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Basic Energy Sciences Advisory Committee
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2 December 2020

Dear Marc,

On behalf of the Committee of Visitors charged by the Basic Energy Sciences Advisory Committee to provide an assessment of the processes used by BES to solicit, review, recommend, and document proposal actions and monitor active projects and programs related to the Energy Frontier Research Centers (EFRC) and Energy Innovation Hubs (Hubs) programs, I submit our report.

Should there be any questions about the report, please do not hesitate to contact me.

Yours sincerely,

Ian M. Robertson
Committee of Visitors, Chair.

Committee of Visitors Review Report 2017-2020
Energy Frontier Research Centers and Energy Innovation Hubs
Basic Energy Sciences
U. S. Department of Energy
to the
Basic Energy Sciences Advisory Committee

Chair: Ian Robertson
Co-chair: Polly Arnold OBE FRS
Co-chair: Hans Christen
Co-chair: Gary Rubloff

October 13-16, 2020

1	Executive Summary.....	5
2	Introduction	7
3	Charge to the Committee of Visitors	8
4	The Committee Membership.....	8
5	The Review Process.....	9
6	Major Findings of the COV.....	10
7	Major Recommendations of the COV.....	12
8	EFRC Panel Report	13
8.1	DOE-BES Response to The Recommendations of the 2016 COV.....	13
8.2	Efficacy and Quality of Processes Used for EFRC Selection.....	13
8.2.1	Findings.....	13
8.2.2	Comments	14
8.2.3	Recommendations.....	15
8.3	Pre-Proposal Process Established In 2018 As A Result of the 2016 COV.....	15
8.3.1	Findings.....	15
8.3.2	Recommendations.....	15
8.4	Reviewers.....	16
8.4.1	Findings.....	16
8.4.2	Comments	16
8.4.3	Recommendations.....	16
8.5	Efficiency/Time to Decision	16
8.5.1	Findings.....	16
8.6	Completeness of Documentation for Making Recommendations.....	17
8.6.1	Findings.....	17
8.6.2	Comments	17
8.6.3	Recommendation	18
8.7	Scientific and Institutional Diversity.....	18
8.7.1	Findings.....	18
8.7.2	Comments	18
8.7.3	Recommendation	18
8.8	Efficacy and Quality of Processes used for Center Management Oversight: Management Processes	19
8.8.1	Findings.....	19
8.8.2	Recommendation	19

8.9	Management Reviews Including Guidance Provided, Documentation Received, Reviewer Qualifications, BES Feedback, EFRC Response to Feedback	19
8.9.1	Findings.....	19
8.9.2	Comments	20
8.9.3	Recommendations.....	20
8.10	Mid-Term Reviews Including Guidance Provided, Documentation Received, Reviewer Qualifications, BES Feedback, EFRC Response to Feedback.....	20
8.10.1	Findings.....	20
8.10.2	Comments	20
8.10.3	Recommendations.....	21
8.11	Principal Investigator Meeting.....	21
8.11.1	Findings.....	21
8.11.2	Comments	21
8.11.3	Recommendations.....	21
8.12	Web Resources.....	21
8.12.1	Findings.....	21
8.12.2	Comments	22
8.13	Effective Interactions Between BES Program Managers and EFRCs	22
8.13.1	Findings.....	22
8.14	Advisory Boards and Management Structure	22
8.14.1	Findings.....	22
8.14.2	Comments	22
8.14.3	Recommendations.....	22
8.15	Monthly Directors’ Meeting.....	22
8.15.1	Findings.....	22
8.15.2	Comments	23
8.16	Impact and Standing of the EFRCs	23
8.16.1	Breadth and depth of EFRC awards.....	23
8.16.2	Findings.....	23
8.16.3	Comments	23
8.16.4	National and international standing of the EFRCs	23
8.16.5	Findings.....	23
8.16.6	Comments	24
8.16.7	Recommendations.....	24

9	HUBS Panel Report.....	25
9.1	DOE-BES Response to the Recommendations of the 2016 COV	25
9.2	Efficacy and Quality of Processes used for the HUB Awards Selection and BES Management Oversight	25
9.2.1	Findings.....	25
9.2.2	Comments	27
9.2.3	Recommendation	28
9.3	Oversight and Management of HUBs	28
9.3.1	Findings.....	28
9.3.2	Comments	29
9.3.3	Recommendations.....	30
9.4	Impact and Standing.....	30
9.4.1	Findings.....	30
9.4.2	Comments	31
	Appendix I. Charge to the Committee of Visitors	32
	Appendix II. Members of The COV and Their Affiliation.....	34
	Appendix III. Agenda for the Virtual Meeting	35
	Appendix IV. Checklists for the Panels	38
	Checklist for EFRC	38
	Checklist for Solar Fuels Panel	40
	Checklist for JCESR.....	42

1 Executive Summary

A Committee of Visitors (COV), under the auspices of the Basic Energy Sciences Advisory Committee (BESAC), reviewed the solicitation, procurement and management processes of the Energy Frontier Research Centers (EFRCs) and the Energy Innovation Hubs (HUBs) that are supported and managed by the Basic Energy Sciences (BES) Program within the Department of Energy (DOE) Office of Science for the fiscal years 2017 through 2020. The COV was chaired by Prof. Ian Robertson. In addition to the chair, there were sixteen other members of the COV. The review was conducted virtually on October 13-16, 2020. To facilitate the review, the COV members were divided into two groups, one tasked with reviewing the EFRCs (10 members) and the other the HUBs (6 members).

