temperature due to a longer required time for ice nucleation.

"We can put the numbers into models, and then we're able to tell manufacturers, with more accuracy than before, 'if you're at -10 degrees, you have this much time to raise the temperature until the cell shuts down and won't work,'" he said.

They also take the diagnostics and results from the modeling to their industry partners. Weber said he's been working with industry giant 3M for the last few years to see how the company's fuel cell operates in low temperatures.

"Working with a diverse team of industry, academia, and national laboratories, we've shown how we can increase performance of a 3M cell by removing the liquid water from one side of the cell; showing how it operates and how it works better," Weber said.

Artificial Photosynthesis: Creating Fuels from Sunlight

Another project attracting attention for Weber is his work with artificial photosynthesis—producing fuels, like hydrogen, from sunlight. Weber is the team leader for the modeling and simulation team at the Joint Center for Artificial Photosynthesis—a U.S. Department of Energy-funded innovation hub combining team members primarily from California Institute of Technology and Berkeley Lab.

Weber and his team are working to model and understand the various physics to design integrated photoelectrochemical cells that can efficiently produce hydrogen gas or maybe even liquid fuels from the atmosphere and water. He thinks this technology might have the efficiency needed to "close the fuel-cell loop," producing the hydrogen that is then used in other fuel cells to produce electricity.

Looking Into the Future

Weber is enthusiastic about the future of his work at Berkeley Lab, pointing to his work on hydrogen/bromine redox (reduction-oxidation) flow batteries-a system that uses essentially the same framework (and sometimes materials) as those of fuel cells.

"The hydrogen/bromine flow battery is essentially a reversible fuel cell, with many of the same components but different issues," says Weber.

Except that these cells can store electricity from wind and solar electric generation for grid applications in order to curtail their inherent intermittency.

As it was intended to do, his recent award has provided good incentive for his future work.

"It was very inspiring to see the people getting awards and hear the breadth of the research being done," Weber said. "Getting the presidential award was a vote of confidence—not just for what we have already done, but for what we can do in the future. They are telling us, 'Your best science is ahead of you, and we're looking forward to seeing what you can do next,'" he said.

—Kyra Epstein

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New EnergyIQ Features Ease Benchmarking and Increase Accuracy

Lawrence Berkeley National Laboratory (Berkeley Lab) has added significant new features and updates to EnergyIQ [http://energyiq.lbl.gov/] , its free, web-based, action-oriented benchmarking tool for non-residential buildings. These improvements help new and current users speed and simplify energy benchmarking against a growing database of buildings.

To help existing users of the ENERGY STAR Portfolio Manager easily take advantage of EnergyIQ's deeper benchmarking features, users are now able to import building data that was previously entered into Portfolio Manager directly into EnergyIQ.

Users will also find many more buildings to benchmark theirs against. Previously, peer groups could only be drawn from the California Commercial End-Use Survey (CEUS) or Commercial Buildings Energy Consumption Survey (CBECS) databases, but now users can also benchmark themselves against other users of EnergyIQ. In addition, users can now benchmark a single building exclusively against their own portfolio of buildings.

Evan Mills

"Our user base has grown to 1,139 firms who have collectively entered data for 781 buildings, with an aggregate floor area of 106 million square feet," says EnergyIQ project leader Evan Mills. "EnergyIQ utilization has tripled in the past six months, and now that the automated data import from Portfolio Manager import is working, we expect those numbers to grow quickly."

Beyond the explosive data growth, however, is an improvement in accuracy. Users can now add a larger number of building features, which facilitates more accurate and meaningful peer-group definitions. In addition, new filters, including hours of occupancy and type of building certification (e.g., ENERGY STAR, LEED) allow for more relevant peer-group definition, whether a user is evaluating an existing building or one in the design stage.

Finally, EnergyIQ is getting even more user-friendly. The peer group definition user interface is now easier to use (there are slider bars for key inputs), and users are no longer limited to pre-set blocks; they can specify custom ranges, such as vintage bands.

