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Guide to FY2014 Research Funding at the Department of Energy (DOE)

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Executive Summary and Index

This document provides succinct insights into the various DOE funding opportunities for University research, with special attention to changes anticipated in FY2014. More information is provided at the Central Desktop "Mission Agency Program Summary" (MAPS) website, including the charts cited in the text.

The mission of the Energy Department is to ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions. Basic research is funded through the Office of Science, which includes Advanced Scientific Computing Research (ASCR), Basic Energy Sciences (BES), Biological and Environmental Research (BER), Nuclear Physics, High Energy Physics and Fusion Energy Sciences. Applied research is funded through Electricity Delivery and Energy Reliability (EDER), Energy Efficiency and Renewable Energy (EERE), Fossil Energy (FE), Nuclear Energy (NE) and ARPA-E. Innovation Hubs, Clean Energy Manufacturing Innovation Institute (Advanced Manufacturing) and BioEnergy Centers are large-scale Center opportunities.

Appendix 1 FY2014 DOE Basic Research - New Programs and/or Program Change

The FY2014 budget for basic research is essentially flat or decreasing in some areas. Only two items have any appreciable growth – Energy Frontier Research Centers (EFRC) and foundational genomics. The growth is measured from the FY2012 budget.

	Growth ($M)	page(s)
Basic research		
ASCR projected significant budget growth is in:		
Applied Math	from 46 to 50	11
Computer Science	from 47 to 55	11
BES projected significant budget growth is in:		
Energy Frontier Research Centers (EFRC)	from 100 to 169	11
BER projected significant budget growth is in:		
Foundational Genomics	from 64 to 76	11

Appendix 2 FY2013 DOE Applied Research - New Programs and/or Program Growth

There is significant growth requested in the several RR&D lines; however note that in recent years Congress has frequently not appropriated the requested amounts.

	Growth ($M)	page(s)
Applied Research and Development		
ARPA-E projected significant budget growth is in:		
Transportation Systems	from 138 to 197	12
Stationary Power Systems	from 115 to 148	12
Applied Research and Development		
EERE projected significant budget growth is in:		
Vehicles	from 320 to 575	13
Bioenergy Technologies	from 195 to 282	13
Solar Energy	from 284 to 356	13
Advanced Manufacturing	from 113 to 365	14
Building Technologies	from 215 to 300	14
EDER projected significant budget growth is in:		
Electricity Systems Innovation Hub	from 0 to 19	14
Cybersecurity for Energy Delivery Systems	from 29 to 38	14
Clean Energy Transmission and Reliability	from 25 to 32	14

Appendix 3: Illustration of a DOE program manager data sheet

Appendix 4: Acronym glossary (including Technology Readiness Levels)

Overview
The mission of the Energy Department is to ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions. This includes funding for priority areas such as clean energy, research and development to spur innovation, and advanced manufacturing. It improves the competitiveness of U.S. industries by research and development on advanced manufacturing processes and advanced industrial materials, enabling companies to cut costs by using less energy while improving product quality. Its efforts span basic research, applied research, development, demonstration and deployment (RDD&D)

The Department of Energy (DOE) is the single largest federal government supporter of basic research in the physical sciences in the United States, providing more than 40% of total federal funding for this vital area of national importance. In particular, DOE oversees - and is the principal federal funding agency of - the nation's research programs in high-energy physics, nuclear physics, and fusion energy sciences.

The DOE offices that fund research grants at Universities are:

- **Office of Science (SC)**
  Focus: Basic research in energy sciences, advanced computing, biological and environmental research, fusion energy, high energy physics, and nuclear physics.
- **Office of Energy Efficiency & Renewable Energy (EERE)**
  Focus: RDD&D in clean energy technologies
- **Office of Electricity Delivery and Energy Reliability (EDER)**
  Focus: RDD&D in reliable, efficient energy
- **Office of Fossil Energy (FE)**
  Focus: RDD&D in energy from fossil resources
- **Office of Nuclear Energy (NE)**
  Focus: RDD&D in nuclear energy
- **ARPA–E**
  Focus: "Out-of-the-box," transformational energy RD&D

A summary of DOE Office research funding levels at universities for 2011 (most recent data) is shown in Table 1. The FY2014 funding request for the various offices pertinent to University research efforts is shown in Table 2.

Basic Research Programs
The DOE Office of Science (SC) invests in basic research to achieve transformational discoveries. The requested FY2014 funding and program officers for those basic research programs more open to University participation are listed in Table 2a. About 20% of the SC basic research funding went to Universities/Colleges in the 2006-2009 budget years.

See *Annual Notice -Continuation of Solicitation for the Office of Science Financial Assistance Program* for all Office of Science programs (http://science.doe.gov/grants/announcements.asp). Discussion with the appropriate DOE program manager is recommended to ascertain interest in your ideas and availability of funds. One can find existing Office of Science awards to Universities at http://science.energy.gov/funding-opportunities/award-search/. This can be useful for understanding a program managers interests. Guidance on proposal preparation and submission can be found at: http://science.doe.gov/grants/guide.asp. There are no submission deadlines, however, it is recommended that a full application be sent between June 1st and November 30th. Three to four years is the usual grant duration. Matching funds are usually not required. The Office of Science requires the submission of all financial assistance applications through Grants.gov.