The COV was charged by Dr. Marc Kastner, chair of BESAC. The charge was: i) For both EFRCs and HUBs, to assess the efficacy and quality of the processes used to solicit, review, recommend, and document proposal actions and monitor active projects and programs. ii) Within the boundaries defined by DOE missions and available funding, to comment on how the award process has affected the breadth and depth of portfolio elements, and the national and international standing of the portfolio elements.

The COV commends the DOE-BES staff and program managers for their dedication, professionalism, and skill. The level of detail documented about each step of the process is exemplary and demonstrates the careful consideration that goes into the selection of awards. The management and oversight of the EFRCs and the HUBs is exceptional and are contributing factors to their success. The COV found that outstanding science is being funded and that the science and individuals are of both national and international caliber.

The DOE-BES staff, program managers, and management are thanked for their help before and during this virtual COV, and for the flawless organization. The entire COV process was conducted in an efficient and productive manner. Everyone involved responded in a timely manner to the questions and requests for information during the COV process.

The COV recommends that DOE-BES:

- Document the processes leading to a reduction in the scope of work when the requested budget is reduced. Such documentation will provide an archival record of the process, which will provide continuity should a change in program manager occur and will enable future COVs to assess the entire award process.
- Continue to communicate about future funding directions and opportunities, proposal submission, etc., extensively with the community at large and to use the communication strategies learned from the COVID19 pandemic to further broaden their reach and impact.
- Streamline - where and when they can - the management and oversight reporting requirements for EFRCs and HUBs. In this regard, the reports should be informative rather than cumulative, duplication of reported material should be minimized, and strict, specified page limits should be introduced. It is recognized that the project scopes vary between EFRCs and HUBs and even across HUBs, and the management and oversight requirements should be balanced to reflect the funding level and scope of the project.

- Continue to have a diverse and balanced representation of reviewers from academia, industry, Federal Funding Agencies, and Federal Laboratories. In addition, the number of reviewers selected should correlate with the scope and complexity of the project and the level of funding. The use of virtual panel reviews presents an opportunity to enhance the overall diversity of the panel.
- Should have the flexibility to determine the best practices for conducting panel reviews both for in-person and virtual panels.
- Continue to ensure the EFRCs and HUBs, and all other DOE-BES activities, are inclusive in the broadest sense, welcoming manifestations of diversity including scientific expertise (discipline, research expertise, career stage), institutional (academia, industry, government laboratories), and people (gender, race, ethnicity, etc.).

Finally, the COV recommends that BESAC:

- Consider the aim, purpose and usefulness of charge 2(b): “*Within the boundaries defined by DOE missions and available funding, comment on how the award process has affected the national and international standing of the portfolio elements.*” This COV, similarly to previous COVs, recognizes that this is a complicated and demanding analysis if done comprehensively, and not one that can realistically be addressed with the time and resources allotted to a COV.

In the remainder of the document, the charge to the committee, the membership of the committee, the process of the review, the major findings and recommendations, are summarized. Finally, the reports of the panels for the EFRC and HUBs are presented.

2 Introduction

A Committee of Visitors (COV), under the auspices of the Basic Energy Sciences Advisory Committee (BESAC), reviewed the solicitation, procurement and management processes of the Energy Frontier Research Centers (EFRCs) and the Energy Innovation HUBs (HUBs) that are supported and managed by the Basic Energy Sciences (BES) Program within the Department of Energy (DOE) Office of Science for the fiscal years 2017 through 2020. The COV was chaired by Prof. Ian Robertson. The seventeen members of the COV conducted the review virtually on October 13-16, 2020. This was the third review of the EFRCs and the HUBs; with the others being held in 2016 and 2013. The EFRC review focused on the FY18 and 20 re-competitions, and the oversight and management of existing EFRCs. The HUBs review focused on the required ending of the Joint Center for Artificial Photosynthesis (JCAP), the renewal in 2018 of the Joint Center for Energy Storage Research (JCESR) and its continued activities, and the FY20 re-competition in the Fuels from Sunlight HUB Program.

The FY18 Funding Opportunity Announcement (FOA) (FOA number DE-FOA-0001810), DOE-BES announced a re-competition of EFRCs, encouraging both new and renewal proposals. The total level of funding was anticipated to be \$98M annually. Proposals were required to address priority research directions identified by the series of “Basic Research Needs” (BRN) reports, the scientific grand challenges identified in the report *Directing Matter and Energy: Five Grand Challenges for Science and the Imagination*, and the opportunities described in the report *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science*. The resulting themes funded included catalysis science, electrical energy storage systems, materials chemistry by design, nuclear energy, quantum materials, separation science, solar energy utilization, subsurface fractures and flow and synthesis science. This competition introduced a pre-proposal step as recommended by the 2016 COV. These pre-proposals were reviewed internally and the decision made to encourage/discourage submission of a proposal. This process reduced the number of full proposals received significantly.