"We now offer a downloadable input form, which makes it easier for users to assemble data before starting their web session," says Mills. "In addition, our APIs [https://developers.buildingsapi.lbl.gov/eiq] enable software developers to create customized web interfaces for energy benchmarking. We always welcome feedback and suggestions for improvements—anything that will lead to better, quicker benchmarking."

—Mark Wilson

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Additional Information

EnergyIQ [http://energyiq.lbl.gov]

Cost and Benefit Estimates of Renewable Portfolio Standards

Lawrence Berkeley National Laboratory's (Berkeley Lab's) Electricity and Markets Policy Group has released a new report, authored jointly by Berkeley Lab and the National Renewable Energy Laboratory, titled, *A Survey of State-Level Cost and Benefit Estimates of Renewable Portfolio Standards*.

Renewable portfolio standard (RPS) policies are in place in more than half of all U.S. states and have played a critical role in driving renewable energy deployment over the past decade. In many states, however, fierce debates have recently arisen regarding the cost of RPS policies, and proposals have been introduced to repeal, reduce, or freeze existing requirements. This report seeks to inform these debates by summarizing available data on the costs and benefits of RPS policies to-date and by highlighting key methodological issues that must be considered.

The report draws on a variety of data sources, including estimates developed by utilities and public utility commissions (PUCs) and renewable energy certificate pricing, to summarize the net (or "incremental") costs incurred by utilities to comply with RPS requirements. The report also surveys recent studies that have assessed the magnitude of potential broader societal benefits (though for a variety of reasons, those benefits estimates cannot be directly compared to RPS compliance costs).

Key findings from this study include the following:

- Among the 24 states for which the requisite data were available, estimated RPS compliance costs over the 2010–2012 period were equivalent to, on average, roughly 1 percent of retail electricity rates, though substantial variation exists across states and years.
- Expressed in terms of the incremental (or "above-market") cost per unit of renewable generation, average RPS compliance costs during 2010–2012 ranged from -$4/megawatt-hour (MWh) (i.e., a net savings) to $44/MWh across states.
- Methodologies for estimating RPS compliance costs vary considerably among utilities and states, though a number of states are in the process of refining and standardizing their methods.
- Utilities in eight states assess surcharges on customer bills to recoup RPS compliance costs, which in 2012 ranged from about $0.50/month to $4.00/month for average residential customers.
- Cost-containment mechanisms incorporated into current RPS policies will limit future compliance costs, in the worst case, to no more than 5 percent of average retail rates in many states and to 10 percent or less in most others.
- Although typically not considered within utilities' estimates of net compliance costs, a number of states have separately estimated the value of RPS benefits associated with avoided emissions (ranging from $4–$23/MWh of renewable generation), economic development ($22–$30/MWh), and/or wholesale electricity price suppression ($2–$50/MWh).

Important caveats and context for the findings cited above are explained fully within the report, which can be freely downloaded at the URL below. Findings from the report were presented in a June webinar.

—Galen Barbose

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Additional information:

Download the report [http://emp.lbl.gov/publications/survey-state-level-cost-and-benefit-estimates-renewable-portfolio-standards]

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LAWRENCE BERKELEY NATIONAL LABORATORY
Environmental Energy Technologies Division
NEWS

Frank Asaro, Nuclear Chemist Who Contributed to Dinosaur Extinction Theory and Archaeological Studies, Passes Away

Frank Asaro

Frank Asaro, a nuclear chemist known for his work on the asteroid impact theory and mass extinctions, as well as for determining the origins of archaeological artifacts around the world and for his work on alpha decay, passed away on June 10, 2014, at the age of 86. He was for many years a scientist at the Environmental Energy Technologies Division (EETD) of Lawrence Berkeley National Laboratory (Berkeley Lab), and prior to that, in the former Nuclear Chemistry Division.

Asaro is most famous for being a member of the team that proposed the mass extinctions that took place 65 million years ago were caused by Earth's collision with an asteroid. University of California, Berkeley, physicist and Nobel Prize winner Luis Alvarez, geologist Walter Alvarez (his son), Asaro, and Helen Michel analyzed rock samples collected by Walter in Italy and other locations. They found that the samples contained a clay layer enriched in the element iridium by 600 times the normal concentration found on Earth.

