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Agency Update: Status and Upcoming Competition for DOE Energy Frontier Research Centers

Lewis-Burke Associates LLC – July 2019

This update provides advance intelligence on the next Department of Energy (DOE) Energy Frontier Research Centers (EFRC) competition planned in Fall 2019 and an analysis of the last EFRC competition in fiscal year (FY) 2018.

EFRCs are multi-investigator, multi-disciplinary centers that support fundamental research aimed at overcoming barriers to the development of new energy technologies and accelerating use-driven research to address energy needs. The topics outlined in each EFRC solicitation are guided by reports generated as part of a series of Basic Research Needs (BRN) workshops hosted by DOE. Each report identifies Priority Research Directions (PRDs) for a specific topic in energy sciences.

In addition to the BRN PRDs, EFRCs must address one of the five "grand challenges" identified in the 2007 Basic Energy Sciences Advisory Committee (BESAC) report entitled *Directing Matter and Energy: Five Challenges for Science and the Imagination* as well as the "transformative opportunities" outlined in the 2015 BESAC report entitled *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science*.

Upcoming EFRC Competition

In Fall 2019, DOE plans to release a $40 million funding opportunity announcement to compete EFRCs. DOE would like to compete EFRCs ever two years instead of every four years to bring in fresh ideas and be more responsive to breakthroughs in science and instrumentation and changing energy priorities. Of the $40 million, $10 million will be focused on science topics relevant to DOE's environmental management mission and the four existing centers will be up for recompetition. The remaining $30 million will fund between six and 15 new EFRCs in three priority research areas:

- **Quantum information science**: The current EFRCs are focused on quantum materials and DOE would like to fund new centers that have an expanded scope in materials research and chemistry to address a broader set of issues in quantum information science.
- **Microelectronics**: This is a new topic area focused on advanced materials and chemistry to develop next generations microelectronics technologies for applications relevant to DOE's mission, including computing, power grid management, and science facility workloads. The BRN workshop on microelectronics took place after the last EFRC funding call.
- **The energy-water nexus**: The water security grand challenge is a top priority for Secretary of Energy Rick Perry and this research area helps advance fundamental knowledge in a broad set of DOE mission areas.[1]

[1] Links to all the relevant BRN reports can be found in the Sources and Additional Information section at the end of the document.

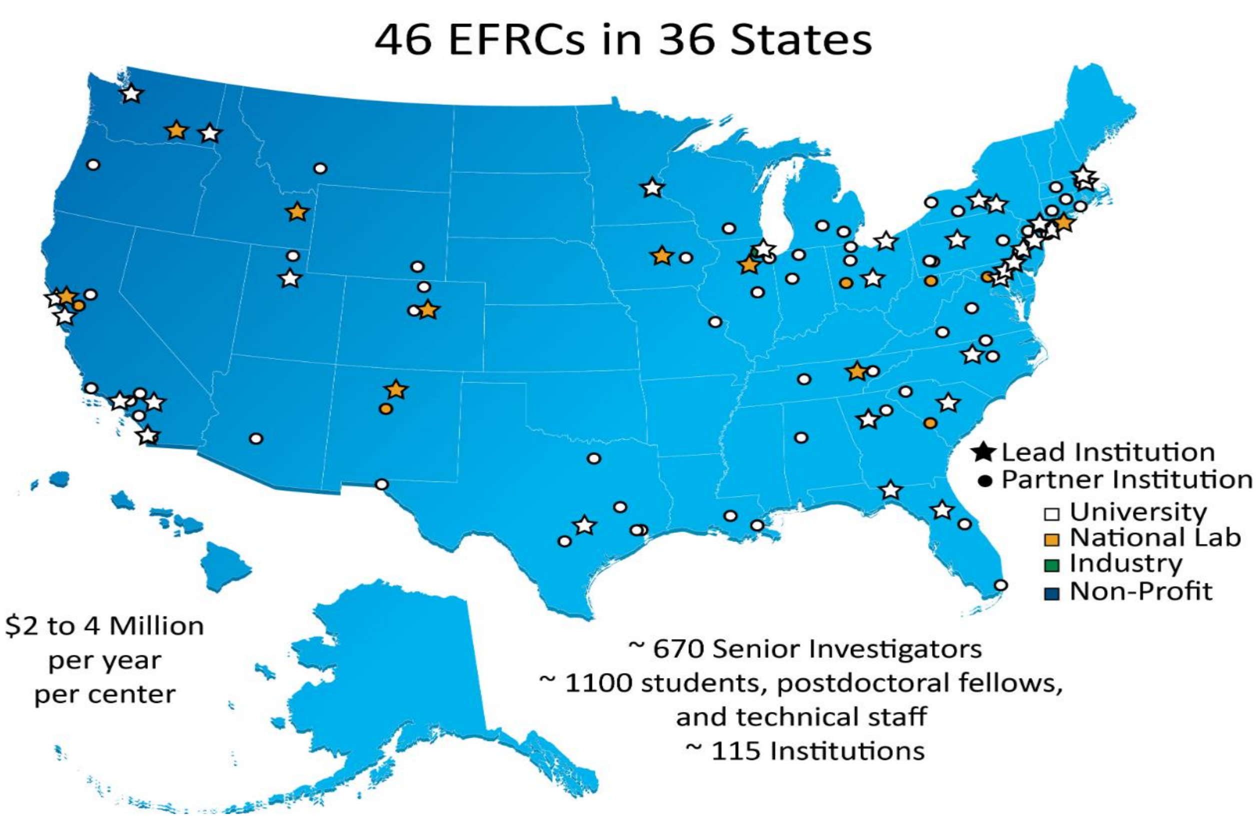
DOE is currently evaluating research gaps in its EFRC portfolio and may include a few other topics in the final funding call, but it will be more narrowly focused that the 2018 funding opportunity.