The FY20 FOA (number DE-FOA-0002204) for the EFRC re-competition required proposals to address priority research directions identified by the series of BRN and Roundtable reports, the scientific grand challenges identified in the report *Directing Matter and Energy: Five Grand Challenges for Science and the Imagination*, and the opportunities described in the report *Challenges at the Frontiers of Matter and Energy: Transformative Opportunities for Discovery Science*. The total level of funding was anticipated to be \$25M annually. The four topical areas for this FOA were: 1) Environmental Management (new and renewal proposals); 2) Quantum Information Science (new proposals only); 3) Microelectronics (new proposals only); and 4) Polymer Upcycling (new proposals only). Pre-proposal submissions were again required and as in the FY18 FOA this resulted in fewer full proposals being submitted.

The FY20 FOA Fuels from Sunlight HUB (DE-FOA-0002254) solicited new proposals for multi-investigator cross-disciplinary fundamental research to address emerging new directions as well as long-standing challenges in liquid solar fuels generation via artificial photosynthesis approaches. The proposals had to address at least two of the priority research opportunities identified in the *Liquid Solar Fuels* Roundtable report and had to build upon scientific advances and capabilities developed by the field, including efforts funded by DOE-BES through core

programs, EFRCs, and JCAP. The outcome was the awarding of two HUBs, the Liquid Sunlight Alliance (LiSA), led by California Institute of Technology, and the Center for Hybrid Approaches in Solar Energy to Liquid Fuels (CHASE), led by the University of North Carolina at Chapel Hill. The total funding for the two HUBs over five years, pending appropriations, is \$100M.

JCESR was launched in December 2012 and in FY18 following appropriations language, DOE-BES requested a renewal proposal from JCESR. This renewal emphasized the science questions identified in the BRN on *Next Generation Electrical Energy Storage* as well as those identified by JCESR at the end of the first five years. Following review, DOE announced the renewal of JCESR at \$24 million annually, pending appropriations, for a total of \$120 million over the five years.

3 Charge to the Committee of Visitors

The charge to the COV was established in a letter from the Chair of BESAC, Dr. Marc Kastner, to Prof. Ian Robertson, who had agreed to chair the COV. The letter is attached as Appendix I. The charge was to provide an assessment of the processes used to solicit, review, recommend, and document proposal actions and to monitor active projects and programs from FY17 through FY20. In addition, the panel was asked to review both procurement and management activities for the EFRC program and the BES-supported HUBs for Fuels from Sunlight and for Batteries and Energy Storage.

The COV was asked to focus on the following major elements:

1. For both EFRCs and HUBs, assess the efficacy and quality of the processes used to:
 - a) solicit, review, recommend, and document proposal actions; and
 - b) monitor active projects and programs.
2. Within the boundaries defined by DOE missions and available funding, comment on how the award process has affected:
 - a) the breadth and depth of portfolio elements; and
 - b) the national and international standing of the portfolio elements.

4 The Committee Membership

The co-chairs of the COV were selected by Prof. Ian Robertson in consultation with the chair of BESAC and the DOE-BES leadership. The co-chairs were Prof. Polly Arnold OBE FRS, UC-Berkeley and Lawrence Berkeley Laboratory; Dr. Hans Christen, Oak Ridge National Laboratory; and Prof. Gary Rubloff, University of Maryland. The other members of the COV were selected by the chair and co-chairs in consultation with the chair of BESAC and the DOE-BES Leadership. The members of the COV and their affiliation are provided in Appendix II. The thirteen members were chosen to represent a cross-section of experts in scientific fields relevant to the EFRCs and HUBs. The members of the committee were from academia (12), Federal laboratories (2), Federal Agencies (2), and industry (1), with two of the academic members having previous industry experience. Of the COV members three had recently served on a COV for DOE BES. Three of the committee members are current members of BESAC and three had served on BESAC previously.

Given the scope of materials to be reviewed, the COV members were divided into two panels, with the co-chairs serving as leads: Prof. Polly Arnold and Dr. Hans Christen led the EFRC panel and Prof. Gary Rubloff the HUB panel.

The membership of the panels is given in Table 1.

Table 1. Distribution of COV members between EFRCs and HUBS.

EFRC	HUBS
Polly Arnold	Gary Rubloff
Hans Christen	Carol Bessel
Jim Coleman	Phil Britt
Patricia Dove	Shirley Meng
Greg Girolami	Abbas Ourmazd
Mike McKittrick	Chris Palmstrom
Nag Patibandla	
Yue Qi	
Frances Ross	
Theresa Windus	

5 The Review Process

The COV was originally scheduled to take place October 14–16, 2020 at the Rockville Hilton Hotel, but due to the COVID19 pandemic the meeting was held virtually between October 13-16. The additional day was added to the schedule and the length of each day was optimized to accommodate COV members who live on the west coast. The agenda for the COV is provided in Appendix III; after the first day, the agenda was modified to provide sufficient time to complete each section of the review and for meetings of the COV to discuss progress.