Asteroid Impact research team, left to right: Helen Michel, Frank Asaro, Walter Alvarez, and Luis Alvarez.

They concluded, in a classic paper published in the journal *Science* in 1980, that this iridium had extraterrestrial origins and was deposited when the mixture of dust and ash from the impact of an iridium-enriched asteroid settled. The team used neutron activation analysis (NAA) to measure the concentration of iridium in the layer. Their report caused a sensation in the scientific world and among the public. In 2010 an international panel of experts in geology, paleontology, and related fields ruled in favor of the asteroid theory.

Asaro later designed and named the Luis Alvarez Iridium Coincidence Spectrometer specifically to measure trace iridium. Asaro set the standard for measurement of this and other trace elements in the field of archaeometry.

Applying Chemistry and Physics to Archaeology in the 1960s

In the 1950s, with Isadore Perlman, Asaro helped to develop neutron activation analysis into a technology precise enough to determine the origins of archaeological artifacts by measuring their chemical compositions. Neutron activation analysis uses the gamma ray emissions of radioactive chemical elements in irradiated pottery samples to accurately measure the abundances of elements in the sample.

The unique composition of an artifact provided a chemical signature that archaeologists could use to help determine the provenance, or point of origin, of artifacts. Knowing the origin helps archaeologists understand patterns of mobility, trade, wealth, and settlement in ancient civilizations. The paper they published on NAA in 1969 became a landmark, the field's most heavily cited reference.

Although he was best known for his work on the iridium layer and the asteroid theory of extinction, Asaro spent a considerable fraction of his career applying NAA to archaeological studies. With Michal Artzy, Perlman and Asaro demonstrated in 1967 that an innovative Late Bronze Age style of pottery known as Palestinian bichrome, long considered to have been manufactured in Palestine, was actually manufactured in Cyprus and exported to Palestine. In 1973, Asaro and colleagues studied the Colossi of Memnon, two 50-foot quartzite statues near Luxor, and showed that the original rock for the statues came from quarries in Cairo, 420 miles away—an amazing distance to transport so much weight at that time.

Drake's Plate—A *bona fide* fake

Next to the extinction research, Asaro may best known for demonstrating that "Drake's Plate," a metal plaque that was purportedly left by Sir Francis Drake when his ship the Golden Hinde landed on the California coast in 1579, was actually a fake.

In 1936, the plate was reported found in Marin County, and acquired for the Bancroft Library at the University of California (UC) Berkeley. However, in 1977, Asaro and Michel applied neutron activation analysis to the plate and determined that the brass was probably manufactured between the last half of the nineteenth century and the early part of the twentieth; proving that California's best known artifact was a fake—a practical joke that had gone out of control.

65-Million Year Journey Began in 1927

Frank Asaro was born July 31, 1927, and grew up in Escondido, California, the son of an avocado farmer, Nicolo Asaro, and Annie Asaro. He earned his undergraduate degree and PhD in chemistry at UC Berkeley. He studied alpha decay processes in nuclear chemistry for his doctorate under the supervision of Perlman, who was also the head of the Lawrence Berkeley National Lab's Chemistry Division. Asaro worked with Perlman another 14 years, studying nuclear structure. They conducted groundbreaking work that contributed evidence to support the now accepted unified model of the nucleus. In 1967, Perlman became interested in archaeology, and Asaro changed directions along with him.

"How good was Perlman at choosing new fields?" Asaro later said. "I thought I would take three months off to do this. I made that decision in 1967, and I'm still doing this work [some 40] years later."

Even after his retirement from Berkeley Lab in 1991, Asaro continued to work "just for the fun of it." With archaeologist David Adan-Bayewitz of Bar-Ilan University in Israel, he employed neutron activation analysis to investigate a series of archaeological and historical problems. With the help of Robert Giauque, they showed that high-precision X-ray fluorescence (XRF) measurements could be more effective, in certain cases, than those of NAA for studies of local trade. On another project, Asaro developed a new coincidence technique of silver analysis by NAA, which he used to check NAA and X-ray fluorescence measurements. This research demonstrated that anomalously high silver concentrations were found only at urban sites and were context-related. Asaro considered this work to be potentially as important as the work on the iridium anomaly.