Prior to a comprehensive merit evaluation, DOE will perform an initial review to determine that (1) the applicant is eligible for the award; (2) the information required by the Federal Opportunity Announcement (FOA) has been submitted; (3) all mandatory requirements are satisfied; and (4) the proposed project is responsive to the objectives of the funding opportunity announcement. Those accepted will be subjected to scientific merit review (peer review) and will be evaluated against the following evaluation criteria, which are listed in descending order of importance:

1. Scientific and/or Technical Merit of the Project;
2. Appropriateness of the Proposed Method or Approach;
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources; and
4. Reasonableness and Appropriateness of the Proposed Budget.

The evaluation process will include program policy factors such as the relevance of the proposed research to the terms of the FOA and the agencies' programmatic needs. Note that external peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Both Federal and non-Federal reviewers may be used.

The several Office of Science programs include:
<u>Engineering Frontier Research Centers (EFRC)</u> (www.er.doe.gov/bes/EFRC/index.html)
These integrated, multi-investigator Centers conduct fundamental research focusing on one or more of several "grand challenges" and use-inspired "basic research needs" identified in major strategic planning efforts. The Centers integrate the talents and expertise of leading scientists to accelerate research toward meeting our critical energy challenges. Funded at ~$3M/yr for five years. In FY2014 there will be a new competition open to applications from existing centers and others. See DOE chart 13.

<u>Adv Scientific Computing Research Program (ASCR)</u> (http://science.energy.gov/ascr/)
To discover, develop, and deploy computational and networking capabilities to analyze, model, simulate, and predict complex phenomena. See Table 2a and DOE charts 14-17.

<u>Basic Energy Sciences Program (BES)</u> (http://science.energy.gov/bes/)
To support fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels to provide the foundations for new energy technologies. Two divisions manage the University research portfolio: Materials Sciences and Engineering; and Chemical Sciences, Geosciences, and Biosciences. See Table 2a and DOE charts 18-24.

<u>Biological and Environmental Research Program (BER)</u> (http://science.energy.gov/ber/)
To understand biological, climate, and environmental systems by: exploring the frontiers of genome-enabled biology; discovering the phys, chem, and bio drivers of climate change; and seeking the bio, geochem and hydrological molecular determinants of environmental sustainability and stewardship. Two Divisions manage the research portfolio: Biological Systems Science, and Climate & Environmental Sciences. See Table 2a and DOE charts 25-38.

Fusion Energy Science Program (FES) (http://science.energy.gov/hep/)
To advance the fundamental understanding of matter at very high temperatures and densities, and to develop the scientific foundations needed for a fusion energy source. See Table 2a and DOE charts 29-31.

High Energy Physics Program (HEP) (http://science.energy.gov/hep/)
To understand how our universe works at its most fundamental level by discovering the elementary constituents of matter and energy; probing the interactions between them; and exploring the basic nature of space and time. See Table 2a and DOE charts 32-34.

Nuclear Physics Program (NP) (http://science.energy.gov/np/)
To discover, explore and understand all forms of nuclear matter and to understand how the fundamental particles—quarks and gluons—fit together and interact to create different types of matter in the universe, including those no longer found naturally. See Table 2a and DOE charts 35-37.

Workforce Development for Teachers and Scientists (http://science.energy.gov/wdts/)
To help DOE and the Nation have a sustained pipeline of highly trained science, technology, engineering, and mathematics (STEM) individuals for the U.S. workforce. See Table 2a and DOE charts 38-39.

Scientific User Facilities (http://science.energy.gov/user-facilities/)
State-of-the-art facilities shared with the science community worldwide and offer some technologies and instrumentation that are available nowhere else.

Bioenergy Centers (http://genomicscience.energy.gov/centers/)
To focus the most advanced biotechnology-based resources on the biological challenges of biofuel production, DOE established three Bioenergy Research Centers (BRCs - BioEnergy Science, Great Lakes Bioenergy Research, and Joint BioEnergy Institute) in September 2007. Each center is pursuing the basic research underlying a range of high-risk, high-return biological solutions for bioenergy applications. Advances resulting from the BRCs will provide the knowledge needed to develop new biobased products, methods, and tools that the emerging biofuel industry can use. They are funded by the Office of Science at ~$25M/yr each. See DOE chart 28.

Innovation Hubs (http://energy.gov/hubs)
Major multidisciplinary, multi-investigator, multi-institutional integrated research centers, the Hubs are modeled after the centralized scientific management characteristics of the Manhattan Project. There are currently five funded Hubs (at ~$25M/yr each), two by Office of Science - Fuels from Sunlight and Energy Storage, two by the Office of Electricity Efficiency and Renewable Energy - Energy Efficient Buildings and Critical Materials, and one by the Office of Nuclear Energy - Nuclear Energy Modeling and Simulation. The FY2014 budget proposes a sixth hub focused on Electrical Systems funded by the Office of Electricity Delivery and Energy Reliability (EDER – Electricity Systems). See DOE chart 8.