Prior to October 14, each COV member was supplied with a link to access the COV documents in PAMS that included a comprehensive set of information. For the EFRC program, this included general information about the EFRC; FOA FY18, pre-proposals, reviews and outcomes, proposal reviews and outcomes, annual reports, management reviews FY17 and FY19, midterm reviews FY18 and FY20; FOA FY20, pre-proposal process, proposals and outcomes. For the JCESR HUB this documentation included management documents, quarterly reports, annual reports, final report of the original program; renewal process, reviews and outcome that renewed JCESR, management documents, quarterly reports and annual reports. For the Solar Fuels HUB, the documents provided included JCAP management documents, quarterly reports FY17-20; annual reports FY17-20; annual review FY18-20; and FY20 Fuels from Sunlight re-competition, review and award process. In addition to these documents, DOE-BES management made their overview presentations available to the panel members and asked for them to be reviewed prior to the start of the COV. COV members were encouraged to submit questions to DOE-BES about the presentations and the COV process in general. This process reduced the amount of time needed for the overview presentations at the start of the COV.

To familiarize the COV panel members with the use of Zoom for holding such a meeting, navigating PAMS and the ORISE SharePoint site, DOE-BES and ORISE staff held two learning sessions. These were extremely valuable in helping the COV start and run smoothly.

The first day started with the COV formally being charged by the BESAC chair, Dr. Marc Kastner. Dr. Linda Horton, the Director of DOE-BES, followed with a brief overview of BES, and then Drs. Andrew Schwartz, John Vetrano and Gail McLean presented overviews of EFRC, JCESR and Solar Fuels, respectively. The panel members were then presented with some details of the overall COV review process by the COV Chair, Prof. Ian Robertson, before adjourning to their panel breakout rooms. Following a review of the PAMS systems, the COV members used the remainder of the day to review the documents.

For much of the second and third days, the panel members continued reviewing documents and preparing their comments and drafting their preliminary findings to address the points listed in the panel checklist documents; these checklists are provided in Appendix IV. The COV met in executive session at the end of the third day for an initial discussion of the major findings and recommendations from the EFRC and HUB panels. The morning of the last day, the panels finalized the findings and prepared materials for the final report. The entire COV then met in executive session to discuss and reach consensus on the major findings and recommendations. Finally, the entire COV met with DOE-BES management and staff to provide a preliminary debrief of the major findings and recommendations.

The written reports from the panels are provided as sections 8 and 9 for the EFRCs and HUBs, respectively. The conclusions and recommendations drawn from these reports and the executive session discussions provided the basis for this report.

6 Major Findings of the COV

With respect to the charge to the COV, the committee responds as follows:

- Concerning the efficacy and quality of the processes used to solicit, review, recommend, and document proposal actions, the committee finds that the EFRCs and HUBs follow best practices and that overall the processes are exemplary.
- Concerning the efficacy and quality of the processes used to monitor active projects and programs, the committee finds that the overall level of active management and engagement is appropriate and are contributing factors to the overall success of the EFRC and HUB programs.
- Concerning how the award process has affected the breadth and depth of portfolio elements, the committee finds that the scope of efforts within the EFRCs and HUBs are appropriate, and are driven by the community through their contribution and input to the BRN reports, workshops, roundtables etc.

- Concerning how the award process has affected the national and international standing of the portfolio elements, the committee found this to be a challenge to assess because of the lack of readily available comparative benchmarking data. It is recognized that such comparative data are difficult to collect. The committee was made aware that BESAC is looking into international benchmarking of other areas of the DOE-BES portfolio and hope their report will provide guidance for future COVs. In any case, it was noted that the EFRCs and HUBs have members with outstanding national and international reputations, and are publishing in appropriate journals, generating intellectual property, and generating spin-off companies in some cases. In this regard, the EFRCs and HUBs are highly regarded nationally and internationally, which brings distinction to DOE-BES.

The COV highlights the following findings:

- a. For both EFRCs and HUBs, the process employed by DOE-BES in the review, management and oversight of the programs is exemplary. The processes leading up to the negotiation of the budgets to be awarded are transparent and well documented, allowing for the decision-making process to be followed and assessed. These processes were also deemed excellent. Documentation could be clearer regarding the negotiation of the change in scope of work due to a reduction in the requested budget. Similarly, the use of advisory boards by EFRCs and HUBs could be better documented in the reports to DOE-BES. The improvement needed is considered relatively minor overall, but it will aid program management continuity at DOE-BES and permit future COVs to assess the entire life-cycle from the solicitation to award.
- b. DOE-BES is commended for its significant and concerted efforts to disseminate information about topics of priority that could be represented in future funding opportunities. Such early guidance to the community is important given the short time windows that often occur between the release of BRN, Roundtable, workshop reports, and related FOAs, as well as between the release of some FOAs and the pre-proposal deadline, leaving too little time to build multi-disciplinary and multi-institutional teams to develop and submit pre-proposals and proposals.
- c. The reporting requirements for the EFRCs and HUBs, and, hence, the review and management effort on the DOE-BES side, could be made more effective and efficient by, where possible, streamlining the requirements and utilizing available or new tools for collection of standard data. For example, rather than being cumulative, management reports should be more informative, emphasizing the management changes made between reporting periods and the rationale for making them.
- d. For the JCESR renewal, there were concerns that, given the scope and funding levels, that too few reviewers were used, with insufficient balance of reviewers between national and international reviewers, and between academia, Federal Laboratories, Federal Funding Agencies, and industry reviewers. The COV recognizes this was a renewal proposal as opposed to a re-competition, which is an important distinction. The re-competition of the Fuels from Sunlight HUBs used more reviewers. The challenge of identifying experts who do not have a conflict of interest to serve on reviews of large-scale multi-institutional

proposals is recognized. The COV noted that Fuels for Sunlight re-competition renewal review was held with an anonymous virtual panel - a different format from past panel reviews.

