



Environmental Energy Technologies Division

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Award

Max Tech

Research Highlights

Sources and Credits

Congratulations to EETD Division Director Ashok Gadgil, winner of the Zayed Future Energy Prize lifetime achievement award, about which you can read in this issue. We also present research on how energy efficiency program managers can better reach middle-income families, and perhaps help them reduce their energy bills through home energy improvements. Other research covered in this issue: measuring particulate emissions from trucks at the Port of Oakland, and a Berkeley Lab contribution to the science supporting corporate average fuel economy standards—an analysis of how reducing vehicle weight affects safety.

If you are new to EETD News, please subscribe [\[http://eetd.lbl.gov/newsletter/sub/newsletter_signup.php\]](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 [\[http://eetd.lbl.gov/newsletter/cbs_nl/cbsnews.html\]](http://eetd.lbl.gov/newsletter/cbs_nl/cbsnews.html).

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Environmental Energy Technologies Division

NEWS

Helping Middle-Income Families Find Energy Savings

A recent study by researchers at Lawrence Berkeley National Laboratory (Berkeley Lab) identifies steps that energy-efficiency program managers can take to deliver significant savings on home energy bills to middle-income households.



"Middle income households have been hit hard by the recent recession, and sagging home prices have undermined the traditional reliance of middle-income households on home equity for financing home improvements," says Berkeley Lab's Mark Zimring, a researcher in the Environmental Energy Technologies Division (EETD) and co-author on the report. "It is really difficult to motivate them to invest in improving the efficiency of their homes, and to overcome the up-front cost barrier once they're motivated."

Middle-income households—those making about \$32,500 to \$72,500 per year—account for a third of total U.S. residential energy use. They figure prominently in meeting energy-savings targets that now exist in most states, and in reducing air emissions and managing demands on the grid.

To achieve those targets, utilities and governments are beginning to look beyond typical residential energy-efficiency programs that discount compact fluorescent light bulbs or provide rebates for high-efficiency appliances and equipment. Increasingly, they are turning to programs that improve the energy efficiency of the entire house—by sealing up leaks, reducing plug loads, adding insulation, and replacing inefficient heating and cooling systems. These more-comprehensive programs typically offer the same incentives for all non-low income households and usually require customers to pay a significant portion of the costs.

"Because comprehensive home energy improvements often cost \$5,000 to \$15,000 per home, higher income households are simply better positioned financially to take advantage of those programs," says Merrian Borgeson, co-author and EETD researcher. "Persuading middle-income households to undertake these whole-home energy improvements has proven challenging, and with declines in median income and home equity—coupled with rising energy costs—that challenge has become more acute."

Delivering comprehensive energy-efficiency improvements to just one-third of these middle-income single-family households could save roughly as much energy each year as is used by every home in Houston, Phoenix, and San Francisco.

"This economic middle of the country is highly diverse. One size does not fit all," said Ian Hoffman, co-author and EETD researcher. "The keys to energy and cost savings in the residential sector are flexibility and innovation in what efficiency programs offer these households, and a framework of policies that supports delivering these savings."

The report, *Delivering Energy Efficiency to Middle Income Single Family Households* [PDF [<http://eetd.lbl.gov/ea/emp/reports/lbnl-5244e.pdf>]], offers recommendations for efficiency programs:

- **Solve a problem that households recognize.** Messaging matters, and middle-income households may be motivated to participate in energy-efficiency programs for different reasons than their higher-income peers. In addition to reducing energy costs, framing efficiency as an investment in maintaining and increasing the value of one's home, as an opportunity to replace aging or broken equipment, or to address health and safety issues may all be powerful motivators for middle-income households.
- **Use multiple pathways to achieve deep energy savings in homes.** Comprehensive home energy improvements are not affordable in today's economy for some middle-income households. Residential energy-efficiency program administrators

should also offer lower-cost pathways that start with the basics—air sealing, insulation, and duct repair—and then encourage the most efficient options when households replace furnaces, air conditioners, or other equipment.

- **Reduce household risks.** Middle-income households need energy-efficiency investments to pay for themselves. They typically have less discretionary income to pay for these investments if energy savings or increases in home value are lower or materialize slower than expected. Efficiency program managers should consider tiered work packages and financial incentives based on income to reduce household risk and incentivize deep energy savings.
- **Increase access to capital.** The recession has reduced middle-income households' access to capital. Efficiency programs can use alternative underwriting criteria (e.g., utility bill repayment history) to responsibly increase the number of middle-income households who qualify for financing. Credit enhancements such as loss reserves can reduce lender risk and encourage them to serve a broader portion of the residential market. Efficiency program administrators should also work with the financial community to gain more experience with innovative financing tools that link loan repayments to utility bills, properties, and paychecks.
- **Leverage other public programs and funding.** In many areas, energy efficiency can be integrated into larger public endeavors, such as neighborhood revitalization, housing rehabilitation, and economic development. Some middle-income homes have structural or health and safety problems that may be best addressed by other public initiatives and funding sources. Coordination and collaboration among social service agencies could increase the efficiency of service delivery and enhance household outcomes.

The report also describes policy options that could bring more focus and funding to bear on unlocking this resource.

- **Regulation.** States and utility regulators can adopt targets for energy savings or require utilities or program administrators to acquire all cost-effective savings; these can provide the impetus to seek out savings economy-wide, including in middle-income households. Governments can also adopt energy labeling, disclosure, and upgrade regulations to make energy efficiency more visible—and valuable—in the home real estate market.
- **Codes and standards.** Local, state, and federal governments can implement building codes and appliance and equipment efficiency standards to complement the demand pull of efficiency programs with a market push.

