



# Environmental Energy Technologies Division

## NEWS

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As the nation continues moving toward a more energy-efficient economy, research at the Environmental Energy Technologies Division plays its part in developing the technologies it needs for the Smart Grid, and in evaluating policies aimed at increasing energy efficiency workforce training. Other stories in this issue look at research evaluating the possible dangers of "third-hand" tobacco smoke, and the net metering of residential photovoltaic systems. Congratulations to John Newman on winning the Acheson Award, one of the field of electrochemistry's signal honors.

—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 [\[http://eetd.lbl.gov/newsletter/cbs\\_nl/cbsnews.html\]](http://eetd.lbl.gov/newsletter/cbs_nl/cbsnews.html).

Spring Newsletter: Vol. 8, No. 4 [\[http://eetd.lbl.gov/newsletter/nl31/\]](http://eetd.lbl.gov/newsletter/nl31/)

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## Environmental Energy Technologies Division

## NEWS

## OpenADR Supports Smart Grid Technologies

Smart Grid technology products are gaining more traction in the market, thanks in part to the open-source OpenADR communications specification developed by Lawrence Berkeley National Laboratory (Berkeley Lab) and its research partners.

The OpenADR specification provides a common "language" for Smart Grid technology developers, allowing building control systems to respond automatically to Internet-based signals that provide electricity grid prices and reliability messages.



Mary Ann Piette is Deputy Head, Building Technologies Department, EETD, and Research Director of the Demand Response Research Center.

Building controls take pre-planned steps to reduce electricity use in a process called *automated demand response* (Auto-DR), which is a significant enabling technology of the Smart Grid. Funded by the California Energy Commission's Public Interest Energy Research program, Berkeley Lab's Demand Response Research Center (DRRC) has led a multi-year research program to demonstrate Auto-DR, in cooperation with California utilities.

For Auto-DR to be viable on a national scale, there must be a common "language" that any company's building control software and hardware products can use to communicate with one other. OpenADR is that specification. As an open-source specification, any company can make products conforming to OpenADR.

OpenADR was developed by Berkeley Lab researchers, led by Mary Ann Piette, and their partners, including start-up company Akuacom. Together with Pacific Gas and Electric, Southern California Edison, and California's other investor-owned utilities, they developed and demonstrated the OpenADR specification in California's grid.

### Honeywell Acquires Akuacom

In mid-May, Honeywell acquired Akuacom, a move that further positions OpenADR as the basis for communications among Smart Grid technology products. In addition to Honeywell and Akuacom, more than 30 energy management and control systems vendors offer products based on OpenADR.

"Many major controls companies, utilities, and grid systems operators have deployed OpenADR-based programs that reduce peak electric demand by tens of megawatts," says Piette. "Honeywell's acquisition of Akuacom is one of many recent developments that further solidifies OpenADR as a national standard and enables multiple vendors, utilities, and ratepayers to deploy tens of billions of watts of automated demand response nationwide." Honeywell is one of the largest building controls companies in the United States, and its products are widely used in commercial and residential buildings. Akuacom is one of several companies offering products that incorporate the OpenADR information exchange model. It began conducting research and field-testing with Berkeley Lab in 2005.

## New Products Based on OpenADR

The private sector has been introducing new hardware and software products that incorporate OpenADR into the marketplace. Recent products from such companies as Tendril, Residential Control Systems, BuLogics, and Our Home Spaces have expanded OpenADR into residential and small commercial applications. The products include hardware devices and visual displays that link to the grid and provide automated demand response capabilities to homes and businesses.

OpenADR has received broad interest. Smart Grid projects underway in Quincy and Tallahassee, Florida, use OpenADR as the communications specification. Several utilities, including NVEnergy, (serving Nevada and northeastern California), the Bonneville Power Administration (serving the Pacific Northwest), and the Sacramento Municipal Utility District have all identified OpenADR as the communications specification to follow in their Smart Grid plans. OpenADR is in use in a commercial building project by Natural Resources Canada. The California Independent System Operator, which oversees California's electricity grid, is conducting a project to integrate renewable resources into OpenADR. And researchers at Berkeley Lab have also responded to queries from South Korea and India about using OpenADR in their Smart Grid planning.

In 2009, OpenADR was selected by the National Institute of Standards and Technology (NIST) and U.S. Department of Energy (DOE) as the basis for smart grid demand response communications over the Internet. The Smart Grid standards roadmap that NIST is developing for the nation incorporates OpenADR.

"The interest that the private sector is showing in OpenADR, and in Berkeley Lab's automated demand response research generally, demonstrates that this technology is ready for broad adoption in the marketplace," says Piette.