Funding for new EFRCs is contingent on congressional appropriations. In its FY 2020 budget request, DOE proposed $40 million to fund new EFRCs. However, the FY 2020 House Energy and Water bill, which funds DOE, provided only $30 million of the $40 million requested by DOE. The Senate has not yet advanced any appropriations bills.

This will remain one of DOE's most competitive programs. The success rate in the last competition was only 17 percent. In FY 2018, DOE received about 250 pre-proposals, of which 100 were encouraged to submit full proposals. Of the full proposals, 42 were selected for awards.

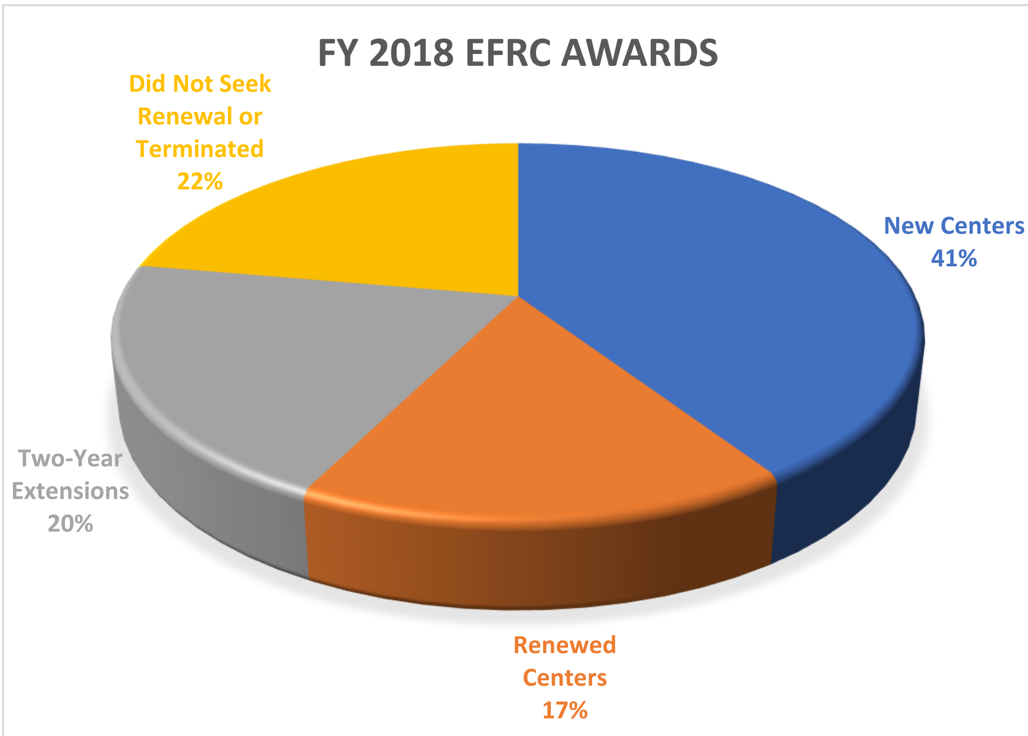
Current EFRCs and Analysis of FY 2018 Competition

DOE currently supports 46 EFRCs. Of these, 42 support a broad range of energy-relevant topics and four are dedicated to DOE's environmental management mission. The graphic below shows the locations of participating EFRC institutions. Total funding for the 42 centers will be $100 million a year funded through the Office of Science Basic Energy Sciences program. DOE provides an addition $10 million a year to fund four other EFRCs focused on environmental management that are up for recompetition in 2020 and currently managed by Florida State, Ohio State, the University of South Carolina, and Pacific Northwest National Laboratory.