High End Computing (http://www.nersc.gov/)

The National Energy Research Scientific Computing Center (NERSC) annually serves researchers at DOE laboratories, universities, industrial laboratories and other Federal agencies. The ASCR Leadership Computing Challenge (ALCC) program allocates up to 30% of the computational resources at NERSC and the Leadership Computing Facilities at Argonne and Oak Ridge for special situations of interest to the Department with an emphasis on high-risk, high-payoff simulations in areas directly related to the Department's energy mission. Allocations of computer time and archival storage at NERSC are awarded to research groups based on a review of submitted proposals. (http://science.energy.gov/ascr/facilities/alcc/)

The Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program invites proposals for large-scale, computationally intensive, research projects to run at America's premier leadership computing facility (LCF) centers. The INCITE program awards sizeable allocations (typically, millions of processor-hours per project) on some of the world's most powerful supercomputers to address grand challenges in science and engineering. In 2013, INCITE awarded 61 projects totaling approximately 2.8 billion processor hours. (http://www.doeleadershipcomputing.org/)

Early Career (http://science.energy.gov/early-career/)
The Office of Science supports an Early Career Research Program in the projects of interest to SC; a typical award is $750K over 5 years. (A list of prior Early Career awardees is available from the DC office). The Principal Investigator must be an untenured Assistant Professor or Associate Professor on tenure track at a U.S. academic institution as of the deadline for the application. No more than ten years can have passed between the year the PI's Ph.D. was awarded and the year of the deadline for the application. No citizenship requirement. Preapplications are required. See DOE chart 12.

Applied Research Programs
The DOE applied research, development, demonstration and deployment programs will usually require some form of matching funds and industrial participation.

Office of Electrical Delivery and Energy Reliability (EDER or OE)
(energy.gov/oe/office-electricity-delivery-and-energy-reliability)
The mission of EDER is to lead national efforts to modernize the electric grid; enhance security and reliability of the energy infrastructure; and facilitate recovery from disruptions to energy supply. The areas of focus include: smart grid, energy assurance and cybersecurity. See Table 2b and DOE charts 41-43.

Office of Energy Efficiency & Renewable Energy (EERE) (www.eere.energy.gov/)
The mission of EERE is to strengthen America's energy security, environmental quality, and economic vitality in public-private partnerships that: enhance energy efficiency and productivity; and bring clean, reliable and affordable energy technologies to the marketplace. The R&D programs include: advanced manufacturing, biomass, buildings, geothermal, hydrogen and fuel cell, solar, vehicles, and weatherization, wind and hydropower. See Table 2b and DOE charts 44-61.

Office of Fossil Energy (FE) (www.fossil.energy.gov/)
The primary mission FE is ensuring that the U.S. can continue to rely on clean, affordable energy from our traditional fuel resources – coal, oil and natural gas. The R&D programs include: Clean

Coal Technologies, Oil and Natural Gas Technologies, Carbon Capture, Utilization and Storage, and Hydrogen & Other Clean Fuels. See DOE charts 62-64.

Office of Nuclear Energy (NE) (www.ne.doe.gov/)
NE promotes nuclear power as a resource capable of meeting the Nation's energy, environmental and national security needs by resolving technical and regulatory barriers through research, development and demonstration. The R&D programs include: advanced modeling and simulation, fuel cycle, and Generation IV Nuclear Energy Systems. The university support (20% of NE R&D funding) is consolidated into the Nuclear Energy University Programs (NEUP). See DOE charts 65-68. (www.ne.doe.gov/universityPrograms/neUniversity_factsheets.html).

ARPA-E (http://arpa-e.energy.gov/)
The focus is on creative "out-of-the-box" transformational energy research that industry by itself cannot or will not support due to its high risk but where success would provide dramatic benefits for the nation. See DOE charts 69-75.

Resources
Website showing the DOE Office of Science solicitations:
http://science.doe.gov/grants/

For access to the information on the Research Advancement's Central Desktop website **Mission Agency Program Site (MAPS)**, contact NLWalker@usc.edu for user name and password.

The MAPS site has:
Under "Wiki" Tab - how to use the site
Under "Files/Discussion" Tab
- Mission Agency (DHS, DOD, DOE, ED, EPA, NASA, NIST, NOAA and cross-agency programs in Adv Manuf, Sustainability, STEM Education)
  - Guide to Agency Funding for FYXX
  - Agency Research Funding Programs
  - Agency Planning Documents
  - Program Officer Data sheets (with contact info, biosketch, program descriptive, personal pubs)
  - Program Officer presentations (when available)

Under "Database" Tab
- USC MAPS - table of all program officers / programmatic interest

The file labeled "Agency (DOE) Research Funding" at the Central Desktop MAPS website provides a compilation of numbered charts with detailed information on the various DOE funding agencies; the various program interests; the program managers, their research interests and contact information; and how to best navigate the agency websites. Chart numbers in the text above reference that file. In addition, at the website there are other useful reports/presentations, a database to identify program officer interests, and program officer data sheets (see illustration in Appendix 3). If you are interested in exploring an opportunity, contact with the appropriate DOE program officer is strongly recommended.

