



Quadrennial Technology Review 2015

**Chapter 9:** Enabling Capabilities for Science and Energy

---

# Supplemental Information



***A Comparison of Research Center  
Funding Modalities***

*High-Performance Computing Capabilities and  
Allocations*



*User Facility Statistics*

*Examples and Case Studies*



U.S. DEPARTMENT OF  
**ENERGY**



# A Comparison of Research Center Funding Modalities

## Chapter 9: Enabling Capabilities for Science and Energy

### A Comparison of Multi-disciplinary, Multi-scale Research Center Funding Modalities

Three Department of Energy (DOE) research center modalities—the Energy Frontier Research Centers (EFRC), the Energy Innovation Hubs (Hubs), and the Bioenergy Research Centers (BRC)—examined here foster cross-disciplinary collaborations that enable the energy science research that forms the foundation for the energy technologies of the future. The research problems tackled by these centers are exceedingly challenging to overcome at the single investigator level, but each leverages decades of investment in single principal investigator and small team science made by the DOE and other Federal agencies. Each type of center creates partnerships among researchers from universities, DOE national laboratories, nonprofits, and for-profit firms, facilitating knowledge sharing between disciplines and institutions to accelerate discovery.

The unique characteristics of each type of center are designed to support their specific research scopes, which are described in more detail in the QTR, Chapter 9, *Enabling Capabilities for Science and Energy*. The EFRCs are addressing high-risk, high-reward challenges in basic energy science.<sup>1</sup> The much larger Hubs are taking a vertically integrated approach to developing a potentially transformative energy technology, strongly linking basic scientific discovery with applied research and technology development.<sup>2</sup> The BRCs are developing the scientific basis for commercially viable cellulosic biofuel production.<sup>3</sup>

The success of these endeavors is supported, in part, by the more than 125 institutions engaged by the centers,<sup>4,5</sup> the thousands of discoveries described in the peer reviewed literature,<sup>6,7,8</sup> and the new technologies that have been developed and/or disseminated, as shown through hundreds of patent applications, IP disclosures, and technology licenses.<sup>9,10,11</sup> In the case of the EFRCs, their scientific achievements have contributed significantly to the progress made to date on the original five Grand Challenges for Basic Energy Science, leading to a new set of five Transformative Opportunities for discovery science described in the recently released report “Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science”.<sup>12</sup>

Each of the EFRCs, Hubs, and BRCs has been selected as a result of an open, competitive proposal process using rigorous scientific peer review. 46 EFRCs were funded as a result of the original 2009 solicitation. The second solicitation, in 2014, was an open re-competition, with 32 EFRCs being funded. The 2014 awards included 22 renewals and 10 new centers.<sup>13</sup> The renewal announcements for two of the four Hubs (the Joint Center for Artificial Photosynthesis (JCAP) and the Consortium for Advanced Simulation of Light Water Reactors (CASL) in 2015) and the three BRCs (in 2012) were publically disclosed but were not open to new proposal submissions. Each renewal was predicated on two primary factors: the success of the center during the



first award period as determined, in part, by the annual peer reviews,<sup>14</sup> and by the outcome of an external peer review of a renewal proposal submitted by the center. The two other Hubs (the Joint Center for Energy Storage Research (JCESR) and the Critical Materials Institute (CMI)) are still in their first project period and have not yet been subjected to a renewal process.

Table 1 compares the three types of centers across four facets: center investigators and their institutions; the period of the award and its management; the typical annual award amount; and the core motivation and research focus of the center.

**Table 1** A comparison of three Department of Energy multi-disciplinary collaborative research center funding modalities.