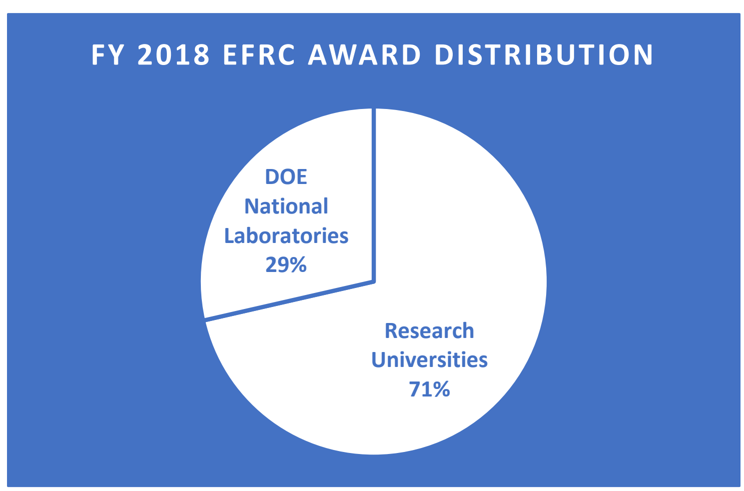


Source: DOE Office of Science.

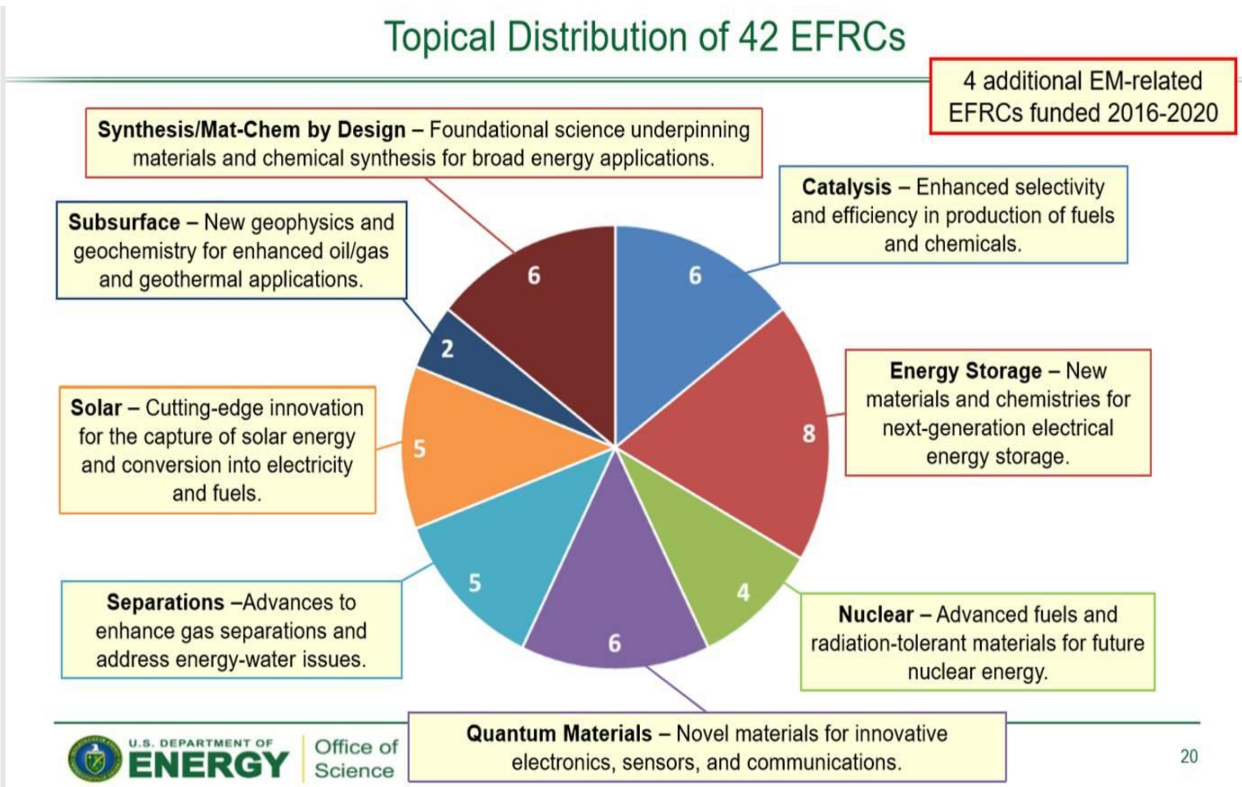
The last EFRC competition was in FY 2018. On June 29, 2018, DOE announced awards for 42 EFRCs. The awards included 22 new centers and renewals for nine existing centers. These four-year centers will receive on average approximately $2 million to $4 million per year through 2022. For the first time, DOE also awarded two-year extensions to another 11 existing centers which will receive on average about $2 million over the two years to complete research activities through 2020. The twelve other existing centers either did not seek renewal or were terminated. The graphic below shows the distribution of awards.