Assistance in Locating Funding and Preparing Proposals

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Table 1: 2009 / 2011 DOE funding ($M) for Basic and Applied Research at Universities and Colleges

	2009			2011		
	Basic	Applied	Total	Basic	Applied	Total
Total for DOE	**4061**	**3127**		**4023**	**3455**	
Total at Universities	**744**	**163**	**907**	**739**	**191**	**930**
Physical Sciences	**503**	**64**	**567**	**437**	**68**	**505**
Astronomy						
Chemistry	84.68	6.40				
Physics	417.95	57.77				
Other						
Environmental Sciences	**69**	**9**	**78**	**28**	**7**	**35**
Atmospheric	38.05	0.57				
Geological	9.75	1.13				
Oceanology						
Other	20.95	7.78				
Mathematics and Computer	**46**	**4**	**50**	**42**	**0**	**42**
Computer Sciences	6.70					
Mathematics	21.32					
Other	18.03	4.09				
Engineering	**32**	**85**	**117**	**42**	**64**	**105**
Aeronautical						
Astronautical						
Chemical		12.89				
Civil		13.28				
Electrical		12.10				
Mechanical		0.77				
Metal/Materials	32.00	0.81				
Other		45.09				
Life Sciences	**95**	**0**	**95**	**110**	**0**	**110**
Agriculture						
Biological	85.46		85.46			
Environmental						
Medical	9.20					
Other						
Psychological	**0**	**0**		**0**	**0**	**0**
Social Sciences	**0**	**0**		**0**	**0**	**0**
Other Sciences	**0**	**0**		**81**	**52**	**132**

From NSF "Federal Funds for Research and Development: FY2009-2011"
NSF 12-318, July 2012

Basic Research	2008	Tables 27 and 68-71
Applied Research	2008	Tables 38 and 76-79
Basic Research	2010	Tables 29 and 67
Applied Research	2010	Table 40 and 75

Table 2a: DOE SC Budget ($M, Basic Research) for FY12 (actual), FY13 (President's Budget Request - PBR) and FY14 PBR

	FY12 Actual ($M)	FY13 PBR ($M)	FY14 PBR ($M)	Program Manager
Basic Energy Sciences Program				
Materials Sciences and Engineering Research Division				
Experimental Condensed Matter Physics	43	51	43	Dr. Andrew Schwartz
Theoretical Condensed Matter Physics	36	42	36	Dr. James Davenport
Mechanical Behavior and Radiation Effects	20	23	20	Dr. John Vetrano
Physical Behavior of Materials	25	33	25	Dr. Refik Kortan
Neutron and Xray Scattering	38	45	38	Dr. P. Thiyagarajan
Neutron and Xray Scattering				Dr. Lane Wilson
Electron and Scanning Probe Microscopies	24	29	24	Dr. Jane Zhu
Synthesis and Processing Science	20	25	20	Dr. Bonnie Gersten
Materials Chemistry and Biomolecular Materials	53	59	53	Dr. Michael Sennett
Materials Chemistry and Biomolecular Materials				Dr. Michael Markowitz
Energy Frontier Research Centers	57	68	98	
Energy Innovation Hub - Batteries and Energy Storage	19	24	24	
Chemical Sci, Geosci, and Energy Biosci Research Divison				
Atomic, Molecular, and Optical Science	21	22	21	Dr. Jeff Krause
Chemical Physics Research - Gas Phase	54	49	55	Dr. Wade Sisk
Solar Photochemistry	36	40	36	Dr. Mark Spitler
Photosynthetic Systems	17	19	17	Dr. Gail McLean
Physical Biosciences	16	18	16	Dr. Robert Stack
Catalysis Science	46	54	46	Dr. Raul Miranda
Separations and Analysis	13	16	13	Dr. Larry Rahn
Heavy Element Chemistry	15	17	15	Dr. Phillip Wilk
Geosciences Research	21	24	21	Dr. Nicholas Woodward
Energy Frontier Research Centers	43	52	71	
Energy Innovation Hub - Fuels from Sunlight	24	24	24	
Scientific User Facilities	839	919	990	Dr. Pedro Montano
Advanced Scientific Computation Research Program (~25% to Universities)				
Math, Computational, and Computer Sciences Research				
Applied Mathematics	46	50	50	Dr. Alexandra Landsberg
Computer Science	47	55	55	Dr. Sonia Sachs
Computational Partnerships (SciDAC)	44	57	47	Dr. Steven Lee
Next Generation Networking for Science	13	16	16	Dr. Thomas Ndousse-Fetter
High Performance Computing and Networking Facilities	286	273	293	Dr. Dan Hitchcock
Biological and Environmental Research Program (~35% to Universities)				
Biological Systems Science Division				
Genomic Science	184	188	197	Dr. Susan Gregurick
Radiological Sciences	35	28	19	Dr. Prem Srivastava
ELSI	0	0		
Medical Applications	0	0		
Climate and Environmental Sciences Division				
Atmospheric System Research	26	26	26	Dr. Ashley Williamson
Environmental System Science	68	79	72	Dr. R.Todd Anderson
Climate and Earth System Modeling	74	78	74	Dr. Dorothy Koch
Climate and Earth System Modeling				Dr. Renu Joseph