Delivering Energy Efficiency to Middle Income Single Family Households [PDF <http://eetd.lbl.gov/ea/emp/reports/lbnl-5244e.pdf>] was written by Mark Zimring, Merrian Goggio Borgeson, Ian Hoffman, Elizabeth Stuart, Megan Billingsley, Annika Todd, and Charles Goldman. This research was funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

—Allan Chen

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Environmental Energy Technologies Division

NEWS

The LBNL Institute for Globally Transformative Technologies (LIGTT)

The U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) is establishing the LBNL Institute for Globally Transformative Technologies (LIGTT) to close the innovation gap for developing countries and create a pipeline of demand-driven technologies. LIGTT will focus on key areas for international development, including fuel-efficient cookstoves, safe drinking water, and access to electricity. These technologies will fight global poverty while helping to ensure environmental sustainability by matching Berkeley Lab's advanced research capabilities in affordable, low-carbon solutions with the needs of developing countries. The work will particularly target those in sub-Saharan Africa and South Asia, where the vast majority of people live on less than \$1.25 per day. Through locally appropriate business models, the Institute will work with carefully selected partners to deploy these technology solutions and bridge the gulf between their invention in the lab and their arrival in the marketplace.

Through our existing partners (WaterHealth International [<http://www.waterhealth.com/>], Oxfam America [<http://www.oxfamamerica.org/>] and Darfur Stoves Project [<http://darfurstoves.org/>]), Berkeley Lab's technologies are active in eight countries in Asia and Africa. These organizations are excited about new opportunities to partner with LIGTT to deploy critical new technologies to the developing world.

- Read the White House press release. [<http://www.whitehouse.gov/the-press-office/2012/02/08/fact-sheet-harnessing-innovation-global-development>]
- Read the Berkeley Lab press release. [<http://newscenter.lbl.gov/news-releases/2012/02/08/ligtt/>]
- LBNL Institute for Globally Transformative Technologies (LIGTT) website. [<http://www.lbl.gov/LBL-Programs/LIGTT/>]

**Questions and Answers about LIGTT with Ashok Gadgil**

Ashok Gadgil, Director of Berkeley Lab's Environmental Energy Technologies Division, answers some questions about the LBNL Institute for Globally Transformative Technologies.

What exactly is LIGTT?

The LBNL Institute for Globally Transformative Technologies is a new institute to develop and deploy new technology to fight poverty around the globe using sustainable methods. LIGTT is pronounced "light." It will engage Berkeley Lab scientists and partner organizations around the world to develop technologies that can provide robust, affordable, innovative technology solutions that bring people out of poverty, provide employment, and bring communities economic development.

Why is it important? To you? To Berkeley Lab?

For me, it's an extension of the work I've been doing for many years, beginning with UV Waterworks in the early 1990s. That was motivated by the 1993 cholera epidemic in India and nearby countries. It could have been prevented through very inexpensive water purification methods, but they just weren't available in those areas at that time.

By leveraging some of the research we already do here at Berkeley Lab, we can develop technologies that improve human health and provide for basic human needs without multi-billion dollar investments of capital, or large bureaucracies. There are proven, effective ways to get technologies in the hands of those who need them through partnerships with communities and international organizations, and careful adaptation of technology to local needs. We have been working for many years on technologies that purify drinking water, and energy-efficient stoves, among others.

To Berkeley Lab, LIGTT is important as a way of furthering the mission of Carbon Cycle 2.0 [<http://carboncycle2.lbl.gov>] —developing and deploying low-carbon technologies that can help mitigate climate change, while providing a path for the world's poorest inhabitants toward development, employment, and better lives.

What types of technologies/efforts might be included?

The poorest two billion people of the world face shortages of safe drinking water, access to electricity, and good quality shelter that is affordable. We need game-changing innovative technologies to meet these needs affordably and with low carbon impact.

Inexpensive, energy-efficient stoves can reduce the amount of wood that families need to cook their meals. These stoves save them money by reducing the amount of fuel they need to buy, or if they gather wood, efficient stoves reduce hardship in the fuel-collection effort, and environmental damage, by lowering the amount of wood they need to gather.

We've already had years of experience in these areas, with manufacturing and distribution of our technologies through a start-up company and local partner organizations.

We have also been developing affordable and robust technologies to remove arsenic from drinking water, which is a major problem in Bangladesh, parts of India, and other areas of the world where arsenic occurs naturally in groundwater.

We also expect to work on a variety of other technologies to address the need for low-cost shelter, inexpensive energy-efficient lighting and refrigeration, and other services that more-developed areas of the world take for granted.

What will the first project of LIGTT be?

Funding from the U.S. Agency for International Development to extend our work on energy-efficient cookstoves is pending.

As you may know, my research team developed the energy-efficient Berkeley-Darfur Stove. We helped create an independent non-profit, now our partner, The Darfur Stoves Project [<http://darfurstoves.org>], to distribute and set up manufacturing of the Berkeley-Darfur stove in Darfur.

If granted, the USAID funding would help ramp up local manufacturing. This will provide more jobs and expand the local economy, in addition to reducing the exposure of women to violence when they gather fuel wood outside of Darfur camp boundaries.

Ken Chow of Berkeley Lab's Engineering Division will lead this particular effort. This expands the partnership between Engineering and my Division, Environmental Energy Technologies.

The funding would also further develop and deploy an efficient stove for Ethiopia. It would pay for technology assessment studies there to determine what features a stove must have to be successful in Ethiopian environmental and economic conditions.

Why is the Obama administration/Office of Science and Technology Policy interested in this?

The Obama Administration and OSTP would like to leverage the exceptional strength of the United States in science and technology to bring forth game-changing innovations for international development.

Where do you see this Institute five years from now?

Five years from now, I expect we'll see an Institute that is funded by a variety of institutions, such as U.S. and international agencies, foundations, and private sector partners, with many non-governmental organizations as our partners on the ground all over the world. LIGTT will have, we hope, a deep portfolio of projects in such areas as water, agriculture, energy, sustainable housing, and technology for basic energy services such as lighting and refrigeration. Our NGO partners will be working in communities around the globe to help spread the use of technologies that will make the world healthier, happier, and more sustainable.



Environmental Energy Technologies Division

NEWS

EETD Researcher Contributes to New CAFE and Greenhouse Gas Standards for Light-Duty Vehicles

One of the quickest, most inexpensive paths to increasing gas mileage and reducing vehicle carbon dioxide emissions is to reduce vehicle weight, rather than investing in new, expensive vehicle technologies. Concerns that reducing vehicle weight will result in increased fatalities from vehicle accidents have hindered past efforts to substantially increase fuel economy standards, but recent research results, including those of Tom Wenzel, a research scientist at Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division (EETD), are challenging this assumption. If analyses can show that vehicle manufacturers can lower vehicle weight safely, then corporate average fuel economy (CAFE) standards can be strengthened without undue cost to consumers.