	Investigators and Their Institutions	Period of Award and Management	Typical Annual Award Amount	Core Motivation and Research Focus
Energy Frontier Research Centers	<p>Self-assembled groups of about 12 to 25 senior investigators.<sup>15</sup></p> <p>Led by universities, DOE laboratories, and nonprofits, often with teaming across institutions, including industry.</p>	<p>Four years with possibility of renewal based on an open competition.</p> <p>Managed by the Office of Basic Energy Sciences.</p>	\$2M to \$4M per year for 4 years	Fundamental research requiring multiple investigators from several disciplines, with a balance of discovery and use-inspired science in areas identified through a series of community-based workshops. <sup>16</sup>
Energy Innovation Hubs	<p>Large, multi-disciplinary groups of 30-65 senior investigators spanning basic and applied R&amp;D.<sup>17</sup></p> <p>Led by DOE laboratories and universities, with extensive teaming across universities, laboratories, industry, and non-profits.</p>	<p>Five years with a possible 5-year renewal. JCAP and CASL were renewed in 2014 following submission and peer review of a renewal proposal. JCESR and CMI are still in their initial award period.</p> <p>Managed by a single DOE office but with broad coordination across DOE.</p>	<p>About \$22M in year one (with up to \$10M for infrastructure but no new construction).</p> <p>Up to \$25M per year in year two to five.<sup>18</sup></p>	<p>Purpose-driven research, integrating across basic and applied research toward commercialization.</p> <p>Generally, DOE determines the topical areas addressed by the Hubs, and funding opportunity announcements are specific.</p>
Bioenergy Research Centers	<p>Large, multi-disciplinary groups of 40-65 senior investigators with efforts spanning lab scale to field tests.<sup>19</sup></p> <p>Led by universities or DOE laboratories with extensive teaming across universities, laboratories, and industry.</p>	<p>Five years with possible 5-year noncompetitive renewal based on submission and peer review of a renewal proposal. All three BRCs were renewed for a second 5-year period in 2012. Activity in the BRC program after FY2017 will be through an open competition.</p> <p>Managed by the Office of Biological and Environmental Research.</p>	\$25M per year for five years.	<p>Accelerate breakthroughs in the basic science needed to develop cost effective, sustainable technologies that will enable commercially viable production of cellulosic biofuels on a national scale.</p> <p>Strong commitment to transferring knowledge to the private sector community and translating fundamental research advances to the marketplace through IP licensing, partnerships, and collaborative affiliations.</p>