	FY12 Actual ($M)	FY13 PBR ($M)	FY14 PBR ($M)	Program Manager
High Energy Physics Program (only funds for Universities)				
Energy Frontier Experimental Physics	48		41	Dr. Abid Patwa
Intensity Frontier Experimental Physics	20		21	Dr. Alan Stone
Cosmic Frontier Experimental	13		12	Dr. Kathy Turner
Theoretical and Computational Physics	28	29	24	Dr. Simona Rolli
Advanced Technology R&D	11	11	8	
Nuclear Physics Program (only funds for Universities)				
Medium Energy Nuclear Physics	17	18	18	Dr. Ted Barnes
Heavy Ion Nuclear Physics	14	13	13	Dr. James Sowinski
Low Energy Nuclear Physics	20	19	20	Dr. Cyrus Baktash
Nuclear Theory	16	15	15	Dr. George Fai
Fusion Energy Sciences Program (~35% to Universities)				
DIII-D Tokomak Experimental Research	31	27	28	Dr. Mark Foster
Experimental Plasma Research	11	11	11	
High Energy Density Laboratory Plasmas	25	18	7	Dr. Sean Finnegan
Theory	24	21	21	Dr. John Mandrekas
Advanced Fusion Simulations (SciDAC Centers)	8	7	7	Dr. John Mandrekas
General Plasma Science	17	13	15	Dr. Nirmol Podder
Workforce Development for Teachers and Scientists	18	15	16	Dr. James Glownia

Table 2b: DOE Applied Budgets ($M) for FY12 (actual), FY13 (President's Budget Request - PBR) and FY14 PBR

	FY12 Actual ($M)	FY13 PBR ($M)	FY14 PBR ($M)
EERE			
Vehicles			
Batteries and Electric Drive Technology	118		240
Lightweight Materials Technology	27		50
Bioenergy Technologies			
Conversion (thermo-/bio-chemical)	102		141
Solar			
Concentrating Solar Power	45		90
Systems Integration	48		64
Geothermal			
Enhanced Geothermal Systems	15		42
Advanced Manufacturing			
Next Generation Manufacturing R&D	60		120
Clean Energy Manufacturing Innovation Inst	15		192
Building Technologies			
Building Technologies R&D	61		102
Grid Integration Initiative	0		30
EDER			
Electricity Systems Hub	0		20
Cybersecurity for Energy Delivery Systems	29		38

Clean Energy Transmission and Reliability	25	32

Appendix 1: Growth in FY2014 DOE Basic Research Programs

In the following, the budget growth reflects FY14 requested versus FY12 current; the FY13 program funding was not fully apportioned at the time of budget submission, but was roughly the level of FY12.

ASCR

Applied Math — From $46M in FY12 to $50M

Increased research efforts will focus on the most critical challenges from emerging hardware for DOE mission applications with increased emphasis on energy management, data movement, and resiliency.

Computer Science — From 46M in FY12 to 55M

Increased research efforts will focus on tools and software that make emerging high performance computing hardware more usable for DOE mission applications with emphasis on improving the fault tolerance, data management, and energy utilization of applications.

BES

Energy Frontier Research Centers — From $100M in FY12 to $169M

A single funding opportunity announcement (FOA) will be issued for both renewal and new EFRCs for five-year awards beginning in FY2014. The EFRC FOA will encourage the formation of effective teams to address the broad range of fundamental science needed to power transformative energy technologies, including newly identified opportunities in the computational design of materials and chemical processes and mesoscale science. All current EFRCs, including those initially funded through ARRA, will have the opportunity to compete for a second five-year performance period. All awards, both new and renewal, will be based on rigorous peer review of the research proposed for the five year award term. Awardees receiving renewal funding will also be assessed on progress during the first five-year award. One-time funding in the amount of $39,863,000 is provided to fully forward fund some of the new/renewal EFRC awards.

BER

Foundational Genomic Science — From $64M in FY12 to $76M

Increased investment will advance core research areas in Foundational Genomics Research with emphasis on continued development of biosystems design tools and biodesign technologies for bioenergy research, integrative analysis of large experimental genomic science datasets, and efforts to gain a predictive understanding of carbon cycling in the environment. The research portfolio will stress the integration of genome science with experiment and computational modeling to advance a predictive understanding of the design, function and regulation of plants, microbes, and biological communities contributing to the cost-effective production of next generation biofuels as a major secure national energy resource.

Appendix 2: FY14 Growth in DOE Applied Research Programs

ARPA-E

Transportation Systems From $138M in FY12 to 197M

In FY 2014 ARPA-E will continue to work on all aspects of transportation, including synthetic approaches, tools and ancillary devices related to alternative and bio-derived fuels, batteries and components for the electrification of transportation, and advanced vehicle designs and materials. ARPA-E is currently considering investing in the following areas related to Transportation Systems:

- transformational approaches to light weight materials and cost while enabling economically feasible automotive light-weighting.
- improvements to both battery and charging technologies that will facilitate wide-spread capabilities for full charge of electric vehicles in time frames not dissimilar from those required for liquid fuel refilling.
- pathways to the sustainable production of liquid fuels through either entirely new sources of renewable carbon or higher energy yields of photosynthetic biofuels.
- the interaction of surfaces with several types of media across multiple scales and applications. Such a tribology-inspired program could utilize enabling technologies that include computational modeling, materials design and system engineering that significantly impact high friction surfaces and processes.
- additional efforts in the conversion and management of thermal energy for transportation applications, including novel approaches to high-efficiency thermoelectric technology and improved utilization of thermal energy to minimize waste heat.