— Allan Chen

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Additional information:

- More about OpenADR at the Demand Response Research Center [<http://drcc.lbl.gov/openadr/docs.html>]
  - National Institute of Standards and Technology Smart Grid Roadmap [<http://www.nist.gov/smartgrid/>]
  - Automated Demand Response research at Berkeley Lab:
    - Berkeley Lab Researchers Announce OpenADR Specification to Ease Saving Power in Buildings Through Demand Response [<http://newscenter.lbl.gov/press-releases/2009/04/27/openadr-specification/>]
    - In Successful Test of Fast-DR, Northern California Takes Another Step Towards Smart Grid [<http://newscenter.lbl.gov/feature-stories/2009/08/19/smart-grid-success/>]
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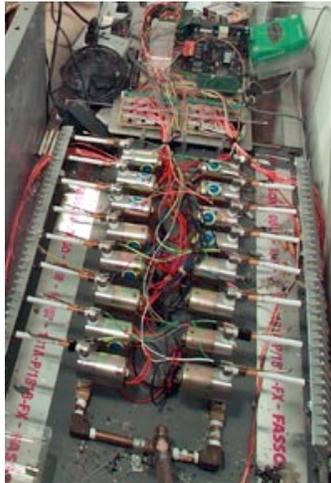


## Environmental Energy Technologies Division

## NEWS

## Nicotine from Third-hand Smoke Presents Danger

A multi-institutional study led by researchers with the Lawrence Berkeley National Laboratory (Berkeley Lab) revealed that nicotine in "third-hand smoke" (the residue from tobacco smoke that clings to virtually all surfaces long after a cigarette has been extinguished) reacts with the common indoor air pollutant nitrous acid to produce dangerous carcinogens.



In tests at Berkeley Lab of cellulose surfaces contaminated with nicotine residues from third-hand smoke, levels of newly formed tobacco-specific nitrosamines (TSNAs) rose 10 times the original level following a three-hour exposure to nitrous acid. TSNAs are potent carcinogens. (Photo by Roy Kaltschmidt, Berkeley Lab Public Affairs)

Hugo Destaillats, a chemist with the Indoor Environment Department of Berkeley Lab's Environmental Energy Technologies Division, explains. "The burning of tobacco releases nicotine in the form of a vapor that adsorbs strongly onto indoor surfaces, such as walls, floors, carpeting, drapes, and furniture. Nicotine can persist on those materials for days, weeks, and even months. Our study shows that when this residual nicotine reacts with ambient nitrous acid it forms carcinogenic tobacco-specific nitrosamines, or TSNAs." "TSNAs are among the most broadly acting and potent carcinogens present in unburned tobacco and tobacco smoke."

Destaillats is the corresponding author of a paper published in the *Proceedings of the National Academy of Sciences* (PNAS) titled "Formation of carcinogens indoors by surface-mediated reactions of nicotine with nitrous acid, leading to potential third-hand smoke hazards."

Co-authoring the PNAS paper with Destaillats were Mohamad Sleiman, Lara Gundel, and Brett Singer (all with Berkeley Lab's Indoor Environment Department), as well as James Pankow with Portland State University and Peyton Jacob with the University of California, San Francisco.

In laboratory tests using cellulose as a model indoor material exposed to smoke, levels of newly formed TSNAs detected on cellulose surfaces were 10 times higher than those originally present in the sample after they had been exposed for three hours to a "high but reasonable" concentration of nitrous acid (60 parts per billion by volume).

Unvented gas appliances are the main source of nitrous acid indoors. However, since most vehicle engines emit some nitrous acid that can infiltrate the passenger compartments, tests were also conducted on surfaces inside the truck of a heavy smoker, including the surface of a stainless steel glove compartment. These measurements also showed substantial levels of TSNAs. In both cases, one of the major products found was a TSNA that is absent in freshly emitted tobacco smoke—the nitrosamine known as NNA. The potent carcinogens NNN and NNK were also formed in this reaction.

"Time-course measurements revealed fast TSNA formation, up to 0.4 percent conversion of nicotine within the first hour," says lead author Sleiman. "Given the rapid sorption and persistence of high levels of nicotine on indoor surfaces, including clothing

and human skin, our findings indicate that third-hand smoke represents an unappreciated health hazard through dermal exposure, dust inhalation, and ingestion."

Since the most likely human exposure to these TSNAs is through either dust inhalation or the contact of skin with carpet or clothes, third-hand smoke would seem to pose the greatest hazard to infants and toddlers. Opening a window or deploying a fan to ventilate the room while a cigarette burns does not eliminate the hazard, and smoking outdoors is not much of an improvement, as co-author Gundel explains.