- e. DOE-BES strives to achieve a balanced and diverse group of reviewers for panels and COVs. During the mid-term reviews, DOE-BES appropriately encourages diversity, in the broadest sense, at all levels in the EFRCs.

7 Major Recommendations of the COV

The COV recommends that DOE-BES:

- Document the processes leading to a reduction in the scope of work when the requested budget is reduced. Such documentation will provide an archival record of the process, which will provide continuity should a change in program manager occur and will enable future COVs to assess the entire award process.
- Continue to communicate about future funding directions and opportunities, proposal submission, etc., extensively with the community at large and to use the communication strategies learned from the COVID19 pandemic to further broaden their reach and impact.
- Streamline - where and when they can - the management and oversight reporting requirements for EFRCs and HUBs. In this regard, the reports should be informative rather than cumulative, duplication of reported material should be minimized, and strict, specified page limits should be introduced. It is recognized that the project scopes vary between EFRCs and HUBs and even across HUBs, and the management and oversight requirements should be balanced to reflect the funding level and scope of the project.
- Continue to have a diverse and balanced representation of reviewers from academia, industry, Federal Funding Agencies, and Federal Laboratories. In addition, the number of reviewers selected should correlate with the scope and complexity of the project and the level of funding. The use of virtual panel reviews presents an opportunity to enhance the overall diversity of the panel.
- Should have the flexibility to determine the best practices for conducting panel reviews both for in-person and virtual panels.
- Continue to ensure the EFRCs and HUBs, and all other DOE-BES activities, are inclusive in the broadest sense, welcoming manifestations of diversity including scientific expertise (discipline, research expertise, career stage), institutional (academia, industry, government laboratories), and people (gender, race, ethnicity, etc.).

Finally, the COV recommends that BESAC:

- Consider the aim, purpose and usefulness of charge 2(b): “*Within the boundaries defined by DOE missions and available funding, comment on how the award process has affected the national and international standing of the portfolio elements.*” This COV, similarly to previous COVs, recognizes that this is a complicated and demanding analysis if done comprehensively, and not one that can realistically be addressed with the time and resources allotted to a COV.

8 EFRC Panel Report

8.1 DOE-BES Response to The Recommendations of the 2016 COV

This COV evaluated the responses of DOE-BES to the recommendations of the 2016 COV.

- a. The 2016 COV clearly and unanimously recommended that the minimum time period for maximal output from the EFRCs be increased from four to five years. This COV largely agrees with that assessment, but recognizes that the constraints of funding, and the 2/4-year periodicity of the EFRC calls, have led instead to the current implementation of 4-year EFRCs, with 2- or 4-year renewals. This clearly simplifies the management of new proposals, mid-terms, and renewals to a rigorous and transparent schedule with 2-year increments. This approach, in which EFRCs can last 4, 6, 8 or more years is, in the view of this COV, consistent with the spirit of the previous COV's recommendation. DOE-BES is encouraged to continue with this approach.
- b. The 2016 COV recommended that the EFRCs, HUBs and reviewers produce concise and clear report and review documents, respectively. Although DOE-BES did take actions to address this recommendation, this COV recommends that further action is needed to streamline the reporting requirements by reducing duplication of material and setting strict page limits.
- c. In response to the recommendation from the 2016 COV that DOE-BES explore mechanisms to reduce the number of full proposals received and evaluated in response to the FOAs, a pre-proposal step was introduced. The pre-proposals were reviewed internally using most of the DOE-BES program managers. Each pre-proposal was reviewed by three program managers and evaluated in the following categories: responsiveness to the objectives of the FOA; scientific and technical merit; appropriateness of the proposed research approaches and likelihood of scientific impact. The review process developed by DOE-BES for these pre-proposals was reviewed by this COV. It was found to be appropriate, well executed and well documented. A more detailed assessment of this new process is provided in section 8.3

8.2 Efficacy and Quality of Processes Used for EFRC Selection

8.2.1 Findings

This COV found that the EFRC procurement processes resulted in the funding of research centers of extraordinary quality, echoing comments made by the 2016 COV for the previous time frame. The centers are led by internationally recognized and highly accomplished teams of scientists and have high potential for substantive scientific impact in areas relevant to the DOE-BES mission. The quality and productivity of the centers selected for funding are clearly evident in the documentation of the initial review process and, more importantly, in the mid-term reviews of centers selected for support.

The COV evaluated two different FOAs: a broad call in FY18 and a more focused one in FY20. Overall, the FOAs are well written and contain the needed information. Many aspects are

particularly useful such as the list of DOE definitions, descriptions of areas that are outside of the scope of the call, and areas that are de-emphasized with respect to a previous call. To identify the topics to be funded, DOE-BES uses a well-established process that involves the scientific community, Councils, BRN workshops, and topical Roundtables. In addition, the FOAs require the proposals to link to the content of the “*Grand Challenges*” and the “*Transformative Opportunities*” reports. Workshops and Roundtables produce documents that guide the community and illustrate what topics will be the subject of forthcoming calls.