Stationary Power Systems From $115M in FY12 to 148M

In FY 2014 ARPA-E will continue to work on all aspects of stationary power systems, including building efficiency, stationary energy storage systems, grid modernization, and stationary energy generation. ARPA-E is currently considering investing in the following areas related to Stationary Power Systems:

- novel technologies for collecting, mining, standardizing, and protecting information for a diverse set of energy systems. Such information management may be coupled with additional technology development of new control software and hardware to reliably exert control over energy systems, such as the grid network.
- novel materials and manufacturing for energy applications including further advances in low-cost semiconductor materials, magnetics and motors, and low-cost/light-weight materials and manufacturing
- improve efficiency and decision making across the entire energy spectrum. Examples of such technologies could include autonomous sensing devices that facilitate energy use reduction in buildings, and devices for the inspection and repair of transmission infrastructure.
- improving the energy efficiency of conventional fossil fuel processes aimed at significant reductions in emissions, including greenhouse gases.
- development of transformational technologies to harness energy from other renewable sources, including but not limited to wave energy, energy of mixing at river/ocean interfaces, and low-grade heat.
- alternative high efficiency/low cost means of wind energy capture and conversion, software sensors, and sensing control optimization.

Energy Efficiency and Renewable Energy
Incubator Programs: The great majority of EERE's investments, both currently and going forward, are primarily driven by detailed short, medium, and long term RDD&D roadmaps. However, new Incubator Programs proposed by a number of EERE technology programs in the FY 2014 budget are designed to use a small fraction of these programs' annual R&D budget to regularly introduce potentially high-impact "offroadmap" emerging technology and innovations, such as those initially successfully proven at ARPA-E, into the technology program's portfolio.

Vehicles — From $320M in FY12 to 575M
A cross-cutting initiative focused on breakthroughs in plug-in electric vehicle technology.

- Increased funding for battery cost reduction through Innovative manufacturing R&D, scale-up of advanced battery component materials and next-generation "beyond lithium" research (+$70.5 million).
- Increased funding for R&D in higher performance electric drive systems using wide bandgap semiconductors for advanced power electronics (+$35.8 million).
- Increased funding to develop and demonstrate the necessary technologies for transactive communications and controls among electric vehicles, demand responsive buildings, and rooftop solar photovoltaic (PV) behind-the-meter on the distribution grid (+$20.0 million).
- Increased funding to develop integrated computational materials engineering tools for carbon fiber composites and to support advanced aluminum alloy and process development (+$12.6 million).
- Increased funding for Alternative Fuel Vehicle Community Partner Projects (+$90.0 million).
- Increased funding for Vehicle Technologies Incubator to enable the introduction of innovative new technologies into the VT portfolio (+$30.0 million).

Bioenergy Technologies — From $195M in FY12 to 282M

- Additional Feedstock Logistics R&D projects from the FY 2013 FOA, targeting commercial-scale deployment and demonstration equipment, technologies, and systems to deliver high-quality feedstocks (+$11.5 million).
- The Low-Cost Carbon Fiber FOA Initiative will fund R&D on the utilization of components of biomass for the manufacturing of low cost carbon fiber (+20.0 million).

Solar Energy — From 285M in FY12 to 356M

- Concentrating Solar Power (CSP) funding increase will enable front funding work focusing on thermal storage for solar systems to stabilize input into the grid and smooth out intermittencies; and on development of advanced component technologies' reliability (+$45.1 million).
- Systems Integration funding increase will help develop improved solar power grid integration technologies including power electronics and systems level research on renewables integration, such as a collaboration with the Buildings and Vehicles Technologies programs (with $30.0 million from Solar) to coordinate a systems approach to grid integration (+$16.4 million).
- Balance of Systems Soft Cost Reduction: This funding increase will enable work with state and local governments to reduce permitting, interconnection, inspection, and other soft

costs which now account for more than 50% of residential systems costs (+$29.2 million).

Advanced Manufacturing From $113M in FY12 to 365M

- Advanced Manufacturing R&D Facilities subprogram funding increases will support the creation of Clean Energy Manufacturing Innovation Institutes, consistent with the President's vision for a larger multi-agency National Network for Manufacturing Innovation (NNMI). These are shared research facilities where industry and research institutions come together to develop and leverage cutting-edge cross-cutting advanced manufacturing capabilities to develop high-impact commercial manufacturing innovations. (+$183.0 million).
- Next Generation R&D Projects subprogram funding increases focus on Advanced Manufacturing R&D projects in foundational cross-cutting manufacturing technologies to dramatically increase U.S. manufacturing energy productivity at the bench and prototype scale (+$60.0 million).
- The *Wide Bandgap Semiconductors for Clean Energy Initiative* led by the Advanced Manufacturing office with coordinated activities in Vehicles and the Hydrogen/Fuel Cells offices is an EERE effort focused on capturing the significant, urgent, and crosscutting opportunities in clean energy related to emerging wide bandgap (WBG) semiconductor technologies.
- The *Clean Energy Manufacturing Initiative*, anchored by the Advanced Manufacturing Office and with strong involvement and dedicated funding through several EERE Technology Offices, is focused on the urgent economic opportunity in U.S. clean energy manufacturing.