Of the 42 centers, 30, or 71 percent, were awarded to universities and the remaining 12, or 29 percent, to DOE national labs (see the graphic). This is consistent with prior years and a recognition that universities offer innovative approaches to energy technologies. Similarly, of the 11 existing centers with two-year extensions, eight, or 73 percent, were awarded to universities and the remaining three to DOE national laboratories. Two institutions were awarded two EFRCs—Stanford University and SUNY Stony Brook.



The centers cover a broad range of energy-relevant topics, such as solar energy, nuclear energy, energy storage, catalysis, subsurface science, and quantum materials (see graphic below). All the new centers were awarded in the six priority category research areas identified in the Basic Research Needs workshops and reports released before the funding opportunity: synthesis (e.g., Stony Brooks new Next Generation Synthesis Center), quantum (e.g., UC-San Diego's new Quantum Materials for Energy Efficient Neuromorphic Computing center), next-generation energy storage, (e.g., Case Western Reserve University's Breakthrough Electrolytes for Energy Storage center), catalysis (e.g., Cornell University' Center for Alkaline-Based Energy Solutions center), future nuclear energy technologies (e.g., Los Alamos National Laboratory's Fundamental Understanding of Transport Under Reactor Extremes center), and the energy-water nexus (e.g., Argonne National Laboratory's Advanced Materials for Energy-Water Systems center).



Source: DOE Office of Science.

The table below provides information on each of the 46 existing EFRCs.

Key:

White	New centers
Light Grey	Renewed Centers
Dark Grey	Extended only two years

Center	Lead Institution	Partners	Mission	States Represented	Class
Quantum Materials					
Center for Novel Pathways to Quantum Coherence in Materials (NPQC)	Lawrence Berkeley National Laboratory	Argonne National Laboratory, Columbia University, Lawrence Berkeley National Laboratory, University of California, Santa Barbara	To expand dramatically our understanding and control of coherence in solids by building on recent discoveries in quantum materials along with advances in experimental and computational techniques.	3	2018-2022
Programmable Quantum Materials (Pro-QM)	Columbia University	Carnegie Mellon University, Columbia University, University of Washington	To discover, characterize, and deploy new forms of quantum matter controllable by gating, magnetic proximity and nano-mechanical manipulation.	2	2018-2022
Center for the Advancement of Topological Semimetals (CATS)	Ames Laboratory	Ames Laboratory, Argonne National Laboratory, Harvard University, Los Alamos National Laboratory, Massachusetts Institute of Technology, University of California, Santa	To understand and discover new quantum phenomena and functionality in topological materials for future applications in spin-based electronics, computing, and sensing.	5	2018-2022

		Barbara, University of Waterloo			
[Institute for Quantum Matter (IQM)]	Johns Hopkins University	Cornell University, Johns Hopkins University, Pennsylvania State University, Princeton University, Rutgers University	To realize, understand, and control revolutionary quantum materials and structures where quantum effects such as entanglement and coherence find collective macroscopic manifestations.	4	2018-2022
[Center for Molecular Magnetic Quantum Materials (M2QM)]	University of Florida	California Institute of Technology, Florida State University, Los Alamos National Laboratory, University of Central Florida, University of Florida	To provide the materials physics and chemistry understanding of molecular magnetic quantum materials essential for quantum and conventional computing beyond Moore's Law.	3	2018-2022
[Quantum Materials for Energy Efficient Neuromorphic Computing (Q-MEEN-C)]	University of California, San Diego	Argonne National Laboratory, Brookhaven National Laboratory, National Center for Scientific Research, National Institute of Standards and Technology, New York University, Northwestern University, Purdue University, University of California, Davis, University of California, San Diego, University of California, Santa	To lay down the quantum-materials-based foundation for the development of an energy-efficient, fault-tolerant computer that is inspired and works like the brain ("neuromorphic").	5	2018-2022