The COV finds that the FOAs scope is well-managed within the limits of the strategic DOE goals, programmatic limitations, and available funds, and encourages DOE-BES to continue doing so. Limiting the scope of the calls is a way to limit the number of proposals being written and evaluated, and thus focus efforts toward DOE needs, both of which are needed for a finite funding amount. The FOAs clearly reflect DOE priorities, and the narrow topics make it possible to change priorities between calls.

The two EFRC calls were the first to employ a 2-stage review process, which had been recommended by the 2016 COV; The purpose of establishing a new pre-proposal stage was to reduce the number of full proposal submissions, and thus the burden on DOE-BES and the reviewer community.

The FY18 and FY20 FOAs, encouraged “*topical diversity*”, “*diversity of research activities*”, and “*diverse teams of scientific and technical professionals...*”, and the FY20 FOA added “*diverse group of world-class scientists from different disciplines.*” It was noted that self-reporting of diversity information by the applicants was not encouraged in the call documents.

It was discussed that the time from the release of the FOA, and some relevant BRNs and Roundtable reports, to pre-proposal deadline is short, and by itself is too short to form broad teams. At the same time, it is recognized that there are many opportunities for researchers to gain insight into likely future funding opportunities – DOE-BES budget request documents, conference presentations by DOE-BES staff, BESAC presentations, as well as in-person and more recent virtual visits by DOE-BES staff to universities and national laboratories. These efforts are critical in communicating upcoming opportunities to enable multi-institutional and multi-disciplinary teams to form.

8.2.2 Comments

The COV welcomes the practice of defining excluded areas outside the scope of the call but notes it is not uniformly implemented throughout the two evaluated FOAs.

Although a list of acronyms is provided in the FOA, the use of acronyms and DOE-BES specific terms (e.g., PRD versus PRO) should be minimized where possible, to encourage responses from the widest range of institution, and PIs.

It was noted that DOE-BES could more broadly circulate potential new topics and ask for feedback, so as to engage a larger and intellectually more diverse community.

While it is recognized that there are clear benefits to limiting the number of pre-proposals per institution, there is also a downside that internal selection processes at institutions may favor established teams and ideas over emerging, frontier opportunities. DOE-BES might reconsider what this number should be, and what advantages or disadvantages would result from any changes.

8.2.3 Recommendations

It is recommended that DOE-BES:

- Strive to minimize the use of acronyms and DOE-BES jargon in FOAs.
- Continue to communicate new research directions and funding opportunities as broadly and early as possible.
- Continue the practice of clearly articulating the areas of research that will be funded and, equally importantly, will not be funded in response to a particular FOA. They should continue the practice of limiting the research scope of a FOA to mirror the appropriated budget.

8.3 Pre-Proposal Process Established In 2018 As A Result of the 2016 COV

8.3.1 Findings

The pre-proposal review process is well thought-out and appropriate for handling the large number of potential applications. At least three program managers review the pre-proposal and provide scores and comments. The presented panel summaries are generally reflective of the individual reviews.

The COV found the FY18 process to be more comprehensive and easier to assess than the process used in FY20. There were two key differences. First, in FY18 the reviewers were identified with their comments and scores. The COV was able to evaluate the consistency of the review of each reviewer across all pre-proposals; this was found to be remarkably consistent. Second, the documentation for FY18 had the reviewers' separate their comments for each criterion; whereas in FY20 all comments from a reviewer were captured together. The aggregated comments made it more difficult to distinguish how the reviewers' comments aligned to the review criteria.

The scientific/technical merit and impact review criteria were clear and appeared to be interpreted similarly by reviewers across the pre-proposal reviews. However, the appropriateness criteria were less well-defined.

Overall, this is a well-executed and appropriate process and is one DOE-BES is encouraged to continue.

8.3.2 Recommendations

This COV recommends that DOE-BES

- Consider opportunities to improve consistency and clarity of the internal review process by better articulating instructions to reviewers related to the criteria of appropriateness, and by evaluating best practices for aggregating reviewer comments and scores.

- Ensure that reviewers assess the scope of proposed research to confirm its novelty and need for a team approach.

8.4 Reviewers

8.4.1 Findings

The reviewers are chosen to be diverse in terms of location of institution and gender, although possibly less so in terms of the institutional size. The number of reviewers varies from four to six. Four reviews seem to be the minimum number obtained, but the program managers have shown this to be sufficient to make a recommendation on the merits of the proposal. Overall the reviewers selected are well-qualified and have the appropriate expertise to review the proposals. While it is obvious that finding enough reviewers for EFRC proposals is challenging because of conflicts of interest, the program managers are still able to find enough highly-qualified reviewers from national and international institutions.

The quality of the reviews is uniformly, and pleasantly surprisingly, high. Some reviews are more thorough than others, with only a few having insufficient quality.

The program managers demonstrated considerable skill in extracting the correct sense of the quality of the proposal from the written portion of the reviews, and clearly go beyond simply considering numerical (or E/VG/G/P) scores.

For renewals, the COV did not find a clear indication of the extent program managers considered past performance as a component of renewal decisions. This is clearly an important aspect.