Asaro's work shows us that the past is not necessarily a closed book. People leave traces of themselves in the effect they have on others, and the unique chemical compositions of their artifacts, read from traces of energy that Asaro learned how to use, tell stories of human time and movement.

—Allan Chen

Additional information:

Alvarez Theory on Dinosaur Die-out Upheld [http://newscenter.lbl.gov/2010/03/09/alvarez-theory-on-dinosaur/]

Nuclear Physics Sheds Light on Ancient Archaeological Mysteries [http://www2.lbl.gov/Science-Articles/Archive/nuclear-archaeology.html]

Silver Anomalies Found in Jerusalem Pottery Hint at Wealth During Second Temple Period [http://newscenter.lbl.gov/2006/09/27/silver-anomalies-found-in-jerusalem-pottery-hint-at-wealth-during-second-temple-period/]

Drake's Plate: End of the Mystery? [http://newscenter.lbl.gov/2003/04/04/drakes-plate-the-end-of-the-mystery/]

Historical Journal Reveals Secrets Behind Infamous Drake's Plate Hoax [http://www.berkeley.edu/news/media/releases/2003/02/18_drake.shtml]

Full-length obituary [http://eetd.lbl.gov/news/article/57850/frank-asaro-nuclear-chemist-who]

Lawrence Berkeley National Laboratory
Environmental Energy Technologies Division
NEWS

Lev Ruzer, EETD Affiliate and Editor of the *Aerosol Handbook,* Passes Away at Age 92

Lev Ruzer

Dr. Lev Ruzer, who worked as an affiliate with the Environmental Energy Technologies Division's Indoor Environment Group for 24 years, has passed away. During his tenure at Lawrence Berkeley National Laboratory (Berkeley Lab), Ruzer worked without financial support; purely for the love of science.

Ruzer was born in the Soviet Union, where he studied nuclear physics at Moscow University but was unable to work as a scientist upon graduation for political reasons. Once the political tides turned, he worked as a researcher, assessing dosages to animals exposed to radon and its decay products—work that would earn him an equivalent to a PhD in 1961. He founded and chaired the Aerosol Laboratory at the Institute of Physico-Technical and Radiotechnical Measurements in Moscow from 1961 to 1979, and in 1968 published a book on radioactive aerosols. In 1970 he became a doctor of technical sciences, and in 1977, became a professor. However, in 1979, with another political shift, he was discharged, and was unable to work for eight years.

In 1987, he emigrated to the United States, and he began to work as an affiliate at Berkeley Lab in 1989. He published papers in the emerging field of dosimetry of nanoparticles, as well as a book on radioactive aerosols; all in all, he authored more than 130 publications and was granted three patents. He also served as editor of *Aerosol Handbook: Measurement, Dosimetry, and Health Effects*. The expanded and updated second edition was published in 2012, when Ruzer was 92 years old.

Lev was always friendly, with a great sense of humor. He enjoyed telling stories of his life in the Soviet Union, and when asked how he was doing, would often say, "Not as good as yesterday…but better than tomorrow!"—an example, he said, of Russian optimism. His commitment to science was unwavering, and watching him taught one the value of persistence; even in his nineties, when typing became a challenge, he produced long, detailed papers.

Berkeley Lab was fortunate to have hosted Lev and his research for more than two decades. "We will miss Lev," says William Fisk, Head of the Indoor Environment Group. "I am happy that we could serve as his host for these many years."

—Mark Wilson

Lawrence Berkeley National Laboratory
Environmental Energy Technologies Division
NEWS

Research Highlights

2014 ITRI-Rosenfeld Fellowship Winners Announced

Zhenhua Liu and Chinmayee Subban were recently announced as the winners of the 2014 ITRI-Rosenfeld Postdoctoral Fellowship. The fellowship honors the contributions of Arthur H. Rosenfeld, of Lawrence Berkeley National Laboratory's (Berkeley Lab's) Environmental Energy Technologies Division (EETD), for his pioneering work toward the advancement of energy efficiency on a global scale. The selection process includes scrutiny of the applications by a selection committee, presentations by the finalists, and panel interviews. The award enables the applicants to engage in innovative research that leads to new energy-efficiency technologies or policies, as well as the reduction of adverse energy-related environmental impacts. It is made possible through a gift from the Industrial Technology Research Institute of Taiwan (ITRI) and with EETD support.