Wenzel's role in examining the relationship between vehicle weight and traffic fatalities began years ago, when the National Highway Transportation Safety Administration (NHTSA) published its first studies on the subject in 1997 and 2003. While reviewing the results of those studies, he noticed some shortcomings.

"The reports' conclusions weren't necessarily based on their analytical results," he recalls.

So, supported by several foundations, he reviewed and commented on the earlier studies. Then, when the most recent rulemaking to raise CAFE standards began, the U.S. Department of Energy (DOE) funded him to analyze the most recent NHTSA analysis, and also to look at independent data on the relationship between reductions in vehicle weight and casualty risk (which addresses both fatalities and serious incapacitating injuries) per vehicle crash.

"They brought me in very early on," says Wenzel. "I met twice a month via phone with the EPA, DOE, and NHTSA, so I had input on the initial NHTSA study. Charles Kahane, who did the NHTSA studies, shared his databases with me, so I was able to use the same data and methods that he used for the NHTSA report."

However, Wenzel evaluated Kahane's data a bit differently. For example, Kahane used a regression model that accounted for many variables—other vehicle characteristics and safety technologies, driver age and gender, and crash conditions (day or night driving, on high or low speed roads, in rural or urban locations.) However, his report did not focus on the effect of these other variables on risk, many of which can affect fatality rates much more than changes in the weight of vehicles. For example, night driving is much riskier than driving during the day; changes in vehicle mass have a small effect on fatality risk compared to the effects of many of the other variables that Kahane included in his regression models.

Wenzel took a different tack.

"Ideally, to really determine the change of mass on fatalities, you would take the exact same car and take, say, 100 pounds off it while keeping all other variables the same. Computer-assisted engineering allows one to model how mass reduction might affect safety in a particular vehicle design. On the other hand, regression analysis attempts to isolate the effect of mass reduction on fatality risk using real-world data on vehicle crashes, while controlling for all the other ways in which vehicles, drivers, and crashes differ. I found that, even after accounting for all of the variables Kahane included in his regression model, there is very little correlation between a vehicle model's mass and its fatality risk. There's a wide range in risk among vehicle models—on the order of two to three times difference—even for models that weigh roughly the same. And there are other differences among the designs of vehicle models that aren't explained in the regression analysis."

The First Study

Wenzel's first study assessed Kahane's 2011 NHTSA logistic regression analysis. The 2011 NHTSA analysis had updated earlier NHTSA studies of the relationship between vehicle mass and U.S. societal fatality risk per vehicle mile traveled (VMT), using data for model year 2000-2007 vehicles in calendar years 2002 through 2008. Societal fatality risk is analyzed, which includes fatalities in both the case vehicle and in any of its crash partners, including bicyclists and pedestrians. The analysis examines the effect of mass reduction on three vehicle types (cars, light trucks, and crossover utility vehicles/minivans) in nine types of crashes, for a total of 27 regression models. The NHTSA analysis found that reducing vehicle mass by 100 pounds while holding the vehicle's footprint fixed would increase the fatality risk per VMT by 1.44% for lighter-than-average cars and 0.52%

for lighter-than-average light-duty trucks. However, mass reduction in heavier-than-average light-duty trucks, while holding footprint constant, would *reduce* fatality risk by 0.40%. The study found that only the effect of mass reduction on lighter cars was statistically significant. The NHTSA concluded that the effect of vehicle mass reduction on U.S. fatalities is small.

The NHTSA found a much smaller effect of mass reduction on risk in its 2011 study than it had in its 2003 and 2010 studies, particularly for cars. NHTSA attributes this decrease to the phase-out of relatively light car models with an unusually high fatality risk; an observed improvement in how light, small cars are driven (which reduces their tendency to be involved in serious crashes); and improvements made to light trucks to improve their compatibility with other vehicles. The 2011 NHTSA analysis also found that reducing vehicle footprint by one square foot while holding mass fixed would increase fatality risk per VMT by 1.89% in cars and 1.73% in crossover utility vehicles (CUVs) and minivans.

Wenzel replicated the NHTSA analysis to analyze how sensitive the results were to changes in the data and control variables used in the regression models. He found that:

- The effect of many of the other variables on fatality risk are much larger than the effect of mass or footprint reduction on fatality risk.
- The 1.44% increase in risk from reduction mass in the lighter cars is somewhat sensitive to small changes in the specification of, or the data use in, the regression models.
- After accounting for all of the variables that NHTSA used in its regression analyses, there still remains a wide variation in risk by vehicle make and model, and this variation is unrelated to vehicle mass.
- Any future market shifts from SUVs or pickups to cars or car-based CUVs and minivans will result in larger reductions in fatality risk than the relatively small increases in risk expected from mass or footprint reduction. For example, a large-scale shift in the market share of pickups and SUVs to CUVs, minivans, and cars will reduce overall fatalities by nearly 4 percent.

Perhaps Wenzel's most surprising result is that, although risk tends to decrease as mass increases on average, an increase in mass for individual vehicle models does not inherently result in reduced risk. As shown in the figure below, after accounting for all the variables NHTSA used in its regression analyses, fatality risk and mass are not strongly correlated, with the R^2 ranging from 0.33 for CUVs to less than 0.15 for all other vehicle types (an R^2 of 0.00 would indicate no correlation between vehicle mass and risk, while a value of 1.00 would indicate perfect correlation). For full-size (i.e. ¾- and 1-ton) pickups, risk actually *increases* as mass increases, with an R^2 of 0.43. Wenzel also found that the remaining (or residual) risk not explained by the variables used in the regression models also is not correlated with mass.

The figure indicates that some vehicles on the road today have the same (or lower) risk than models that weigh substantially more and have a substantially larger footprint. After accounting for differences in driver age and gender, safety features installed, and crash times and locations, there are numerous examples of models from different manufacturers with similar weight and footprint, yet widely varying fatality risk. Differences in vehicle design can, and already do, mitigate any potential safety penalty from reduced mass; this is consistent with NHTSA's opinion that some of the changes in its regression results between the 2003 study and the 2011 study are due to the redesign or removal of certain smaller and lighter models of poor design.