Berkeley Lab chemists Lara Gundel and Hugo Destailats led the research team. (Photo by Roy Kaltschmidt, Berkeley Lab Public Affairs)

"Smoking outside is better than smoking indoors, but nicotine residues will stick to a smoker's skin and clothing," she says. "Those residues follow a smoker back inside and get spread everywhere. The biggest risk is to young children. Dermal uptake of the nicotine through a child's skin is likely to occur when the smoker returns, and if nitrous acid is in the air, which it usually is, then TSNAs will be formed."

Mainstream and secondhand tobacco smoke are well documented as a cause of cancer, cardiovascular disease and stroke, pulmonary disease, and birth defects. Only recently, however, has the general public been aware of threats posed by third-hand smoke. The term was coined in a study that appeared in the January 2009 edition of the journal *Pediatrics*, in which it was reported that only 65 percent of non-smokers and 43 percent of smokers surveyed agreed with the statement that "Breathing air in a room today where people smoked yesterday can harm the health of infants and children."

Anyone who has entered a confined space such as a room, an elevator, or a vehicle where someone recently smoked knows that the scent lingers for an extended period of time. Scientists have been aware for several years that tobacco smoke is adsorbed on surfaces where semi-volatile and non-volatile chemical constituents can undergo reactions, but reactions of residual smoke constituents with atmospheric molecules such as nitrous acid have been overlooked as a source of harmful pollutants. This is the first study to quantify the reactions of third-hand smoke with nitrous acid.



Lead author Mohamad Sleiman. (Photo by Roy Kaltschmidt, Berkeley Lab Public Affairs)

"Whereas the sidestream smoke of one cigarette contains at least 100 nanograms equivalent total TSNAs, our results indicate that several hundred nanograms per square meter of nitrosamines may be formed on indoor surfaces in the presence of nitrous acid," says lead author Sleiman.

Co-author James Pankow notes that these results should raise concerns about the purported safety of electronic cigarettes. Also known as "e-cigarettes," electronic cigarettes claim to provide the "smoking experience," but without the risks of cancer. A battery-powered vaporizer inside the tube of a plastic cigarette turns a solution of nicotine into a smoky mist that can be inhaled

and exhaled like tobacco smoke. Since no flame is required to ignite the e-cigarette and there is no tobacco or combustion, e-cigarettes are not restricted by anti-smoking laws.

"Nicotine, the addictive substance in tobacco smoke, has until now been considered to be non-toxic in the strictest sense of the term," says Kamlesh Asotra of the University of California's Tobacco-Related Disease Research Program, which funded this study. "What we see in this study is that the reactions of residual nicotine with nitrous acid at surface interfaces are a potential cancer hazard, and these results may be just the tip of the iceberg."

The Berkeley Lab researchers are now investigating the indoor long-term stability of the TSNAs produced as a result of third-hand smoke interactions with nitrous acid. They are also looking into the development of biomarkers to track exposures to these TSNAs. In addition, they are conducting studies to gain a better understanding of the chemistry behind the formation of these TSNAs and to find out more about other chemicals that are being produced when third-hand smoke reacts with nitrous acid.

"We know that these residual levels of nicotine may build up over time after several smoking cycles, and we know that through the process of aging, third-hand smoke can become more toxic over time," says Destailats. "Our work highlights the importance of third-hand smoke reactions at indoor interfaces, particularly the production of nitrosamines with potential health impacts."

In the PNAS paper, Destailats and his co-authors suggest various ways to limit the impact of the third-hand smoke health hazard, starting with the implementation of 100 percent smoke-free environments in public places and self-restrictions in residences and automobiles. In buildings where substantial smoking has occurred, replacing nicotine-laden furnishings, carpets, and wallboard might significantly reduce exposures.

— Allan Chen

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For more information about Berkeley Lab's Indoor Environment Department and its researchers, visit the Indoor & Outdoor Environmental Quality [<http://eetd.lbl.gov/r-indoor.html>] website.

For more information on the research of James Pankow [<http://www.pdx.edu/chem/profile/dr-james-f-pankow>].

For more information on the research of Peyton Jacob [[http://cancer.ucsf.edu/people/jacob\\_peyton.php](http://cancer.ucsf.edu/people/jacob_peyton.php)].

For more information on the University of California's Tobacco-Related Disease Research Program (TRDRP) [<http://www.trdrp.org/>].