		Barbara, University of Chicago			
Energy Storage					
[Center for Alkaline-Based Energy Solutions (CABES)]()	Cornell University	Binghamton University, Carnegie Mellon University, Cornell University, Los Alamos National Laboratory, National Renewable Energy Laboratory, Pennsylvania State University, University of Wisconsin, Yale University	To achieve a detailed understanding of the nature, structure, and dynamics of electrocatalysis in alkaline media.	6	2018-2022
[Breakthrough Electrolytes for Energy Storage (BEES)]()	Case Western Reserve University	Brookhaven National Laboratory, Case Western Reserve University, Columbia University, CUNY Hunter College, New York University, University of Notre Dame, University of Tennessee, University of Texas at Austin	To develop fundamental understanding of: (i) solvation and transport properties; (ii) electrode-electrolyte interfaces; and (iii) electron transfer reactions in deep eutectic solvents and soft nanoparticle electrolytes.	5	2018-2022
[Fluid Interface Reactions, Structures and Transport Center (FIRST)]()	Oak Ridge National Laboratory	Ames Laboratory, Argonne National Laboratory, Drexel University, North Carolina State University, Oak Ridge National Laboratory, Pennsylvania State University, Tulane University, University of California, Riverside, University of Tennessee,	To achieve fundamental understanding and validated, predictive models of the atomistic origins of electrolyte and coupled electron transport under nanoconfinement that will enable transformative advances in capacitive electrical energy storage and	8	2009-2022

		Vanderbilt University	other energy-relevant interfacial systems.		
[Center for Mesoscale Transport Properties (m2mt)]()	Stony Brook University	Brookhaven National Laboratory, Columbia University, Cornell University, Drexel University, Georgia Institute of Technology, Lawrence Berkeley National Laboratory, Stony Brook University, University of Texas at Austin	To build the scientific knowledge to enable creation of scalable electrochemical energy storage systems with high energy, power, and long life, through fundamental understanding of transport properties gained by identification and purposeful probing of materials and interfaces under dynamic conditions from the molecular to the mesoscale.	6	2014-2022
[Center for Synthetic Control Across Length-scales for Advancing Rechargeables (SCALAR)]()	University of California, Los Angeles	California Institute of Technology, SLAC National Accelerator Laboratory, University of California, Los Angeles, University of California, San Diego, University of California, Santa Barbara, University of Southern California	To design materials, interfaces, and architectures that revolutionize the performance of energy storage systems by dramatically expanding the range of materials systems and chemistries that can be employed in next generation batteries.	1	2018-2022
[NorthEast Center for Chemical Energy Storage (NECCES)]()	Binghamton University	Binghamton University, Cambridge University, Massachusetts Institute of Technology, Rutgers University, Stony	To develop an understanding of how key electrode reactions occur, and how they can be controlled to improve electrochemical	4	2009-2020

		Brook University, University of California, San Diego, University of California, Santa Barbara, University of Michigan	performance, from the atomistic level to the macroscopic level through the life-time of the operating battery.		
Precision Ion-electron Control in Solid State Storage (PICS3)	University of Maryland	Michigan State University, Sandia National Laboratories, University of California, Los Angeles, University of Maryland, University of Utah	To reveal scientific insights and design principles that enable a next-generation electrical energy storage technology based on dense mesoscale architectures of multifunctional solid-state nanostructures.	5	2009-2020
Center for Electrochemical Energy Science (CEES)	Argonne National Laboratory	Argonne National Laboratory, Northwestern University, Purdue University, University of Illinois Urbana-Champaign	To create a robust fundamental understanding of the phenomena that control the reactivity of electrified oxide interfaces, films and materials relevant to lithium-ion battery chemistries.	2	2009-2020
Nuclear					
Fundamental Understanding of Transport Under Reactor Extremes (FUTURE)	Los Alamos National Laboratory	Bowling Green State University, Los Alamos National Laboratory, North Carolina State University, Pacific Northwest National Laboratory, University of California, Berkeley, University of Virginia, University of Wisconsin	To understand how the coupled extremes of irradiation and corrosion work in synergy to modify the evolution of materials by coupling experiments and modeling that target fundamental mechanisms.	7	2018-2022

Center for Thermal Energy Transport under Irradiation (TETI)	Idaho National Laboratory	Air Force Research Laboratory, Columbia University, Idaho National Laboratory, Oak Ridge National Laboratory, Ohio State University, Purdue University, University of Central Florida	To provide the foundational work necessary to accurately model and ultimately control electron- and phonon-mediated thermal transport in 5f-electron materials in extreme irradiation environments.	6	2018-2022
Molten Salts in Extreme Environments (MSEE)	Brookhaven National Laboratory	Brookhaven National Laboratory, Idaho National Laboratory, Oak Ridge National Laboratory, Stony Brook University, University of Iowa, University of Notre Dame	To provide a fundamental understanding of molten salt bulk and interfacial chemistry that will underpin molten salt reactor technology.	5	2018-2022
Energy Dissipation to Defect Evolution (EDDE)	Oak Ridge National Laboratory	Oak Ridge National Laboratory, University of Michigan, University of Tennessee, University of Wyoming, Virginia Polytechnic Institute and State University	To understand how extreme chemical complexity can be exploited to control energy dissipation and defect evolution under equilibrium and non-equilibrium conditions and to guide the development of radiation-tolerant alloys with unique magnetic and thermal properties.	4	2014-2020
Solar					
Center for Hybrid Organic Inorganic Semiconductors for Energy (CHOISE)	Lawrence Berkeley National Laboratory	Argonne National Laboratory, Columbia University, Lawrence Berkeley	To expand dramatically our understanding and control of coherence in solids	3	2018-2022