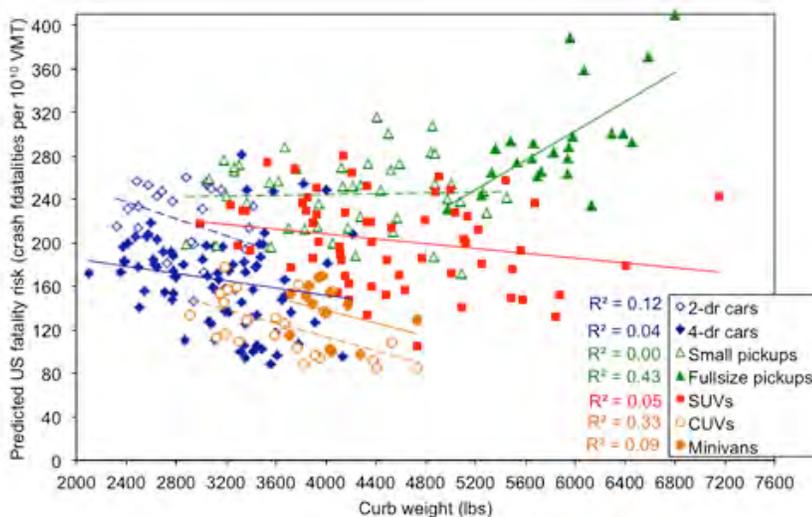


Figure 1. Predicted U.S. fatality risk per VMT vs. curb weight by vehicle type, after accounting for all driver, crash, and vehicle variables except mass and footprint

The Second Study

Wenzel's second study used similar methods to analyze the effect of mass and footprint reduction on casualty risk per police-reported crash, using data from 13 states. Wenzel's study differed from the NHTSA study in two respects: (1) it analyzed risk per crash, using data on all police-reported crashes from 13 states, rather than risk per VMT, and (2) analyzed *casualty* (which encompasses both fatality *and* serious injury) rather than just fatalities alone.

"By looking at risk per crash, rather than risk per estimated VMT," explains Wenzel, "we're able to isolate the two components of risk per VMT: a vehicle's crash frequency (number of crashes per VMT) and its 'crashworthiness' (number of casualties per crash). We can then examine the effect of mass and footprint reduction on how well a vehicle protects its occupants once a crash occurs. And by extending the analysis to casualties, rather than just fatalities, we're able to both reduce the statistical uncertainty and include incapacitating injuries, which can be just as traumatic and costly as fatalities."

Wenzel found that mass reduction:

- slightly increases crash frequency, in all vehicle types;
- has a smaller negative effect, and in some cases a small positive effect, on casualty or fatality risk per crash, than it has on casualty or fatality risk per VMT;
- actually *decreases* casualty risk per crash in all vehicles except the lightest cars—and in three of the four cases, these reductions are statistically significant (although small).

In terms of footprint reduction, Wenzel found that:

- It *increases* crash frequency in cars and light trucks, but slightly *reduces* crash frequency in CUVs and minivans.
- It does not have a statistically significant effect on risk per crash, except for a small increase in fatality risk per crash for light trucks.

As in the first study, the analysis of casualty risk per crash showed that, while the effect of mass reduction can result in a statistically significant increase in risk in certain cases, the increase is small, and is overwhelmed by other known vehicle, driver, and crash factors. Also, in general, mass or footprint reduction has a smaller effect on casualty risk per crash than on fatality risk per crash. And there is little correlation between a vehicle model's weight and its casualty risk, even after accounting for driver, vehicle, and crash characteristics.

Conclusions Confirmed

Overall, Wenzel's two analyses confirmed NHTSA's general findings that the relationship between vehicle weight and risk is small. And although he expected those findings, Wenzel was surprised at just how little relationship he found between vehicle weight and risk. "I knew it was weak, but not *that* weak," he says. "These results should help policy makers feel more comfortable in encouraging car manufacturers to reduce weight."

Increasing vehicle mass does not inherently increase safety in all kinds of crashes. For example, installing a stronger roof and support pillars, which happen to weigh an additional 100 lbs, will provide increased protection in rollovers but little additional protection in crashes with other vehicles; while adding a stronger bumper, also weighing 100 lbs, will improve safety in frontal crashes (and likely *reduce* safety in crash partner vehicles) but not in rollovers. Both of these increases in vehicle mass will have larger overall safety benefits than putting 100 lbs of topsoil in your vehicle's trunk. So increased mass does not inherently increase vehicle safety; it all depends on where and how it is added; in short, how it is incorporated into the overall vehicle design.

Effect on CAFE Standards and Greenhouse Gas Emissions

In November 2011, the U.S. Department of Energy and the NHTSA issued a joint proposal to improve fuel economy and reduce greenhouse gas emissions for model year 2017 through 2025 light-duty vehicles. The proposed standards would require an industry fleetwide average of 54.5 miles per gallon for all passenger cars, light-duty trucks, and medium-duty passenger vehicles. Given the current CAFE standards of 34.1 mpg for model year vehicles 2012 through 2016, it's easy to wonder whether consumers can afford the change, and even if the industry can meet the targets.

"Mileage standards are based on cost-effectiveness," says Wenzel. "As part of their analysis, the federal agencies evaluate whether a consumer can recoup the increased first-cost of a vehicle through fuel savings over a three-year period. If they can, that's considered a reasonable trade-off."

As for the auto industry's ability to build vehicles to meet the goals, studies such as Wenzel's give automakers and policy makers the information they need to make those determinations. In fact, there is potential to substantially reduce mass and even size, and therefore improve fuel economy, while making vehicles stronger and more crashworthy, using new lightweight, high-strength materials.

"My studies show that some manufacturers have already mitigated any safety penalty from mass reduction through careful vehicle design," says Wenzel. "There's no reason to expect that they can't make lighter, or perhaps smaller, vehicles that are just as safe, if not safer, than the vehicles on the road today."

—Mark Wilson

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Additional information:

Wenzel, Tom. 2011. *Assessment of NHTSA's Report "Relationships Between Fatality Risk, Mass, and Footprint in Model Year 2000-2007 Passenger Cars and LTVs."* [<http://eetd.lbl.gov/EA/teepa/pub.html#Vehicle>] (Draft final LBNL report published November).