8.4.2 Comments

Clear and careful guidance from DOE-BES in the instructions to the reviewers is important and leads to thorough responses.

8.4.3 Recommendations

This COV recommends that DOE-BES:

- Consider, where possible and permissible, using reviewers from international National Research Laboratories to expand the pool of potential reviewers.
- Consider providing in the instructions to proposers and reviewers of proposals the approximate relative weighting given to each section of the proposal.

8.5 Efficiency/Time to Decision

8.5.1 Findings

The COV notes that DOE-BES has implemented a highly efficient process that allows decisions to be made and communicated quickly.

8.6 Completeness of Documentation for Making Recommendations

8.6.1 Findings

The decision-making process from the written reviews through the panel debrief statement is clearly documented, and the program managers do a very good job at compiling the reviewer reports into the panel debrief summaries. The process, including strategic considerations, is very clearly documented in information that was made available to the COV. It is noted, however, that no such documentation exists for the last, and understandably most strategic, final selection step based on the panel debriefs. The COV understands that this gives DOE-BES Management the needed flexibility to choose which proposals are awarded with decisions based on the reviews, the program manager evaluations, as well as on the program policy factors listed in the FOA. This is entirely appropriate.

The COV noted that the FOA required proposals to address a substantial number of primary research directions/opportunities in BRN and Roundtable reports as well as in grand challenge documents.

It was observed that the vast majority of awarded EFRCs ultimately receive reduced budgets, usually around 75 % of the requested level.

8.6.2 Comments

It is understood that the decision to reduce the budget can be based on the recommendations from the review, and a programmatic decision to support more EFRCs. This is a challenging decision for DOE-BES Management, as it keeps the award success rate at an appropriately high level, but reduces the scope of work that was originally proposed by most centers. While the negotiation on the reduction of scope of work to meet the reduced budget involves communication between the program manager and the EFRC director, these negotiations are not documented in PAMS.

The high likelihood of a reduction in the budget is not well-known across parts of the wider research community. This can place a new EFRC director in a challenging situation as their first action is to reduce the scope of work. It would be helpful for the less DOE-BES-cognizant community to be made aware that most funding awards are lower than the request.

Center Leads could be encouraged to make greater use of the program managers and their own advisory board structures to stand by their rescoping actions.

In some instances, it appeared that the work being carried out by some EFRC members was similar to their already funded research, or an extension of old work, rather than new, collaborative work that the EFRCs are designed to support.

8.6.3 Recommendation

This COV recommends that DOE-BES:

- Consider strategies to inform the community that with limited funding available and the number of proposals selected for funding, the budget of each selected EFRC may be lower than the requested level.
- Consider simplifying how the required elements of BRN brochures and reports, Roundtable reports, and grand challenge documents that must be addressed in a proposal are expressed in FOAs.

8.7 Scientific and Institutional Diversity

8.7.1 Findings

The EFRC portfolio in the different thematic areas is appropriately broad, covering the spectrum of research identified in the BRN and Roundtable reports. The range of institutions is broad, and distributed across the US. The partnerships between academia and DOE National Laboratories are appropriate and increasing in number. The EFRCs also engage and use the DOE User facilities.

The efforts that DOE-BES takes to ensure EFRCs have a welcoming, inclusive and diverse scientific environment can be observed in the solicitation, review, recommendation, and management steps throughout the life-cycle of the EFRCs. The panel found that on average the gender ratio of the principal investigators in the EFRCs was about the same as in the subject area as a whole, and that there had been an increase in the percentage of female center directors from 2018 to 2020. However, much remains to be done in the broader area of diversity. The EFRCs should continue to improve the diversity among the principal investigators and of all participants. The latter effort is considered of high importance as the EFRCs educate and train many post-doctoral fellows, graduate students and scientists.

8.7.2 Comments

The panel noted that program managers chart some diversity data and encourage diversity in the broadest sense. This is important, and the panel notes that a welcoming and inclusive culture makes a center more effective and accomplished. Diversity in the science, institutions, and participants should continue to be emphasized throughout the EFRC process.

The EFRCs are viewed by the panel as an excellent opportunity to promote inclusivity and diversity in research, to help launch the career of early stage scientists and engineers, to provide leadership training opportunities, and to extend collaboration networks.

8.7.3 Recommendation

This COV recommends that DOE-BES:

- Consider asking reviewers to assess the appropriateness of the proposal's concerted and coordinated team effort to address the proposed science.
- Continue to encourage EFRCs to create and maintain an environment that is welcoming and inclusive to all.

8.8 Efficacy and Quality of Processes used for Center Management Oversight: Management Processes

8.8.1 Findings

The EFRCs are evaluated very thoroughly during their tenure and the DOE-BES program managers do an excellent job of facilitating a very successful program. The oversight encompasses management and scientific excellence – with management reviews, mid-term reviews, annual reports, and monthly directors’ meetings. The quality of the information collected is outstanding and very complete. This provides DOE-BES with a wealth of information about the performance within the portfolio – but also creates a significant amount of work for the EFRC directors as well as the program managers. Although the collection of information is thorough, it was not clear how outcomes/decisions based on this information were communicated back to the EFRC director.