		National Laboratory, University of California, Santa Barbara	by building on recent discoveries in quantum materials along with advances in experimental and computational techniques.		
Bioinspired Light-Escalated Chemistry (BioLEC)	Princeton University	Arizona State University, Brookhaven National Laboratory, Massachusetts Institute of Technology, Michigan State University, National Renewable Energy Laboratory, North Carolina State University, Princeton University	To employ light harvesting and advances in solar photochemistry to enable unprecedented photoinduced cross-coupling reactions that valorize abundant molecules.	7	2018-2022
Photonics at Thermodynamic Limits (PTL)	Stanford University	California Institute of Technology, Harvard University, Stanford University, University of California, Berkeley, University of Illinois Urbana-Champaign	To achieve photonic operations at thermodynamic limits by controlling the flow of photons, electrons, and phonons in atomically-architected materials, enabling entirely new energy conversion systems.	3	2018-2022
Center for Light Energy Activated Redox Processes (LEAP)	Northwestern University	Argonne National Laboratory, Northwestern University, Yale University	To develop the fundamental scientific understanding needed to use efficient light-driven multi-electron redox processes to power energy-demanding chemistry.	2	2009-2020

Alliance for Molecular PhotoElectrode Design for Solar Fuels (AMPED)	University of North Carolina at Chapel Hill	Georgia Institute of Technology, University of North Carolina at Chapel Hill, University of Texas at San Antonio	To develop the fundamental molecular basis for solar-driven water oxidation and carbon dioxide reduction catalysis.	3	2009-2020
Catalysis/Bioscience					
Integrated Mesoscale Architectures for Sustainable Catalysis (IMASC)	Harvard University	Brookhaven National Laboratory, Harvard University, Lawrence Livermore National Laboratory, Stony Brook University, Tufts University, University College London, University of California, Los Angeles; University of Florida, University of Pennsylvania	To establish design principles for highly selective catalytic transformations driven by nanoporous dilute alloys.	6	2014-2022
Center for Lignocellulose Structure and Formation (CLSF)	Pennsylvania State University	Cambridge University, Massachusetts Institute of Technology, North Carolina State University, Oak Ridge National Laboratory, Pennsylvania State University, University of Rhode Island, University of Texas at El Paso, University of Virginia	To develop a nano- to meso-scale understanding of cellulosic cell walls, the energy-rich structural material in plants, and the physical mechanisms of wall assembly, forming the foundation for new technologies in sustainable energy and novel biomaterials.	7	2009-2022
Catalysis Center for Energy Innovation (CCEI)	University of Delaware	Brookhaven National Laboratory, California Institute of Technology, Carnegie Mellon	To advance the catalysis science of complex systems with a focus on thermocatalytic transformation of	7	2009-2022

		University, Columbia University, Johns Hopkins University, Rutgers University, Stony Brook University, University of California, Santa Barbara, University of Connecticut, University of Delaware, University of Maryland, University of Massachusetts, University of Minnesota, University of Pennsylvania	lignocellulosic (non-food-based) biomass into chemicals and transportation fuels.		
Inorganometallic Catalyst Design Center (ICDC)	University of Minnesota	Argonne National Laboratory, Clemson University, Massachusetts Institute of Technology, Northwestern University, NuMat Technologies, Pacific Northwest National Laboratory, Stony Brook University, University of California, Davis, University of Minnesota	To discover new classes of energy-science relevant catalytic materials, especially through the exploitation of computational modeling to identify underlying structure-function relationships that are critical to advancing further, predictive catalyst discovery.	7	2014-2022
Center for Molecular Electrocatalysis (CME)	Pacific Northwest National Laboratory	Massachusetts Institute of Technology, Pacific Northwest National Laboratory, Purdue University, University of Washington,	To establish the fundamental principles needed for efficient interconversion of electrical energy and chemical bonds through precise	5	2009-2022

		University of Wisconsin, Yale University	control of electron and proton transfers.		
[Biological Electron Transfer and Catalysis Center (BETCy)]()	Washington State University	Arizona State University, Duke University, Montana State University, University of Georgia, University of Utah, University of Washington, Utah State University, Washington State University	To understand the means by which biology controls the kinetics and thermodynamics of electron bifurcation at both organic and inorganic centers through electron transfer relays, allosteric coupling, and cooperative conformational dynamics.	6	2014-2020
Separations					
[The Center for Enhanced Nanofluidic Transport (CENT)]()	Massachusetts Institute of Technology	Lawrence Livermore National Laboratory, Massachusetts Institute of Technology, Stanford University, University of California, Irvine, University of Florida, University of Illinois Urbana-Champaign, University of Maryland, Yale University	To address emerging and compelling gaps in our knowledge of fluid flow and molecular transport in single digit nanopores and establish the scientific foundation for developing transformative molecular separation technologies impacting the Water-Energy Nexus.	6	2018-2022
[Advanced Materials for Energy-Water Systems (AMEWS)]()	Argonne National Laboratory	Argonne National Laboratory, Northwestern University, University of Chicago	To understand and design water-solid interfaces to enable future advances in materials for efficient water treatment.	1	2018-2022