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## Environmental Energy Technologies Division

### NEWS

#### **Ramping Up Energy-Efficiency Workforce Training to Meet Demand**

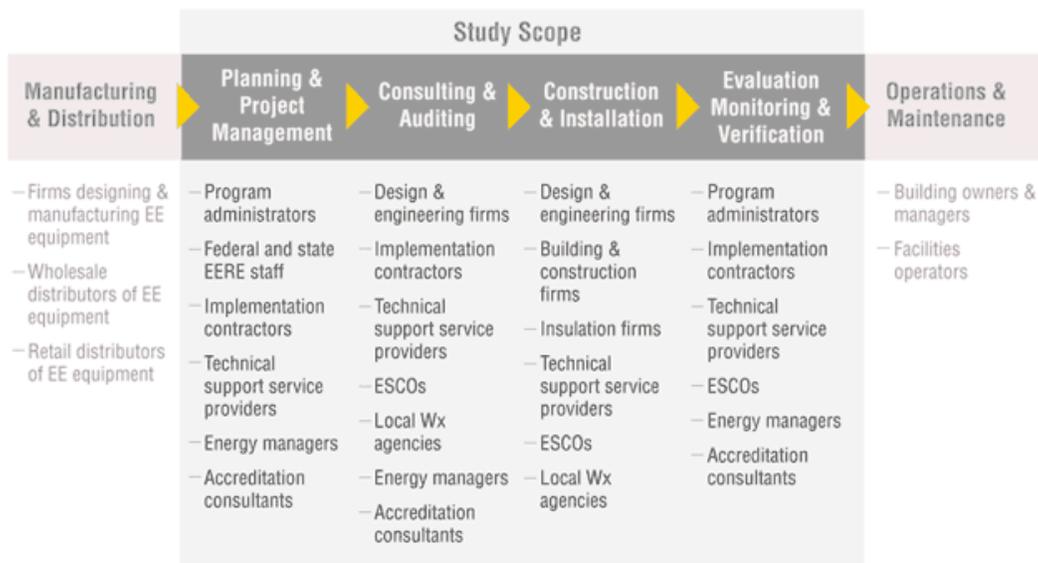
A new Lawrence Berkeley National Laboratory (Berkeley Lab) study has found that the speed with which employment will grow will depend in part on how effectively the nation deploys training and education programs for the energy-efficiency workforce.



"There is a shortage of formal training programs in energy efficiency, and an extremely high demand right now, thanks to the infusion of funding for energy efficiency from the growth in ratepayer-funded utility programs and federal and state budgets devoted to efficiency," says Charles H. Goldman, a scientist in Berkeley Lab's Environmental Energy Technologies Division. Because of this growth, Berkeley Lab researchers decided to examine whether education and training programs were adequate to meet the next decade's workforce needs. The study began in 2008, before the passage of the American Recovery and Reinvestment Act of 2009.

The new report defines an energy-efficiency services sector (EESS) that consists of several distinct occupation types. They include:

1. Program administrators who plan and manage energy-efficiency projects and programs;
2. Energy-efficiency consulting firms who assess facility energy use and recommend efficiency retrofits, implement energy-efficiency programs, or design homes and facilities to be energy efficient;
3. Construction and installation firms and tradespeople who build new structures, or retrofit existing homes and buildings for energy efficiency; and
4. Energy Service Companies (ESCOs) who develop and construct comprehensive energy-efficiency projects and monitor and verify that energy-efficiency retrofits deliver energy savings.



Study scope of the energy-efficiency services sector (EESS).

The study scope does *not* include those who maintain and operate buildings (such as building owners, managers, and operators) or companies that design, manufacture, and distribute energy-efficient equipment. "The narrow focus of this study is designed to allow us to estimate the size of the workforce that provides energy-efficiency services," says Goldman, "and determine whether the education and training programs designed to retrain existing workers and train new workers in this market segment are adequate to meet the coming demand."

The study also does not address the renewable energy workforce, or any energy supply-related market segment.

"A key purpose of this study," says co-author Jane S. Peters "is to define the energy- efficiency workforce sector, including occupations, employer needs, and current education and training approaches, which has not been explored in detail in past studies."

### Workforce Growth Anticipated

In a yet-unpublished companion study, the research team estimates the size of the energy- efficiency workforce at about 120,000 full-time equivalent workers (or person-year equivalents, PYE). Because many people in the sector only spend part of their time conducting energy efficiency-related activities or only work part-time, they estimate that total employment in the sector is about 400,000 people. Modeling the expected growth of the sector given current and estimated future funding, the team expects it to grow to anywhere from 220,000 to 380,000 PYE by 2020, which may represent about 1.3 million people.