## Endnotes

- <sup>1</sup> Technical summaries for all 32 EFRCs are available in the document “Energy Frontier Research Centers: Technical Summaries” (updated August 2015) ([http://science.energy.gov/~media/bes/efrc/pdf/technical-summaries/ALL\\_EFRC\\_technical\\_summaries.pdf](http://science.energy.gov/~media/bes/efrc/pdf/technical-summaries/ALL_EFRC_technical_summaries.pdf)).
- <sup>2</sup> A short description of the research scope for each Hub is given in Enabling Capabilities for Science and Energy. Links to more detailed information are provided in the chapter endnotes.
- <sup>3</sup> The scientific basis for the BRCs was established by a 2005 workshop, “Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda.” More on the workshop and the full report is available at <http://genomicscience.energy.gov/biofuels/b2bworkshop.shtml>.
- <sup>4</sup> For example, the 32 EFRCs, representing 33 states and the District of Columbia, engage 530 senior investigators, more than 1250 students, postdoctoral fellows, and technical staff, and more than 100 institutions, including universities, DOE national laboratories, nonprofits, and private sector companies. Full lists of partner organizations for each center can be found on their respective websites and in the document “Energy Frontier Research Centers: Technical Summaries ([http://science.energy.gov/~media/bes/efrc/pdf/technical-summaries/ALL\\_EFRC\\_technical\\_summaries.pdf](http://science.energy.gov/~media/bes/efrc/pdf/technical-summaries/ALL_EFRC_technical_summaries.pdf)).
- <sup>5</sup> The Hubs and BRCs have extensive partner relationships with public and private institutions, each having a unique mix of universities, DOE national laboratories, and private sector firms (both for and not for profit). The number of Hub partner organizations varies from 5 to 19. The number of BRC partner institutions range from 8 to 18. Alternative modes of engagement below the partner level are also available. Lists of partner institutions are available at the respective websites for each center.
- <sup>6</sup> A list of all publications produced by the EFRCs (current as of June 30, 2015) is available at <http://science.energy.gov/bes/efrc/publications/>. Recent research results from the EFRCs are described in the Frontiers in Energy Research newsletter, published on an approximately quarterly basis (<http://www.energyfrontier.us/newsletter>).
- <sup>7</sup> The current lists of publications from the DOE-SC sponsored Hubs JCAP and JCESR are available at <http://solarfuelshub.org/research/publications.html> and <http://www.jcesr.org/presentations/published-papers/>, respectively. An overview of the JCESR accomplishments from their first year of operation was published in AIP Conference Proceedings in 2015 and can be downloaded at <http://scitation.aip.org/content/aip/proceeding/aipcp/10.1063/1.4916174>. Published materials, including conference papers and peer reviewed publications, for CASL is provided at <http://www.casl.gov/publications.shtml#faq-1>.
- <sup>8</sup> From 2008 through 2013, the three BRCs published nearly 1,350 papers in peer-reviewed journals. Key advances in biofuels production based on research conducted at the BRCs over their first 6 years of operation (through 2013) are described (with references) for each of the three Grand Challenges (see section 9.2.3, QTR, Chapter 9, *Enabling Capabilities for Science and Energy* and the BRC homepage), as well as cross-cutting achievements in enabling technology and sustainability and economic analysis, at <http://genomicscience.energy.gov/centers/keyadvances.shtml>.
- <sup>9</sup> From 2009 to 2015, the EFRCs disclosed more than 125 inventions and filed 545 patent applications, of which over 80 were licensed/optioned.
- <sup>10</sup> From 2008 to 2013, the three BRCs disclosed 325 inventions and filed 176 patent applications, of which 72 were licensed/optioned. Selected examples of technology transfer to the private sector are included in Bioenergy Research Centers, U.S. DOE, Office of Science, Office of Biological and Environmental Research, February 2014 (<http://genomicscience.energy.gov/centers/BRCs2014HR.pdf>).
- <sup>11</sup> Since 2010, JCAP has made 40 IP disclosures. Since its inception in 2013, the CMI has disclosed 39 inventions, with 9 leading to patent applications and one currently licensed. The full list is available at <https://cmi.ameslab.gov/research/cmi-invention-disclosures>.
- <sup>12</sup> The full text of the report, released October 2015, is available at [http://science.energy.gov/~media/bes/besac/pdf/Reports/CFME\\_rpt\\_print.pdf](http://science.energy.gov/~media/bes/besac/pdf/Reports/CFME_rpt_print.pdf).
- <sup>13</sup> 24 EFRCs funded in the 2009 solicitation were not renewed following the 2014 solicitation. Information about the 24 non-renewing EFRCs, including the lead institution, director, and center name, as well as links to DOE-SC-hosted pages about the scope of the centers and their partner institutions, is available on the “History” page of the EFRC section of the DOE-SC website (<http://science.energy.gov/bes/efrc/history/>).
- <sup>14</sup> Each Hub undergoes annual review to evaluate progress and performance that includes an independent peer review.
- <sup>15</sup> The definition of a senior investigator is determined by the center, but is typically a university faculty member, DOE national laboratory staff scientist, or the equivalent at another type of partner institution, that currently has a leadership role in the center.
- <sup>16</sup> The five Basic Energy Sciences grand challenges that form the foundation for the scientific problems addressed by the EFRCs are presented in “Directing Matter and Energy” available at: [http://science.energy.gov/~media/bes/pdf/reports/files/gc\\_rpt.pdf](http://science.energy.gov/~media/bes/pdf/reports/files/gc_rpt.pdf). The grand challenges addressed by current and former EFRCs are provided at <http://science.energy.gov/bes/efrc/research/grand-challenges/> and <http://www.science.energy.gov/bes/efrc/history/grand-challenges>. Each EFRC must also address priority research directions identified in one or more Basic Research Needs (BRN) workshop series. The full list of BRN reports is included in QTR, Chapter 1, *Energy Challenges*, supplemental information, “Representative DOE Energy Program Workshops” and can be found at <http://science.energy.gov/bes/community-resources/reports/>. The basic research needs addressed by current and former EFRCs are provided at <http://science.energy.gov/bes/efrc/research/bes-reports/> and <http://science.energy.gov/bes/efrc/history/bes-reports/>.
- <sup>17</sup> JCAP currently designates 33 senior investigators as of September 2015, with an additional 26 scientific staff. JCESR currently has 61 senior investigators, with a total staff of 88. CMI currently has 50 senior investigators, with an additional 38 senior scientists. CASL has approximately 75 to 100 FTE working for the Hub at any time, which includes students, postdoctoral researchers, and senior investigators. Some of these personnel participate on a part-time basis. All numbers provided are accurate as of publication of this report.



<sup>18</sup> Following external merit review of the renewal proposal, JCAP was awarded \$15 million annually for up to 5 years in 2015 (subject to appropriations). CASL was awarded up to \$121.5 million over five years when it was renewed in 2015 (pending congressional approval).

<sup>19</sup> The range of senior investigators at the three BRCs reflects, in part, differences in the institutional participants and their indirect cost rates (i.e. university versus DOE national laboratory). The Great Lakes Bioenergy Research Center, hosted at the University of Wisconsin-Madison, currently has 64 senior investigators. The Bioenergy Science Center (BESC), hosted at Oak Ridge National Laboratory, currently has 55 senior investigators. The Joint Bioenergy Institute (JBEI), hosted at Lawrence Berkeley National Laboratory, currently has 40 senior investigators. Despite both Centers being located at DOE national laboratories, BESC includes more university faculty participation than JBEI, which is reflected in the higher number of senior investigators at BESC despite equivalent levels of funding support.