Wenzel, Tom. 2011. *An Analysis of the Relationship between Casualty Risk Per Crash and Vehicle Mass and Footprint for Model Year 2000-2007 Light-Duty Vehicles.* [<http://eetd.lbl.gov/EA/teepa/pub.html#Vehicle>] (Draft final LBNL report published December).

NHTSA Docket [<http://www.regulations.gov/#!searchResults;rpp=10;po=0;s=NHTSA-2010-0152-0023>]

EPA Docket [<http://www.epa.gov/otaq/climate/regulations.htm#1-1>]



Environmental Energy Technologies Division

NEWS

Drayage Truck Emissions at the Port of Oakland

In 2010, the California Air Resources Board (ARB) began to implement a drayage truck emission control regulation at sea ports and rail yards in an effort to reduce the high levels of air pollutants traditionally found in neighborhoods adjacent to these areas. At the Port of Oakland, this resulted in an accelerated diesel particle filter (DPF) retrofit and truck replacement program—part of the port's Comprehensive Truck Management Program (CTMP). Given the time and expense that truckers, the port, and ARB devoted to this effort, the participants were keen to find out what level of effect it is having on truck emissions.



Thomas Kirchstetter, Environmental Energy Technologies Division

Researchers from Lawrence Berkeley National Laboratory (Berkeley Lab) and the University of California, Berkeley (UCB) were able to supply the answer. Independent of the port and ARB, Thomas Kirchstetter, of Berkeley Lab's Environmental Energy Technologies Division (EETD), and Timothy Dallman and Professor Robert Harley of UCB, began measuring emissions from drayage trucks driving to the Port of Oakland in November 2009, before the regulation took effect. They compared these baseline data to new data that they gathered in June 2010, and published their paper [<http://pubs.acs.org/doi/abs/10.1021/es202609q>] describing this work—"Effects of Diesel Particle Filter Retrofits and Accelerated Fleet Turnover on Drayage Truck Emissions at the Port of Oakland"—in *Environmental Science and Technology* in October 2011.

Addressing a Health Concern of Neighborhoods Adjacent to Ports

Heavy-duty diesel trucks emit significant quantities of fine particulate matter (PM_{2.5}), black carbon (BC, a component of particulate matter), and oxides of nitrogen (NO_x). While all of these emissions can affect health, exposure to diesel PM, in particular, is associated with a variety of adverse health effects, and can lead to cardiovascular and respiratory diseases, as well as lung cancer.

Diesel engines in newer vehicles are much cleaner in terms of emissions than the older ones, but as of late 2008, 17% of drayage trucks entering the Port of Oakland still had 1993 or older model engines, and only 6% were 2004 vintage or newer. Waiting for those vehicles to turn over to newer, less-polluting models would mean that another generation of neighborhood residents would be exposed to high levels of pollutants from those vehicles before the problem improved.

The ARB drayage truck regulation addressed this issue by implementing a ban on 1993 and older engine model years, diesel particle filter (DPF) retrofit requirements for more recent engines, and incentives to replace older trucks with 2007-plus model-year trucks that meet the most stringent exhaust PM emission standards. These combined activities are expected to reduce PM emissions from drayage trucks much more rapidly than what could be achieved by relying on natural fleet-turnover; by 2014 the program is estimated to reduce PM emissions from the state drayage truck fleet 86% from 2007 baseline levels.



Figure 1. The mobile laboratory and pollutants measured in the exhaust of one truck. Note the air sampling inlet positioned above the vertical exhaust stack of the diesel truck driving toward the Port of Oakland.

Mobile Lab Enables Site-Specific Emissions Capture

To determine whether these benefits were being achieved, Kirchstetter, Dallman, and Harley set up a mobile laboratory loaned from the Bay Area Air Quality Management District (BAAMD) on an overpass above a main freeway leading to the port.

The team measured truck emissions in November 2009, and then again in June 2010 after it was estimated that approximately 95% of the retrofit work required by the initial phase of the drayage truck rule had been completed. A video camera recorded the trucks passing, so that the team could verify when individual trucks passed the site. Instrumentation measured $PM_{2.5}$, BC, and NO_x , as well as carbon dioxide (CO_2), from which the team quantified the rate at which passing trucks emitted pollutants in terms of grams of pollutant emitted per kilogram of fuel burned.

Truck Emissions Reductions Confirmed

Emissions of the measured pollutants were markedly lower in June 2010, after the implementation of the drayage truck rule, than they were in November 2009, before the rule was implemented. On average, BC emission factors for trucks at the port decreased 50% with an associated three-fold increase in the fraction of very low-emitting trucks (Figure 2a). This improvement, realized in only seven months, is comparable to a similar BC reduction seen in a nearby traffic tunnel over the course of *nine years*, from 1997 to 2006, where truck emissions were reduced through natural modernization of the truck fleet as opposed to the program of accelerated clean up at the Port.