Zhenhua Liu

Zhenhua Liu earned his PhD in Computer Science at California Institute of Technology (Caltech). His research focuses on the efficient integration of renewable energy into IT and the power grid. His proposal topic for the fellowship was Demand Response: Coordinating IT and the Smart Grid Towards a More Sustainable Future, and his mentor for this work is EETD's Mary Ann Piette. For this project Liu plans to develop new demand management algorithms, develop new demand-response programs, and investigate other opportunities that would help guide the management of data centers, buildings, and other systems. He has already begun working on his project at the Lab.


Chinmayee Subban

Chinmayee Subban earned her PhD from Cornell University's Department of Chemistry and Chemical Biology. Her graduate and postdoctoral research has been focused on the design and characterization of electrode materials for fuels cells and lithium-ion batteries. Her proposed topic of research for the fellowship was Technology Invention: New Electrode Materials for Water Treatment with Capacitive Deionization (CDI), and her mentor for the work is EETD's Ashok Gadgil. Her goal for this project is to develop more efficient, affordable electrode materials for CDI, bringing costs down and thus enabling the widespread use of the technology in treating brackish water for poor and rural communities around the world. She will begin at the Lab in September.

The award ceremony will take place in October 2014, at Berkeley Lab.

The application period for the 2015 ITRI-Rosenfeld Postdoctoral Fellowship will open in August 2014.

—Mark Wilson

EETD Team Wins for Sprinkler App at BERC Cleanweb Hackathon

Team Members: Daniel Olsen, Andrew Weber, Anna Liao, and Robert Sadler (left to right).

At the second annual Berkeley Energy & Resources Collaborative (BERC) Cleanweb Hackathon, a Berkeley Lab Environmental Energy Technologies Division team consisting of Anna Liao, Daniel Olsen, and Andrew Weber, along with Robert Sadler from InTech Energy, took the top prize for best app by developing an intelligent residential irrigation system based on open-source hardware. The app processes weekly weather, drought, and sunrise time data to set optimal watering schedules for automated sprinkler systems.

Each sprinkler "client" is controlled by a server that handles all data processing and control decisions. The same signal can control an unlimited number of sprinkler "clients." The system developed by the team is projected to save between 3,000 and 6,000 gallons of water annually per residence, depending on the type of system replaced and lawn/garden size.

The Cleanweb Hackathon, organized by BERC, encourages teams to build software-based business solutions and open-source code by introducing talented hackers at the University of California, Berkeley, to today's energy and resource challenges.

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About the Sprinkler app [http://sprinklr.herokuapp.com/home]

Cleanweb Hackathon [http://berkeley.cleanweb.co/]

Berkeley Energy & Resources Collaborative [http://berc.berkeley.edu/]

Financing Energy Improvements on Utility Bills—New Report from EETD Researchers

Lawrence Berkeley National Laboratory's (Berkeley Lab's) Electricity Markets and Policy Group [http://emp.lbl.gov/] has released a new, comprehensive report on on-bill efficiency financing programs-which offer loans for energy improvements that can be paid back on the borrower's utility bill. The report, produced through the State and Local Energy Efficiency Action (SEE Action) Network, surveys the landscape of on-bill financing programs and carefully examines program design elements and key performance metrics (e.g., loan volume, default rates).

The Environmental Energy Technologies Division's Mark Zimring, an expert in efficiency financing, was lead author for the study.

States and utilities are increasingly turning to on-bill financing to stretch their limited efficiency program dollars and overcome barriers to the uptake of energy improvements in both residential and non-residential properties. Financing Energy Improvements on Utility Bills [https://www4.eere.energy.gov/seeaction/publication/financing-energy-improvements-utility-bills-market-updates-and-key-program-design] gives an updated overview of the landscape of on-bill programs-and provides actionable insights for policymakers and administrators on key program design considerations.