Center for Understanding and Control of Acid Gas-Induced Evolution of Materials for Energy (UNCAGE-ME)	Georgia Institute of Technology	Georgia Institute of Technology, Lehigh University, Oak Ridge National Laboratory, Pennsylvania State University, Sandia National Laboratories, University of Alabama, University of Wisconsin, Washington University in St. Louis	To develop and harness a deep knowledge base in the characterization, prediction, and control of acid-gas interactions with a broad class of materials to accelerate materials discovery in acid gas separations, conversion, and utilization.	7	2014-2022
Center for Materials for Water and Energy Systems (M-WET)	University of Texas at Austin	Lawrence Berkeley National Laboratory, University of California, Santa Barbara, University of Texas at Austin	To discover and understand fundamental science to design new membrane materials, develop tools and knowledge to predict new materials' interactions with targeted solutes from recalcitrant water sources, provide fit for purpose water, and recover valuable solutes with less energy.	1	2018-2022
Center for Gas Separations (CGS)	University of California, Berkeley	École Polytechnique Fédérale de Lausanne, Lawrence Berkeley National Laboratory, National Energy Technology Laboratory, National Institute of Standards and Technology, Texas A&M University,	To develop new materials and membranes that enable the energy-efficient separation of gas mixtures, as required in the clean use of fossil fuels and in reducing emissions from industry. Particular emphasis	6	2009-2020

		University of California, Berkeley, University of Minnesota	is placed on separations that reduce CO2 emissions from power plants and energy-intensive gas separations in industry and agriculture.		
Subsurface					
[Center for Mechanistic Control of Water-Hydrocarbon-Rock Interactions in Unconventional and Tight Oil Formations (CMC-UF)]	Stanford University	SLAC National Accelerator Laboratory, Stanford University, University of Southern California, University of Wyoming	To seek fundamental mechanistic understanding to achieve control over the various non-equilibrium chemical and physical processes occurring in shale that increases hydrocarbon production while decreasing the amount of produced water, contaminants, and the number of wells drilled.	2	2018-2022
[Multi-Scale Fluid-Solid Interactions in Architected and Natural Materials (MUSE)]	University of Utah	Idaho National Laboratory, Pennsylvania State University, University of California, Davis, University of Utah, University of Wisconsin, University of Wyoming	To synthesize geomaterials with repeatable hierarchical heterogeneity and develop an understanding of transport and interfacial properties of fluids confined within these materials.	6	2018-2022
Synthesis/Mat-Chem by Design					
[Center for Bio-Inspired Energy Science (CBES)]	Northwestern University	Columbia University, Harvard University, New	To develop the next frontier in soft materials relevant	5	2009-2022

		York University, Northwestern University, University of Michigan, University of Pittsburgh	to energy challenges by designing structures that emulate functions we see in biological systems.		
A Next Generation Synthesis Center (GENESIS)	Stony Brook University	Brookhaven National Laboratory, Colorado State University, Columbia University, Farmingdale State College, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Stony Brook University, University of California, San Diego	To develop a new paradigm for synthesis that accelerates the discovery of functional materials by integrating advanced in situ diagnostics and data science tools to interrogate, predict, and control the pathways that govern synthesis and lead to new materials.	4	2018-2022
The Center for the Science of Synthesis Across Scales (CSSAS)	University of Washington	Oak Ridge National Laboratory, Pacific Northwest National Laboratory, University of California, San Diego, University of Chicago, University of Washington	To harness the complex functionality of hierarchical materials by mastering the design of high-information-content macromolecular building blocks that predictively self-assemble into responsive, reconfigurable, self-healing materials, and direct the formation and organization of inorganic components.	4	2018-2022