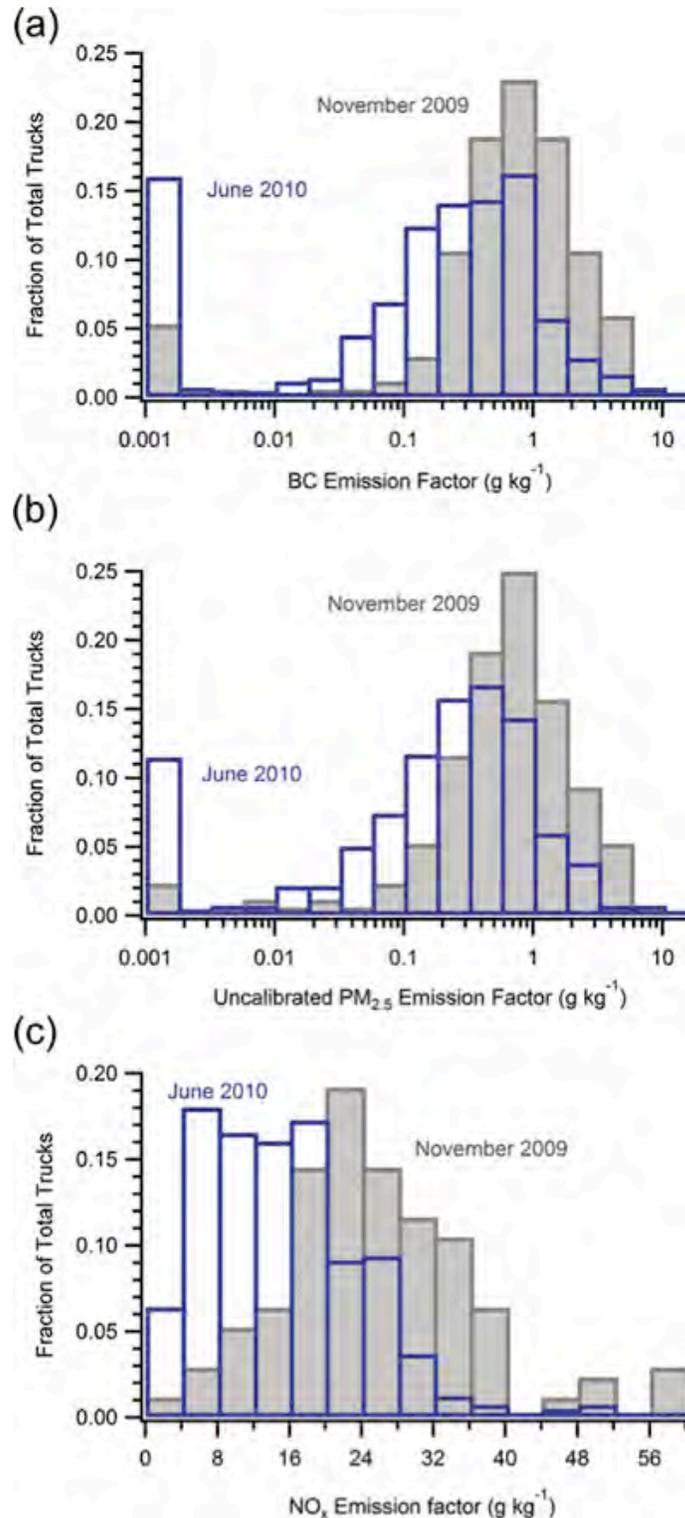


Figure 2. These figures show the fraction of drayage trucks that emit (a) BC, (b) $\text{PM}_{2.5}$, and (c) NO_x at different rates, expressed in terms of grams of pollutant emitted per kilogram of diesel fuel consumed.

Information from the port and the BAAQMD on the composition of the drayage truck fleet at the Port of Oakland suggests how these improvements came about. By 2010, as a result of the truck rule, the fleet was composed of: 0% of trucks with pre-1994 model year engines (down from 17% in 2008), 53% of model year 1994-2003 truck engines retrofitted with DPFs, and 14% of trucks with 2007 and newer model year engines already equipped with a particle filter (up from only 2% in 2008). Trucks with 2004-2006 model year engines made up 33% of the fleet (up from 4% in 2009). Emissions are expected to decline even more as future retrofit and replace deadlines are reached and the fleet of drayage trucks continues to modernize.

The $\text{PM}_{2.5}$ emission factors also show a shift toward lower emissions—in this case, showing a five-fold increase in the number of trucks with no measureable $\text{PM}_{2.5}$ emissions, resulting in a substantial decrease in $\text{PM}_{2.5}$ emissions over the study period. The

NOx emission factor also decreased, by about 40% over the study period. Prior work has shown that DPF systems alone have little to no impact on total NOx emissions, so the improvement is probably the result of older engines being replaced by 2004 and newer engines at the Port of Oakland—from 6% in 2008 to 47% in 2010.

Building on Success

The study verified a substantial positive impact from the retrofit and accelerated truck replacement program in the communities surrounding the Port of Oakland where truck activity is high. Benefits include substantial reductions in exhaust emissions of BC and NOx from trucks operating in the vicinity.

"When we presented our study to the Alameda Board of Supervisors, the reception was good," recalls Kirchstetter. "The supervisors thanked us and so did some of the truckers who attended. The study showed that their efforts have really made a difference."

The first study is just the initial step of a larger effort. "We were back taking measurements at the same spot in November 2011," says Kirchstetter, "and we're going back again in several months. Our newer measurements include the size and number concentration of the PM emissions, and instead of just measuring total NOx, we're differentiating between nitric oxide and nitrogen dioxide."

The more recent measurements may be used to confirm the earlier results, but more important, data from the expanded measurements will provide more granular information for those studying health effects at the port.

—Mark Wilson

For more information, contact:

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Additional information:

Dallmann, Timothy R., Robert A. Harley, and Thomas W. Kirchstetter. "Effects of Diesel Particle Filter Retrofits and Accelerated Fleet Turnover on Drayage Truck Emissions at the Port of Oakland." <http://pubs.acs.org/doi/abs/10.1021/es202609q1> *Environ. Sci. Technol.* 2011, 45 (24). 10773-10779.

Port of Oakland Truck Emissions Study Published in *Environmental Science and Technology* [<http://eetd.lbl.gov/news-archives/news-port.html>]

Study of Port of Oakland Truck Emissions Reported at Hearing [<http://eetd.lbl.gov/news-archives/news-oakland-port.html>]



Environmental Energy Technologies Division

NEWS

Berkeley Lab's Ashok Gadgil Wins Zayed Future Energy Prize's Lifetime Achievement Award



Ashok Gadgil, the Director of the Environmental Energy Technologies Division of the Lawrence Berkeley National Laboratory (Berkeley Lab), has won the Lifetime Achievement award of the Zayed Future Energy Prize. The award was announced in Abu Dhabi at the Zayed award ceremony in January.

The \$3.5 million Zayed Future Energy Prize, managed by Masdar in Abu Dhabi, recognizes and rewards innovation, leadership, and long-term vision in renewable energy and sustainability. The award is named in honor of Sheikh Zayed bin Sultan Al Nahyan [<http://www.zayedfutureenergyprize.com/en/about-zfep/overview/>], the late ruler of Abu Dhabi and the founding father of the United Arab Emirates, who made environmental protection a part of his legacy. The 2012 Zayed Future Energy Prize was presented to three winners and two runners up at the awards ceremony held in Emirates Palace.