The report describes the historical evolution of on-bill programs and draws on data collected from 30 on-bill programs (including 13 in-depth case studies) to review and analyze key trends in on-bill programs, including their geographic reach, loan volumes, loan performance, and four important program design features:

- How is the loan product structured? Power disconnection and meter attachment
- Where does loan funding come from? Selecting sources of capital
- Who is eligible? Assessing customer creditworthiness, underwriting criteria
- What can participants finance? Eligible energy, and non-energy, improvements

The report finds that on-bill programs have delivered more than $1.8 billion in loans and have experienced low default rates (ranging between 0% and 3%).

You can find the report, *Financing Energy Improvements on Utility Bills: Market Updates and Key Program Design Considerations for Policymakers and Administrators,* and a summary presentation by visiting the SEE Action Financing Solutions Working Group's [https://www4.eere.energy.gov/seeaction/] website.

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Download the report [https://www4.eere.energy.gov/seeaction/publication/financing-energy-improvements-utility-bills-market-updates-and-key-program-design]

Electricity Markets and Policy Group [http://emp.lbl.gov/]

SEE Action [https://www4.eere.energy.gov/seeaction/]

FMC Corporation Recognizes Berkeley Lab Battery Researchers

A team of scientists from Lawrence Berkeley National Laboratory (Berkeley Lab) and Argonne National Laboratory was recognized by FMC Corporation, receiving its FMC Scientific Achievement Award. Aaron Reichl, Director of Technology for FMC Minerals, and Marina Yakovleva, Global Technical Programs Manager, presented the award at a ceremony in April.

The team performed fundamental research on FMC's stabilized lithium metal powder (SLMP®) and helped to identify methodologies for applying the technology in high-energy lithium-ion batteries for consumer and transportation applications. This work is part of the Integrated Laboratories and Industry Research Program, supported by the Batteries for Advanced Transportation Technologies Program of the Vehicle Technologies Office, U.S. Department of Energy. FMC Corporation is a global company and world-leading lithium products manufacturer.

This success illustrates the Berkeley Lab's commitment to grow and develop its relationships and collaborations with industry.

The Berkeley Lab awardees are principal investigators Gao Liu, Vincent Battaglia, and Andrew M. Minor, as well as postdocs Zhihui Wang, Bin Xiang, Sang-Jae Park, and Lei Wang.

Gao Liu's research topics in lithium-ion rechargeable batteries include advanced electrode design and formulation, silicon-based anode materials, and electrode binder design and synthesis, electrolytes, and additives.

Vince Battaglia works on electrode design and preparation process optimization, cell components integration, battery testing, and failure analysis.

Andrew Minor's research group uses advanced electron microscopy-based materials characterization to investigate both organic and inorganic materials on topics such as nanomechanical size effects, lightweight alloy metallurgy, characterization of soft materials, and novel in-situ transmission electron microscopy (TEM) methods for materials science research.

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Sources and Credits

Sources

Energy Efficiency & Renewable Energy's Energy Savers

These web pages [http://energy.gov/energysaver/energy-saver] provide information about energy efficiency and renewable energy for your home or workplace.

DOE's Energy Information Administration (EIA)

EIA [http://www.eia.gov/] offers official energy statistics from the U.S. Government in formats of your choice, by geography, by fuel, by sector, or by price; or by specific subject areas like process, environment, forecasts, or analysis.

DOE's Fuel Economy Guide

This website [http://www.fueleconomy.gov/] is an aid to consumers considering the purchase of a new vehicle.

DOE's Office of Energy Efficiency & Renewable Energy (EERE)

EERE's [http://www.eere.energy.gov/] mission is to pursue a better energy future where energy is clean, abundant, reliable, and affordable; strengthening energy security and enhancing energy choices for all Americans while protecting the environment.

U.S. DOE, Office of Science [http://science.energy.gov/]

U.S. EPA, ENERGY STAR Program [http://www.energystar.gov/]

California Energy Commission [http://energy.ca.gov/]

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Ernest Orlando Lawrence Berkeley National Laboratory is a multiprogram national laboratory managed by the University of California for the U.S. Department of Energy. The oldest of the nine national laboratories, Berkeley Lab is located in the hills above the campus of the University of California, Berkeley.

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