Building Technologies From $215M in FY12 to 300M

- Grid Integration Initiative funding will address the role of buildings in grid integration, focusing on the interrelated barriers associated with variable, distributed renewable energy generators; building efficiency, demand response and electric vehicle charging; and controls (+$30.0 million).
- Emerging Technologies increases will also address high-impact technologies and techniques associated with sensors and controls and with HVAC, lighting, plug and subsystem loads which typically drive energy consumption in buildings (+$35.0 million).
- Equipment and Buildings Standards increases will make a first time investment to explore the potential benefits of commercial product labeling, which can provide purchasers with information on expected product energy performance, expected energy expenditures, and other related material (+$15.0 million).

Energy Delivery and Energy Reliability

Electricity Systems Innovation Hub From 0 in FY12 to $19M

The Electricity Systems Hub will address the critical issues and barriers associated with integrating, coordinating, and facilitating the numerous changes that are happening on distribution systems with consideration of changes on the transmission system. By taking a systems-level approach and a "grid-to-edge" perspective, the Hub will focus on advancements that will enable the seamless modernization of the electric grid to drive resiliency and address climate change. It will also help accommodate changes in the generation mix (an "all of the above" portfolio, distributed generation, etc.), changing loads (electric vehicles, energy storage, LED lighting, etc.), and the increasing use of information and communication technologies (building energy management systems, demand response, sensors, phasor measurement units, etc.).

Cybersecurity for Energy Delivery Systems From $29M in FY2012 to 38
Increase expands efforts to improve cybersecurity technologies and capabilities for control systems used in critical energy infrastructure, such as a public-private partnership of energy sector stakeholders supported by National Laboratory R&D that will analyze the relative risk a disclosed cyber-vulnerability represents and recommend mitigations to reduce the risk of power disruption. It expands critical efforts to improve situational awareness and develop operational capabilities in the energy sector including developing ESC2M2 benchmarks; initiating a C2M2 pilot for the oil and natural gas sector; and expanding the Risk Management Process guideline.

Clean Energy Transmission and Reliability From $25M in FY2012 to 32
Energy Systems Predictive Capability – the increase supports analytic efforts that include reliability assessments, energy systems modeling and visualization, and energy infrastructure risk analyses including development of a modeling and analysis capability to assist in assessing the risk and reliability of energy assets. Establishes new activity line to highlight increased efforts.

Appendix 3: Illustration of DOE program manager data sheet

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Biosketch:
Dr. Pederson is the program manager for Theoretical and Computational Chemistry. From 1996 until joining DOE, he was the section head in the "Theory of Molecules, Clusters and Nanoscale Devices" section at the Naval Research Laboratory (NRL). He also spent one year at Max-Planck-Institute (1992) and one year at NSF (2002) as a program director in Theoretical and Computational Chemistry. In 1986, Dr. Pederson joined the NRL as a National Research Council (NRC)-NRL postdoctoral researcher; he was hired as a permanent employee in 1988.

Education
Ph.D., Theoretical Physics, University of Wisconsin, 1986
B.S., Physics, University of Michigan, 1981

Program: Computational and Theoretical Chemistry
http://science.energy.gov/bes/csgb/research-areas/computational-and-theoretical-chemistry/
Research in Computational and Theoretical Chemistry emphasizes integration and development of new and existing theoretical and computational approaches for the accurate and efficient description of processes relevant to the BES mission. Supported efforts are tightly integrated with the research and goals of the Condensed-Phase and Interfacial Molecular Sciences and Gas Phase Chemical Physics programs-which together comprise the Chemical Physics Research portfolio-and many have wider crosscutting relevance, advancing goals of other BES chemistry, biochemistry and geochemistry programs. …

Illustrative Papers Reflecting Personal Research Interests:
Photoelectron spectroscopic and computational studies of the Pt@Pb(10)(1-) and Pt@Pb(12)(1-/2-) anions
Grubisic Andrej; Wang Haopeng; Li Xiang; et al.
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 108(36), 14757-14762 SEP 6 2011

Density-functional-based determination of vibrational polarizabilities in molecules within the double-harmonic approximation: Derivation and application
Pederson MR; Baruah T; Allen PB; et al.
J OF CHEMICAL THEORY AND COMPUTATION 1(4), 590-596 JUL-AUG 2005

Vibrational signatures for low-energy intermediate-sized Si clusters
Pederson MR; Jackson K; Porezag DV; et al.
PHYSICAL REVIEW B 54(4), 2863-2867 JUL 15 1996

Appendix 4: Acronym Glossary (including TRLs)