The research team interviewed more than 350 program administrators, education and training providers, implementation contractors, ESCOs, professional and trade association representatives, and sector experts. This included interviews with almost 200 representatives of the major building trade unions, industry associations that represent professional groups (such as architects and engineers) or technicians involved in the building and construction industry (such as sheet metal workers; electrical contractors; and heating, ventilation, and air conditioning [HVAC] contractors). These include the American Institute of Architects; American Society of Heating, Refrigerating and Air-Conditioning Engineers; American Society of Mechanical Engineers; Associated General Contractors; Association of Energy Engineers; Insulation Contractors Association of America; National Association of Home Builders; and others.

The research team identified 492 higher education or training programs and conducted a screening analysis to identify engineering, architecture, policy, building trades technical training, and interdisciplinary programs whose curricula met minimum criteria of a specific emphasis on energy efficiency. Researchers interviewed staff at 33 of the educational programs.

### Three Primary Bottlenecks Identified

First, there is a shortage of trained, experienced energy-efficiency program managers—senior management staff with years of experience. As a result, mentoring opportunities for the next generation of staff in energy-efficiency services firms are reduced.

Second, there is a shortage of experienced energy-efficiency engineers, in part because not enough formal training programs are available. "Many engineers are also unaware of energy efficiency as a career path," says Goldman. "Moreover, training for mechanical and electrical engineers provides little specific emphasis on efficiency in how to design HVAC systems energy-efficiently."

Finally, says Peters, "the building and construction trades and contractors have limited awareness that the energy-efficiency service sector is poised to grow significantly, and that their skills will be required as part of this growth." The building and construction trades also face other barriers to growth, including an aging, retiring workforce and a limited number of skilled

trainers in some regions. She adds: "Not surprisingly, states that have been operating energy-efficiency programs for years, such as California, and those in New England and the Pacific Northwest, have a better training infrastructure and a larger pool of construction trades trained in implementing energy-efficiency projects than states that are just beginning to pursue energy efficiency."

## **Strategies for Expanding Training and Education**

The research team makes several recommendations to enable the EESS workforce to keep up with projected demand:

1. **Provide energy-efficiency education and training targeted at building and construction tradespeople.**
  - Building and construction trades constitute as much as 70 percent of the overall workforce in the EESS, and there is a notable lack of awareness that the sector is poised for significant growth—especially in states without long-running, ratepayer-funded programs.
  - It will be especially important to integrate building and industrial process system efficiency into *existing* curricula.
2. **Coordinate and track training efforts within states; share best practices across states.**
  - With stimulus funding, many states are initiating or ramping up training activities to target the EESS. However, it is still challenging to identify which training and education programs provide specific EESS education; this information needs to be tracked systematically.
  - Establishing broad statewide education and training efforts (like the New York State Energy Research and Development Authority's collaboration with Hudson Valley Community College) may help to avoid duplication of effort.
3. **Increase short-duration, applied trainings to augment on-the-job training for existing EESS workers and to introduce new entrants to the field.**
  - Much of the growth in the EESS will come from new entrants who already have applicable skills, such as contractors who become efficiency retrofit specialists.
  - There is strong demand for up-to-date training for those who are currently employed in the EESS but who need to update or augment their skills.
  - Mid- and senior-level engineers and managers also need more access to on-the-job and formal training, such as the training conferences offered by the Association of Energy Service Professionals and the Certified Energy Manager certificate program offered by the Association of Energy Engineers.
4. **Increase funding to "train the trainers."**
  - Projected growth in training needs indicate that resources for training trainers is urgently needed.
  - The Building Performance Institute, which provides certifications for residential retrofit contractors, experienced a five-fold increase in the number of certifications between 2005 and 2008.
5. **Prepare the next generation of EESS professionals.**
  - The interviews showed that most professional roles within the EESS require at least a four-year degree, but few colleges or universities offer energy efficiency-specific curriculum. Those that do stated that funding to grow these programs was extremely limited in most cases. Funding is needed to support new and expanded energy efficiency-related programs.
  - Industrial Assessment Centers have been a successful model to provide energy- efficiency services to industry and as a training ground for engineering students. Similar centers could be developed in conjunction with college-based engineering, architecture, planning, and policy-focused programs.

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These findings are detailed in "Energy Efficiency Services Sector: Workforce Education and Training Needs," written by Charles H. Goldman, Elizabeth Stuart, and Merrian Fuller of Lawrence Berkeley National Laboratory and Jane S. Peters and Nathaniel Albers of Research Into Action, Inc. [PDF <http://eetd.lbl.gov/EA/EMP/reports/lbnl-3163e.pdf>]

It was funded by the Department of Energy's Office of Energy Efficiency and Renewable Energy; Weatherization and Intergovernmental Program; and Office of Electricity Delivery and Energy Reliability, Permitting, Siting, and Analysis.