The Zayed Prize organization said that "All three finalists excelled in demonstrating clear impact through their work in disseminating solutions to further knowledge, creating awareness, as well as developing policies and technologies in renewable energy and sustainability."

Other award winners included the UK's Carbon Disclosure Project in the Small and Medium Enterprises (SMEs) & Non-Governmental Organizations (NGOs) category. India's Orb Energy and Environmental Defense Fund of the United States were first and second runners-up, respectively, in the same category. French company Schneider Electric received a Recognition Award in the Large Corporations category. Gadgil's share of the award was \$500,000.

Ashok Gadgil released the following statement on winning the Zayed Future Energy Prize's Lifetime Achievement award:

"Being selected the winner for the Zayed prize is a great honor and tremendous validation of my lifelong passion and efforts for energy innovation and sustainability.

"Looking at the list of past prize winners and runners-up—some of whose work I know well—I am impressed with the energy and ingenuity of this group, and I hope that we can work together, and inspire many others, to advance the aim of the Zayed Future Energy Prize—energy sustainability for the planet.

"Vigorous efforts and political leadership are needed to make the concept of sustainability an integral part of policy decisions. Energy sustainability is a critical and integral part of the sustainability for the planetary ecosystem and of the human economic system, and we need to work quickly to forestall irreversible damage to the Earth's ecosystem and to human well-being.

"Winning the Zayed Energy Prize deepens my commitment to energy innovation for sustainability. Together with my colleagues and co-workers, I will continue to advance the research, design, testing, and scale-up of fuel-efficient low-emission

stoves for about three billion people (mostly women) that use biomass for cooking. I will also continue efforts to innovate, field test, demonstrate, and help scale-up the technology for arsenic remediation of drinking water for close to 100 million people in Bangladesh, West Bengal, and tens of millions of others elsewhere poisoned with arsenic in their drinking water."

In addition to being Director of the Environmental Energy Technologies Division of Lawrence Berkeley National Laboratory, Gadgil is a Professor of Civil and Environmental Engineering at UC Berkeley. He has substantial experience in technical, economic, and policy research on energy efficiency and its implementation—particularly in developing countries. For example, the utility-sponsored compact fluorescent lamp leasing programs that he pioneered are being successfully implemented by utilities in several east-European and developing countries. He has several patents and inventions to his credit, among them the "UV Waterworks," a technology to inexpensively disinfect drinking water in the developing countries, for which he received the Discover Award in 1996 for the most significant environmental invention of the year, as well as the Popular Science award for "Best of What is New-1996." In recent years, he has worked on ways to inexpensively remove arsenic from Bangladesh drinking water, and on fuel-efficient stoves for Darfur.

Dr. Gadgil has received several other awards and honors for his work, including the Pew Fellowship in Conservation and the Environment in 1991 for his work on accelerating energy efficiency in developing countries, the World Technology Award for Energy in 2002, the Tech Laureate Award in 2004, the Heinz Award in 2009, the European Inventor Award in 2011.

—Allan Chen

Additional information:

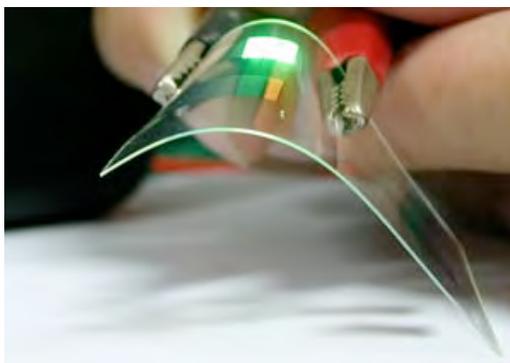
- More about Ashok Gadgil [<http://eetd.lbl.gov/staff/gadgil/agadgil.html>]
 - Read the Zayed Future Energy Prize Announcement [http://www.wam.ae/servlet/Satellite?c=WamLocEnews&cid=1289997002813&pagename=WAM%2FWAM_E_Layout&parent=Query&parentid=1135099399852]
 - Zayed Future Energy Prize website [<http://www.zayedfutureenergyprize.com/>]
-



Environmental Energy Technologies Division

NEWS

Inspiring Energy Efficiency Research in the Nation's Universities



Solar energy has long captured the hearts and minds of U.S. university students, with the Solar Decathlon biennially celebrating their achievements on the National Mall in Washington, D.C. But what of energy efficiency, the workhorse for cost-effective carbon emission reductions? Can we inspire the nation's brightest minds to pursue radical efficiency improvements in the appliances and equipment that consume the nation's energy? This is the goal of the Max Tech and Beyond Appliance Design Competition.

Designed to Advance Appliance Efficiency and Engineering Capability

The competition was initiated by Lawrence Berkeley National Laboratory's (Berkeley Lab's) Robert Van Buskirk and Antonio Bouza at the U.S. Department of Energy (DOE) in 2010. In its first year, Max Tech and Beyond ranked the energy savings potential [http://ees.ead.lbl.gov/bibliography/max_tech_and_beyond] of 150 categories of appliances and equipment. Based on those results, the competition challenged university engineering teams to go beyond the current "max tech" by exploring new appliance and equipment designs that could become the next generation of ultra-low energy use appliances. That competition is now under way.

In June 2011, the Max Tech team sent a request for proposals to university and college engineering and science departments across the nation. Applicants were directed to focus on residential or commercial appliance designs that could demonstrate significant energy savings. A panel of Berkeley Lab and private sector experts reviewed the proposals and funded nine teams [<http://maxtechandbeyond.lbl.gov/teams>] in August 2011. The chosen teams received up to \$20,000 to implement their proposal over the course of the 2011/2012 academic year.

The portfolio of selected projects represents a broad range of appliances and technologies, and a cross-section of universities. Each team, comprised of one or two faculty members and a group of undergraduate and/or graduate students, meets a series of deliverables dates—such as providing website materials, submitting status reports, and attending teleconference meetings—throughout the academic year.

New Products Coming to Light

The competition is proceeding according to plan, and the anticipation is building. The teams have completed their design, development, and procurement phases and are currently concentrating on construction, to be followed by prototype testing later this winter and spring. The prototypes are expected to show energy-efficiency advances in lighting, HVAC, water heating, refrigeration, clothes dryer, and cooking applications.