ALCC	ASCR Leadership Computing challenge
ARPA-E	Advanced Research Project Agency - Energy
ASCR	Advanced Scientific Computing Research Program (in SC)
BES	Basic Energy Sciences Program, SC
BER	Biological and Environmental Research Program (in SC)
CEBAF	Continuous Electron Beam Accelerator Facility
CRA	Core Research Areas (for BES)
Defense Prog	National Nuclear Security Administration Defense Programs
DOD	Department of Defense
DOE	Department of Energy
EDER	Office of Energy Delivery and Energy Reliability
EERE	Office of Energy Efficiency and Renewable Energy
EFRC	Energy Frontier Research Center
ELSI	Ethical, legal, social implications
Envir Mgmt	Office of Environmental Management
EPAct	Energy Policy Act
ESC2M2	Electricity Subsector Cybersecurity Capability Maturity Model
EV	Electric Vehicle
FE	Office of Fusion Energy
FES	Fusion Energy Science Program (in SC)
FOA	Funding Opportunity Announcement
Fossil	Office of Fossil Energy
HEDLP	High Energy Density Laboratory Plasma
HEP	High Energy Physics Program (in SC)
HVAC	Heating, Ventilation and Air Conditioning
INCITE	Innovative and Novel Computational Impact on Theory and Experiment
LCF	Leadership Computing Facility
LED	Light Emitting Diode
LHC	Large Hadron Collider
LWR	Light Water Reactor
MDF	Manufacturing Demonstration Facility
MRI	Major Research Instrumentation
NE	Office of Nuclear Energy
NERSC	National Energy Research Scientific Computing Center
NEUP	Nuclear Energy University Program
NP	Nuclear Physics Program (in SC)
NSAC	Nuclear Science Advisory Committee
NSF	National Science Foundation
ONRL	Oak Ridge National Laboratory
OoS	Office of Science
PBR	President's Budget Request
R&D	Research and Development
RD&D	Research, Development and Demonstration
RDD&D	Research, Development, Demonstration and Deployment
SC	Office of Science
SciDAK	Science Discovery through Advanced Computing (in ASCR)
SISG	Single Investigator - Small Group

STEM Science, Technology, Engineering and Mathematics

Technology Readiness Levels and Manufacturing Readiness Levels
(from the DARPA Transition Guide 2010)

Technology Readiness Level	Description
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and 'flight qualified' through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system 'flight proven' through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

Hardware (HW) and Software (SW)

Technology Readiness Level	Description
1. Basic principles observed and reported	**HW/S:** Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties. **SW:** Lowest level of software readiness. Basic research begins to be translated into applied research and development. Examples might include a concept that can be implemented in software or analytic studies of an algorithm's basic properties.
2. Technology concept and/or application formulated	**HW/S/SW:** Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no

	proof or de-tailed analysis to support the assumptions. Examples are limited to analytic studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	**HW/S:** Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative. **SW:** Active research and development is initiated. This includes analytical studies to produce code that validates analytical predictions of separate software elements of the technology. Examples include software components that are not yet integrated or representative but satisfy an operational need. Algorithms run on a surrogate processor in a laboratory environment.
4. Component and/or bread-board validation in laboratory environment	**HW/S:** Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of ad hoc hardware in the laboratory. **SW:** Basic software components are integrated to establish that they will work together. They are relatively primitive with regard to efficiency and reliability com-pared to the eventual system. System software architecture development initiated to include interoperability, reliability, maintainability, extensibility, scalability, and security issues. Software integrated with simulated cur-rent/legacy elements as appropriate.
5. Component and/or bread-board validation in relevant environment	**HW/S:** Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components. **SW:** Reliability of software ensemble increases significantly. The basic software components are integrated with reasonably realistic supporting elements so that it can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of software components. System software architecture established. Algorithms run on a processor(s) with characteristics expected in the operational environment. Software releases are "Alpha" versions and configuration control is initiated. Verification, Validation, and Accreditation (VV&A) initiated.
6. System/subsystem model or prototype demonstration in a relevant environment	**HW/S:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment. **SW:** Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in software-demonstrated readiness. Examples include testing a prototype in a live/virtual experiment or in a simulated operational environment. Algorithms run on processor of the operational environment are integrated with actual external entities. Software releases are "Beta" versions and configuration controlled. Software support structure is in development. VV&A is in process.
7. System prototype demonstration in an operational environment	**HW/S:** Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft. **SW:** Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in a command post or air/ground vehicle. Algorithms run on processor of the operational environment are integrated with actual external entities. Software support structure is in place. Soft-ware releases are in distinct versions. Frequency and se-verity of software deficiency reports do not significantly degrade functionality or performance. VV&A completed.
8. Actual system completed and qualified through test and demonstration	**HW/S:** Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of

	the system in its intended weapon system to determine if it meets design specifications. **SW:** Software has been demonstrated to work in its final form and under expected conditions. In most cases, this TRL represents the end of system development. Examples include test and evaluation of the software in its in-tended system to determine if it meets design specifications. Software releases are production versions and configuration controlled, in a secure environment. Soft-ware deficiencies are rapidly resolved through support infrastructure.
9. Actual system proven through successful mission operations	**HW/S:** Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions. **SW:** Actual application of the software in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of the system development. Examples include using the system under operational mission conditions. Software releases are production versions and configuration controlled. Frequency and severity of software deficiencies are at a minimum.