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## Environmental Energy Technologies Division

## NEWS

## John Newman Wins Acheson Award

John Newman, a University of California, Berkeley, Professor of Chemical Engineering and scientist in Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division (EETD), is slated to receive The Electrochemical Society's prestigious Acheson Award. The award will be given to Newman at the Society's next meeting, in Las Vegas, in October 2010.



John Newman

Newman's greatest contribution to the "objects, purposes, or activities of The Electrochemical Society" (the definition of the Acheson Award) has been his seminal approach to the analysis and design of electrochemical systems. Since the 1960s, Newman has not only clarified the physicochemical laws that govern the behavior of electrochemical systems, but also demonstrated how to use these laws to correctly formulate and solve problems associated with batteries, fuel cells, electrolyzers, and related technologies. His sophisticated approach to mathematically analyze complex electrochemical problems has been universally accepted by the academic and industrial communities, to the extent that it is now commonly referred to as "The Newman Method."

In addition to his UC Berkeley post as a Faculty Senior Scientist, Newman is Principal Investigator in the EETD and Director of the U.S. Department of Energy's Batteries for Advanced Transportation Technologies program. He is the author or co-author of more than 390 technical publications, numerous plenary and invited lectures, and the book *Electrochemical Systems*, which is now in its third edition and used worldwide as a monograph and graduate text in electrochemical engineering. Professor Newman has mentored many graduate students, post-doctoral fellows, and visiting scientists.

The Edward Goodrich Acheson Award of The Electrochemical Society, which includes a gold medal and a prize of \$10,000, was established in 1928, and it is awarded no more often than every two years. It is named for Edward Acheson, a U.S. inventor best known for the invention of the highly effective abrasive material carborundum (silicon carbide).

Beside the Acheson Award, Newman has received nine other awards from The Electrochemical Society. In addition, he has been recognized as a Highly Cited Author, as identified by Thomson ISI. During 2002, he was an Onsager Professor at the Norwegian University of Science and Technology in Trondheim, and in 1999 he was elected to the National Academy of Engineering.

The Acheson Award is arguably the most prestigious award that an electrochemical scientist could hope to attain, short of a Nobel Prize or a National Medal of Science. The late Professor Charles W. Tobias is among those who have received the Acheson Award (in 1972), and he is the only other member of the Berkeley electrochemical community to be so recognized.

—Frank McLarnon

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More about Professor Newman and his research group. [<http://www.cchem.berkeley.edu/jsngrp/>]

More about The Edward Goodrich Acheson Award [[http://www.electrochem.org/awards/ecs/ecs\\_awards.htm](http://www.electrochem.org/awards/ecs/ecs_awards.htm)] of The Electrochemical Society.

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## Environmental Energy Technologies Division

## NEWS

**Bill Savings from Net Metered Residential Solar Photovoltaic Systems Differ Dramatically**

A Lawrence Berkeley National Laboratory (Berkeley Lab) study found that the financial savings of residential customers with solar photovoltaic (PV) power systems varied significantly under the net metering rates currently offered by California's two largest electric utilities. The report focuses on California, as it is the largest PV market in the United States.



The study shows that the bill savings per kilowatt-hour (kWh) generated by a PV system varies by a factor of four to five for residential customers of Pacific Gas & Electric (PG&E) within the study sample, and by a factor of two to three for the Southern California Edison (SCE) residential customers in the sample.

*Net metering* is a billing arrangement that allows customers with on-site PV systems to offset their monthly consumption with PV generation, regardless of whether or not the electricity demand coincides with the time their systems are generating power. In conjunction with other policy support mechanisms, net metering has been instrumental in jump-starting the market for distributed PV in California and elsewhere in the United States. However, alternative compensation methods are under consideration in some jurisdictions.

"One purpose of this study," says report co-author Ryan Wisner with Berkeley Lab's Environmental Energy Technologies Division, "is to help policymakers and others that seek to support the development of residential distributed PV in California understand the bill savings benefits of PV under net metering, and how those savings compare to other possible compensation mechanisms."

The study acknowledges that this is only one issue that policymakers consider when developing policies related to distributed PV, so the report does not attempt to provide a comprehensive cost-effectiveness evaluation of net metering policies or to evaluate the cost of net metering to utility ratepayers who chose to not install PV.