Center for Complex Materials from First Principles (CCM)	Temple University	Brookhaven National Laboratory, Drexel University, Duke University, Northeastern University, Rice University, Temple University, Tulane University, University, University of Pennsylvania	To develop, test, apply, and experimentally validate improved methods of electronic structure calculation for both simple and complex materials (including quantum materials).	6	2014-2020
Spins and Heat in Nanoscale Electronic Systems (SHINES)	University of California, Riverside	Johns Hopkins University, University of California, Los Angeles, University of California, Riverside, University of Texas at Austin	To control interactions involving spins and lattice to achieve high energy efficiency in nanoscale electronic devices.	3	2014-2020
Center for Next Generation of Materials Design (CNGMD)	National Renewable Energy Laboratory	Brookhaven National Laboratory, Colorado School of Mines, Harvard University, Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, Oregon State University, SLAC National Accelerator Laboratory, University of Colorado	To dramatically transform the discovery of functional energy materials through multiple-property search, incorporation of metastable materials into predictive design, and the development of theory to guide materials synthesis	5	2014-2020
Environmental Management					
Center for Performance and Design of Nuclear Waste Forms and Containers (WastePD)	Ohio State University	Commissariat à l'Energie, France, Louisiana State University, Ohio State University, Pacific Northwest	To understand the fundamental mechanisms of waste form performance and apply that	8	2016-2020

		National Laboratory, Pennsylvania State University, QuesTek Innovations LLC, Rensselaer Polytechnic Institute, University of North Texas, University of Virginia	understanding to design new waste forms with improved performance.		
Center for Hierarchical Waste Form Materials (CHWM)	University of South Carolina	Alfred University, Clemson University, Commissariat à l'Energie, Pacific Northwest National Laboratory, Savannah River National Laboratory, University of Florida, University of South Carolina	To combine experiment and modeling to develop the chemistry and structure motifs needed to create hierarchical materials that effectively immobilize nuclear waste in persistent architectures.	6	2016-2020
Interfacial Dynamics in Radioactive Environments and Materials (IDREAM)	Pacific Northwest National Laboratory	Georgia Institute of Technology, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, University of Notre Dame, University of Washington, Washington State University	To master molecular to mesoscale chemical and physical phenomena at interfaces in complex environments characterized by extremes in alkalinity and low-water activity, and driven far from equilibrium by ionizing (g,b) radiation.	4	2016-2020
Center for Actinide Science & Technology (CAST)	Florida State University	Florida International University, Florida State University, Lawrence Berkeley National Laboratory, Los	To advance our understanding of how electronic structure and bonding control the properties of	6	2016-2020

		Alamos National Laboratory, National High Magnetic Field Laboratory, Purdue University, University at Buffalo, University of Manitoba, University of Pennsylvania	radioactive materials. This knowledge will aid in the development of nuclear technologies that enhance energy security, address nuclear legacy issues and environmental concerns, and foster the next generation of nuclear scientists.		

Sources and Additional Information:

- More information on EFRCs is available at https://science.osti.gov/bes/efrc/.
- The prior FY 2018 EFRC Funding Opportunity Announcement is available at https://science.osti.gov/-/media/grants/pdf/foas/2018/SC_FOA_0001810.pdf.
- Best practices to organize and manage EFRCs is available at https://science.osti.gov/-/media/bes/efrc/pdf/history/other/EFRC-Ref---Good-Practices-2017-12-v2.pdf?la=en&hash=18ECBFCDAC5012ACE261C52B1AEBB4F6042FF63D.
- The two Basic Research Needs reports on quantum information science are available at https://science.osti.gov/-/media/bes/pdf/reports/2018/Quantum_computing.pdf?la=en&hash=C767B23CFFD250A01F846D3B6FB62143BEC258B0 and https://science.osti.gov/-/media/bes/pdf/reports/2018/Quantum_systems.pdf?la=en&hash=291099097EBCCFAB99D86F60F62EA061F996424C.
- A summary of the microelectronics Basic Research Needs report is available at https://science.osti.gov/-/media/bes/pdf/reports/2018/Microelectronics_Brochure.pdf?la=en&hash=5FEFD0131FA3DA1CC8C3196452D1AFB5558DE720.
- The Basic Research Needs report on the energy-water nexus is available at https://science.osti.gov/-/media/bes/pdf/reports/2017/BRN_Energy_Water_rpt.pdf?la=en&hash=A6F8FF3E654429D20CE557EE7D3342BDC2BF75F8.
- The Basic Research Needs report focused on environmental management is available at https://science.osti.gov/-/media/bes/pdf/reports/2016/Basic_Research_Needs_for_Environmental_Management_rpt.pdf?la=en&hash=062E30502B0EAD43CEF118F9C21EAB1754F07F85.
- *Directing Matter and Energy: Five Challenges for Science and the Imagination* is available at https://science.osti.gov/-/media/bes/pdf/reports/files/Directing_Matter_and_Energy_rpt.pdf.
- *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science* is available at https://science.osti.gov/-

/media/bes/besac/pdf/Reports/Challenges_at_the_Frontiers_of_Matter_and_Energy_rpt.pdf?la=en&hash=93DADAB468987BB52900D3EA96F5021EE03ED66A.