

The Department of Energy's Office of Science supports 46 Energy Frontier Research Centers (EFRCs), major collaborative research efforts to accelerate high-risk, high-reward fundamental research that will provide a strong scientific basis for transformative energy technologies of the future.

The EFRCs represent a unique approach to energy research, bringing together the skills and talents of teams of investigators to perform energy-relevant, basic research with a scope and complexity beyond that possible in typical single-investigator or small group research projects. The EFRCs have world-class teams of researchers, often from multiple institutions, bringing together leading scientists from universities, national laboratories, nonprofit organizations, and for-profit firms. The Centers were selected in 2009 by scientific peer review and funded at \$2-5 million per year for a 5-year initial award period, subject to Congressional appropriations. These integrated, multi-investigator Centers are tackling some of the toughest scientific challenges hampering advances in energy technologies.

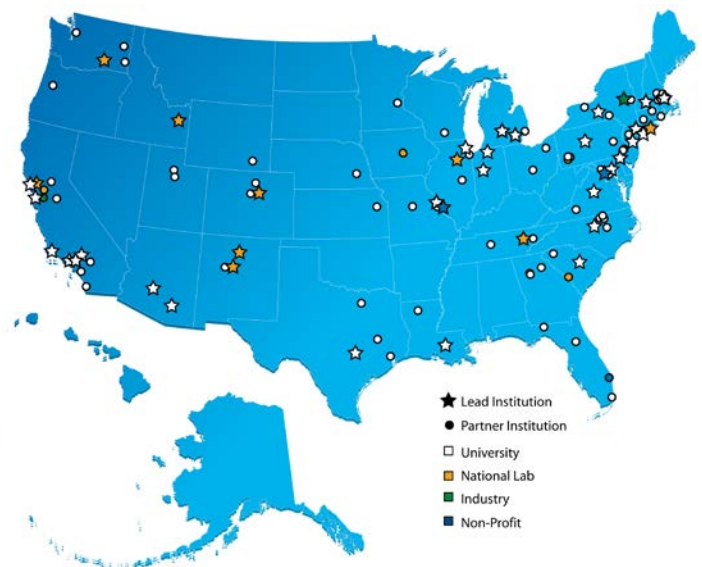
Research Areas

The 46 EFRC awards span the full range of energy research challenges described in the Basic Energy Sciences series of workshop reports (see <http://science.energy.gov/bes/news-and-resources/reports/>) in which the community defined basic research that is needed to enable advances related to clean energy technologies, including: solar energy utilization, clean and efficient combustion, electrical energy storage, carbon capture and sequestration, advanced nuclear systems, catalysis, materials in extreme environments, hydrogen science, solid state lighting, and superconductivity. The EFRCs also address scientific grand challenges described in the report, Directing Matter and Energy: Five Challenges for Science and the Imagination.

The EFRCs provide an important bridge between basic research and energy technologies and complement other research activities funded by the Department of Energy. EFRCs accelerate energy science by providing an environment that encourages high-risk, high-reward research that would not be done otherwise; integrating synthesis, characterization, theory, and computation to accelerate the rate of scientific progress; developing new, innovative experimental and theoretical tools that illuminate fundamental processes in unprecedented detail; and training an enthusiastic, inter-disciplinary community of energy-focused scientists.

EFRCs by the Numbers

- Lead institutions by type:
 - 31 universities
 - 12 DOE National Laboratories
 - 2 nonprofit organizations, and
 - 1 corporate research laboratory
- Over 115 participating institutions, located in 35 states plus the District of Columbia
- 850 senior investigators and, on a full- or part-time basis, an additional estimated 2,000 researchers, including postdoctoral associates, graduate students, undergraduate students, and technical staff
- Total planned award commitment to the 46 EFRCs of \$777 million over five years (FY 2009-2013), subject to Congressional appropriations



Website: <http://science.energy.gov/bes/efrc/>



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Energy Frontier Research Centers: Impact

In 2012, the Basic Energy Sciences held a mid-term assessment of the research productivity and progress for each Energy Frontier Research Center. Merit review panels made-up of external scientific experts found that each EFRC has met or exceeded the expected progress toward its five-year goals in their first two years of operations, and the EFRCs had collectively demonstrated the potential to substantially impact the scientific understanding underpinning transformational energy technologies. The review concluded that the EFRCs:

- Enable high-risk, high-reward research that would not otherwise be attempted;
- Bring together cross-disciplinary teams that challenge their members to ask more difficult questions, leading to potentially transformational results;
- Accelerate the rate of both success and failure, from which lessons are rapidly learned and adjustments quickly made;
- Seamlessly integrate synthesis, characterization, theory, and computation to enhance both the quality and quantity of scientific progress;
- Develop outstanding new experimental and theoretical tools, many of which are available to the entire research community;
- Train next generation energy scientists by attracting high-quality students and postdoctoral researchers, most of whom—based on the reviewers' discussions with these individuals—want to continue a career in energy science.

The scientific output from the EFRCs is impressive by any standard and many EFRCs have reported that their results are already impacting both technology research and industry. Students are completing their training and are growing an energy-savvy workforce in industry and academia.

EFRC Impact by the Numbers

Scientific and Workforce Impact

- Over 3,400 peer-reviewed publications, including more than 110 publications in *Science* and *Nature*
- 18 Presidential Early Career Awards for Scientists and Engineers and 11 Department of Energy Early Career Awards
- EFRC students and staff are entering the workforce:
 - Over 195 to university faculty and staff positions
 - Over 290 to industrial positions
 - Over 115 to national laboratories, government and not-for-profit positions

Technology Impact

- Over 200 patent applications
- Over 60 unpatented invention disclosures
- Over 30 licenses for patented research
- Over 60 companies have benefited from EFRC research



Image courtesy of Virginia Drujon-Kippelen

Using polymers to develop new materials, EFRC researchers created the first completely plastic solar cell, where not just the cell itself but also its electrodes are made of plastic.

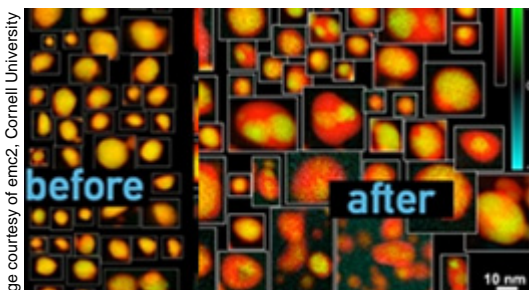


Image courtesy of emc2, Cornell University

Using sophisticated techniques, EFRC researchers are observing, at the molecular level, how hydrogen fuel cells degrade. Microscope images reveal effects of aging on fuel cell catalyst nanoparticles.

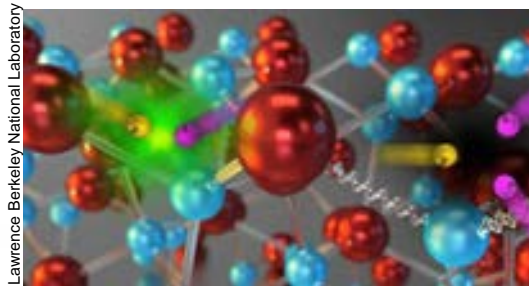


Image courtesy of Lawrence Berkeley National Laboratory

EFRC supercomputer simulation provides a first principles understanding of mysterious "droop" in solid-state lighting, and provides insights to routes to improve device efficiencies.

Websites: <http://science.energy.gov/bes/efrc/>

Research highlights: <http://science.energy.gov/discovery-and-innovation/>



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