The study is based on a sample of over 200 residential customers located in the service territories of PG&E and SCE. Depending on the size of the PV system, the median PG&E customer in the sample is found to receive bill savings of \$0.19 to \$0.25 per kWh generated by the PV system, and the median SCE customers receives bill savings of \$0.19 to \$0.24 per kWh. However, many customers receive savings substantially lower or higher than these figures.

**Rate Structures Are Key**

According to the report, variation in the value of bill savings across customers is primarily the result of the particular residential retail electricity rate structures offered. As report co-author Galen Barbose explains, "The residential rates currently offered by PG&E and SCE have inclining usage tiers, whereby customers that consume more energy each month pay a higher price. Consequently, high-usage residential customers receive relatively high-value bill savings from net metered PV systems." This is particularly true for PG&E customers; among the highest-usage PG&E customers in the study's sample, the bill saving value ranges from \$0.31 to \$0.49 per kWh.

The study notes that the inclining price structure of PG&E's and SCE's residential electricity tariffs is much more pronounced than residential rates offered by other utilities. The specific results of the study therefore do not necessarily apply to other utilities and states, but they nonetheless demonstrate the sensitivity of bill savings from net metered PV to the underlying rate structure.

### **Under Some Net Metering Alternatives, Savings Would Be Lower**

The study also compares the bill savings that residential customers with PV receive under net metering to the bill savings that they might receive under several hypothetical alternative compensation mechanisms. "In general, these comparisons show that net metering provides greater bill savings—in some cases, by a significant amount," says Naïm Darghouth, the lead author of the report.



One of the alternatives examined is a feed-in tariff under which all PV generation is compensated at prices based on California's Market Price Referent (MPR)—a price established by the California Public Utilities Commission that is intended to represent the long-run market price of electricity. The value of bill savings received under such an MPR-based feed-in tariff ranges from \$0.12 to \$0.13 per kWh for most customers. Depending on the PV system size, this equates to a 40 to 54 percent reduction in bill savings relative to net metering for the median PG&E customer in the study sample, and a 32 to 45 percent reduction for the median SCE customer. For high-usage customers, who receive the greatest bill savings under net metering, the reduction in bill savings under the MPR-based feed-in tariff would be substantially greater than these median values.

Another potential compensation mechanism to net metering would allow customers to offset up to 100 percent of their consumption within each hour, but any hourly excess PV generation would be compensated at MPR-based prices, rather than being credited against consumption in other hours. Under this payment system, customers are found to generally experience lower energy bill savings relative to net metering, but the difference is significantly less than under the full MPR-based feed-in tariff. Depending on PV system size, the median PG&E customer would see a 6 to 12 percent reduction in bill savings, and the median SCE customer would see a 6 to 10 percent reduction.

**—Galen Barbose**

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The report, *The Impact of Rate Design and Net Metering on the Bill Savings from Distributed PV for Residential Customers in California*, was written by Naïm Darghouth, Galen Barbose, and Ryan Wisler, and it may be downloaded from the Electricity Markets and Policy [<http://eetd.lbl.gov/ea/emp/re-pubs.html>] web site.

The research was supported by funding from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (Solar Energy Technologies Program) and the Office of Electricity Delivery and Energy Reliability (Permitting, Siting, and Analysis Division).

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## Environmental Energy Technologies Division

## NEWS

## Grant Program Spurs Renewable Energy Capacity and Jobs

A preliminary evaluation of the American Recovery and Reinvestment Act's Section 1603 cash grant program concludes that the program appears to have stimulated incremental renewable power capacity additions in 2009, thereby supporting U.S.-based renewable energy jobs. The report was written by Lawrence Berkeley National Laboratory (Berkeley Lab) researchers Mark Bolinger, Ryan Wisser, and Naïm Darghouth.

The Section 1603 program, so named because it was codified in Section 1603 of the American Recovery and Reinvestment Act of 2009, enables qualifying renewable power projects that are eligible for either the federal production tax credit (PTC) or investment tax credit (ITC) to instead obtain a cash grant for 30% of the "eligible cost basis" of the project, administered by the U.S. Department of the Treasury.



The global financial crisis created significant financing challenges for many renewable power projects, as investor demand for tax credits diminished. This program was enacted so that projects could obtain cash grants instead, with a goal of keeping the renewable power sector afloat and supporting the broader Recovery Act goals of retaining and creating jobs while expanding renewable energy use.

This Berkeley Lab report, which was requested by the U.S. House of Representative Committee on Ways and Means and funded by the U.S. Department of Energy, is an initial, selective evaluation of the program's first year. The analysis, which was completed in March 2010, was conducted under tight time constraints, with incomplete access to relevant data, and a limited operating history of the program being evaluated. As such, the report evaluates only a subset of issues, and its findings are preliminary and subject to revision under a more-rigorous assessment.