The competition will culminate in a national webinar on May 23, 2012, 11:00-2:30 PDT, in which the student teams will demonstrate their prototypes. The event will be open to the public. A diverse panel of experts from Berkeley Lab's Energy Efficiency Standards Group (EES) and DOE's Building Technologies Program will judge the teams based on their webinar presentation and final team reports. The achievements of all of the teams will be reported on the Max Tech website and in the final Berkeley Lab report. Winners will be announced in July 2012.

"This competition has been well received, and many at both Berkeley Lab and DOE are very excited about this year's competing teams, prototype designs, and market feasibility; in addition to its potential growth in the future," says Stacy Pratt, who manages the program at Berkeley Lab.

Karina Garbesi, Lead Principal Investigator in Berkeley Lab's Environmental Energy Technologies Division (Energy Efficiency Standards Group), agrees. "It is terrifically exciting to witness the enthusiasm of the students, the evolution of the prototypes, and to promote the next generation of ultra-efficient appliances at the nation's universities."

—Mark Wilson

Contact Information:

Those interested in obtaining more information about the competition or in helping to sponsor the competition in the future should call (510) 495-2100 or e-mail the program organizers at maxtech@dante.lbl.gov.

Additional information:

Mark Wilson is freelance writer who contributes articles to *EETD News* [<http://eetd.lbl.gov/newsletter/>]. Receive it quarterly for free—sign up here [http://eetd.lbl.gov/newsletter/sub/newsletter_signup.php].

The Max Tech and Beyond website [<http://maxtechandbeyond.lbl.gov/>]



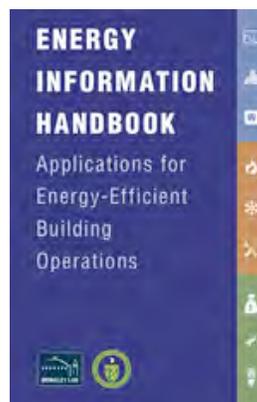
Environmental Energy Technologies Division

NEWS

Research Highlights**EETD Researchers Win BuildSys 2011 Best Paper Award**

Francis Rubinstein and Dennis DiBartolomeo of Lawrence Berkeley National Laboratory's Environmental Energy Technologies Division, and Yao-Jun Wen of Philips Research North America, have won the BuildSys 2011 Best Paper Award. Their paper, "Co-simulation Based Building Controls Implementation with Networked Sensors and Actuators," won the Best Paper Award at the recent BuildSys 2011 meeting. The paper presents a rapid-prototyping controls implementation platform based on the Building Controls Virtual Test Bed framework that is capable of linking to building sensor and actuator networks for efficient controller design and testing.

For more information, see the BuildSys website [<http://www.buildsys.org/2011/>].

Free Energy Information Systems Handbook Released

Lawrence Berkeley National Laboratory (Berkeley Lab) and the U.S. Department of Energy have released *The Energy Information Handbook: Applications for Energy-Efficient Buildings Operations*. This free book helps commercial building owners and operators who have no experience with energy information systems understand how to analyze building energy use and use their analysis to lower energy costs by operating buildings more efficiently. Software developers and energy service providers in the commercial building industry will find the book useful, as will more experienced owners and managers who wish to improve how they visualize, analyze, and manage their building's energy use.

The handbook was written by Jessica Granderson, Mary Ann Piette, Ben Rosenblum, and Lily Hu of the Berkeley Lab's Environmental Energy Technologies Division (EETD), and Dan Harris of New Buildings Institute.

Download the Energy Information Handbook [PDF [<http://eis.lbl.gov/downloads/energy-information-handbook.pdf>]], and learn more about building energy information systems at the Energy Information Systems website [<http://eis.lbl.gov>]. The website also offers outcomes of other work related to building energy management including: a categorization framework and market characterization of building energy information systems (EIS) and a series of case studies with large facility owners to explore users' experiences with EIS.

Related work, also posted at eis.lbl.gov, has developed a categorization framework and market characterization of building EIS and explored users' experience with EIS in a series of case studies with large facility owners.

For more information, see the Energy Information Systems website [<http://eis.lbl.gov>].

Richmond Field Station Chosen for Berkeley Lab Expansion



Richmond Field Station architectural rendering

The University of California (UC) announced today that it has chosen the Richmond Field Station as the preferred site for its consolidation of the biosciences programs of Lawrence Berkeley National Laboratory (Berkeley Lab). The University of California-owned site presents the best opportunity to solve the Berkeley Lab's pressing space problems, while allowing for long-term growth and maintaining the 80-year tradition of close cooperation with the UC Berkeley campus.

The university will now develop environmental impact studies and seek final approval for the project from the U.S. Department of Energy.

In May of 2011, the university narrowed the initial 20 possibilities to six: Albany, Alameda, Berkeley, Emeryville, Oakland, and Richmond. "Each city, community, and their developer partners presented extremely thoughtful and well-formulated proposals for us to consider, for which we are deeply grateful," says Berkeley Lab Director Paul Alivisatos. "We hope that the new relationships we've made will continue to help us foster excitement in science. The enthusiasm is wonderful affirmation of the desire of the entire East Bay to be part of developing scientific solutions to some of the greatest challenges facing our society."

(Click here <http://youtu.be/tjmsAvxVqM> to watch a video of the site selection announcement.)



Environmental Energy Technologies Division

NEWS

Sources and Credits

Sources

Energy Efficiency & Renewable Energy's Energy Savers

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://science.energy.gov/>]

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

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

Credits

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The mission of the Environmental Energy Technologies Division is to perform research and development leading to better energy technologies and the reduction of adverse energy-related environmental impacts.

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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.

With more than 4,000 employees, Berkeley Lab's total annual budget of nearly \$600 million supports a wide range of unclassified research activities in the biological, physical, computational, materials, chemical, energy, and environmental sciences. The Laboratory's role is to serve the nation and its scientific, educational, and business communities through research performed in its unique facilities, to train future scientists and engineers, and to create productive ties to industry. As a testimony to its success, Berkeley Lab has had 11 Nobel laureates. EETD is one of 14 scientific divisions at Berkeley Lab, with a staff of 400 and a budget of \$40 million.

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