The study found that the program has been heavily subscribed, particularly by wind power projects, which received 86% of the nearly \$2.6 billion in Section 1603 grants that had been disbursed as of March 1, 2010. Geothermal, solar, and biomass power projects had received 6%, 4.5%, and 2.8% of all grant dollars at that time, respectively. In capacity terms, 4,250 gigawatts (GW) of renewable power projects had received support through the program as of March 1, including 3,892 megawatts (MW) of wind, 137 MW of geothermal, 130 MW of biomass, and 61 MW of solar. According to the U.S. Treasury, another 2,311 MW of wind power capacity that was built in 2009 had applied for, but had not yet been awarded, cash grants as of March 1. In total, then, roughly 6,200 MW of 2009 wind power capacity additions—representing 64% of all grant-eligible wind power capacity installed that year—had applied for the grant as of March 1.

"Although a significant number of the wind power projects that have chosen the grant likely would have been built under the PTC absent the Section 1603 program, we estimate that the grant program may have helped to directly motivate the construction of as much as 2,400 MW of 2009 wind power capacity that would not otherwise have been built in 2009," says report co-author Bolinger who, along with Wisser and Darghouth, are researchers in Berkeley Lab's Environmental Energy Technologies Division.

In other words, the Section 1603 program may have helped directly motivate more than 20% of the 10,000 MW of wind capacity additions in 2009. Moreover, the cost imposed on the government by so-called "free riders" (that is, those projects that would likely have been built in 2009 even without the Section 1603 program) has likely been modest, since projects are choosing between the grant and other federal incentives of similar cost (in the case of wind power, the PTC), as opposed to choosing between the grant and no other federal incentive.

If one assumes that roughly 60% of all dollars spent constructing an average U.S. wind power project are spent in the United States, then the 2,400 MW of wind power capacity built in 2009 that were potentially motivated by the Section 1603 program are estimated to have supported approximately 51,600 short-term, full-time-equivalent (FTE) gross job-years during the construction/manufacturing phase of the wind projects, and 3,860 long-term FTE gross jobs during the operational phase of those projects. These U.S.-based gross jobs estimates—which are based on modeling results and are, therefore, inherently uncertain—include onsite labor, supply chain, and induced job impacts.

"It is important to keep in mind that these estimates are of *gross jobs*," cautions co-author Wisner. "For example, the model does not account for potential job *losses* at non-wind power plants as wind generation displaces non-wind generation. A full employment analysis would need to consider such macroeconomic influences and net job impacts."

The study also found that the Section 1603 program provides significant economic value to many renewable power projects, relative to the PTC or ITC. Specifically, the grant program reduces the market's dependence on scarce and/or costly third-party tax equity, and also in many cases provides more direct or face value to renewable power projects than does the PTC. In addition, a number of indirect or ancillary benefits favor the grant from a renewable project developer's perspective, potentially helping to drive additional renewable capacity additions.

Potential concerns with the program design and implementation are discussed in the report. One concern is that grants reward initial investment rather than ongoing performance, which could potentially lead to "gold-plating" and/or poor performance—although the report finds no evidence of systemic problems in either area among grant recipients. Others concerns include the location of the jobs supported by the program, and the possibility that some of those jobs may be going overseas. However, the report estimates that the majority of jobs supported by the program—and especially the long-term jobs—are domestic.

Other areas covered by the report include: the program's relatively short window of opportunity (projects must commence construction by the end of 2010 to qualify for the grant); the grant may not completely eliminate the need for third-party tax equity (because it does not cover depreciation deductions); and uncertainty and inconsistency over how the grants are taxed at the state level (which may have negatively impacted the usefulness of the program to solar projects in particular).

—Allan Chen

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Read the full report, *Preliminary Evaluation of the Impact of the Section 1603 Treasury Grant Program on Renewable Energy Deployment in 2009*. [PDF <http://eetd.lbl.gov/ea/emp/reports/lbnl-3188e.pdf>]

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# Environmental Energy Technologies Division

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#### Sources

##### DOE's Consumer Information Fact Sheets

These web pages [<http://www.eere.energy.gov/consumer/>] provide information about energy efficiency and renewable energy for your home or workplace.

##### DOE's Energy Information Administration (EIA)

EIA [<http://www.eia.doe.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://www.er.doe.gov/>]

##### U.S. EPA, ENERGY STAR Program [<http://energystar.gov/>]

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

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