8.8.2 Recommendation

This COV recommends that DOE-BES:

- Streamline the technical and administrative reporting requirements to the extent possible.
- Consider establishing strict page limits for reports, ensuring they are informative rather than repetitive.
- Reduce workload for both EFRC directors and DOE-BES staff through the use of automated data collection and analysis tools to the extent possible, and eliminate duplicate requests for the same data in different formats.
- Continue to provide and document feedback to EFRC directors, through guidance emerging from formal reviews, discussions in monthly EFRC color groups, and *ad hoc* discussions with individual directors.

8.9 Management Reviews Including Guidance Provided, Documentation Received, Reviewer Qualifications, BES Feedback, EFRC Response to Feedback

8.9.1 Findings

Some EFRCs have an exceptional management structure that distributes the workload amongst the PIs. It seems clear that DOE-BES recognizes that strong management is correlated with strong EFRC outcomes and scientific excellence. DOE-BES provides clear guidance on best practices for EFRC management, but leaves the decision on how to implement these practices to each EFRC. This panel sees this latitude as important since uniform approaches do not necessarily achieve the best outcomes.

It is clear that there is a robust process with extensive, detailed information for the EFRC directors and the reviewers, and that DOE-BES continues to fine-tune the process. For example, comparing the 2017 and 2019 Management review documents shows a presentation that provides the EFRC directors in 2019 with clear advice on what to do and what not to do. This addition is seen as a positive response to help EFRC directors prepare for the management review.

The panel found that the management review after one year is well-organized and effective with useful comments from the reviewers.

The process for making significant changes to an ongoing project based on reviews and other project activities is important, and much information was provided to the COV that documents this oversight actively occurs. This applies to both the Management Review at the early stage of the project, as well as the mid-term review. In most cases, DOE-BES has done an excellent job of documenting processes and addressing questions from the community related to those documents. In other situations, it appears that communication likely occurred via emails or phone calls, which are not documented in PAMS, and thus the COV found no evidence that recommended changes were implemented.

Network analyses to identify the number and range of collaborative research publications have been carried out by the program managers. This analysis is interesting and insightful.

8.9.2 Comments

The scientific and management skills of the team are critical to strong outcomes. DOE-BES recognizes this and has a good understanding of management issues and how to ‘see the bigger picture’ of activities.

Centers will likely benefit from seeing their, and others’, network analysis.

8.9.3 Recommendations

It is recommended that DOE-BES

- Continue to share best-practices about how to manage centers and encourage EFRC directors who are new to leadership and management positions to find a mentor.

8.10 Mid-Term Reviews Including Guidance Provided, Documentation Received, Reviewer Qualifications, BES Feedback, EFRC Response to Feedback

8.10.1 Findings

The panel debriefs for the Midterm FY20 reviews were very useful. Information regarding the publication networks provide a useful indicator of the excellence and the correlation between top-ranked centers and top-quality progress reports. The length and requirements of some of the reports appear to be overly burdensome for the program scope and award size.

The panel noted that the midterm review for FY20 required a report on the “practices that promote a diversity of ideas and people” in the EFRC. This panel applauds DOE-BES for requesting this and notes that it has resulted in the charge to some centers to address shortcomings in diversity of ideas, people, and institutions.

8.10.2 Comments

Most of the EFRCs are demonstrating remarkable productivity and evidence of excellence: they have extensive and collaborative publication records, their research is impactful and sometimes leads to spin-off companies and products, and they organize meetings in diverse fields that span from discipline-specific to broader contributions to basic science, facilities-focused conferences,

as well as the PI meetings. These presentations demonstrate the excellence and national/international impact of the EFRC program. DOE-BES feedback during the 4-year review demonstrates that the leadership is alert to these contributions.

8.10.3 Recommendations

It is recommended that DOE-BES

- Consider ways to document the communications regarding outcomes of midterm reviews to EFRC directors. If changes are required in EFRC operation, it should be documented that the EFRC has successfully addressed any concerns in a timely manner.

8.11 Principal Investigator Meeting

8.11.1 Findings

The COV learned that DOE-BES has received positive feedback about the value of the EFRC PI meeting, particularly for students and postdocs. Having such early career scientists in attendance distinguishes the EFRC PI meeting from other DOE-BES PI meetings, and DOE-BES is to be commended for this aspect of workforce development. These early career scientists are provided opportunities to learn about new science, to place their research into the larger context of energy science, and to network with others. The presentations given by DOE-BES program managers to the COV indicate that new collaborations have resulted from interactions at the PI meeting. Another significant outcome is the exchange of ideas and awareness of complementary research across EFRCs.

8.11.2 Comments

Given that the declared goal of the PI meeting is to foster collaboration between EFRCs, can this be measured? How does it compare to collaborations that result from other (topical) meetings?

8.11.3 Recommendations

It is recommended that DOE-BES

- Consider surveying participants to quantify the value of the PI meeting and gather feedback that can be used to further document the impact of the EFRC program.

8.12 Web Resources

8.12.1 Findings

The EFRC program website (<https://www.energyfrontier.us/>) contains good information. The three newsletters per year are well done and must take time to put together. The information about the logistics and science being presented in the PI meetings is up-to-date and is a useful resource for others in the broader community. The COV was unable to see the resources that were private to the EFRC Members.

All EFRCs reviewed by the COV have websites. However, the quality of the websites was highly variable. Some of the websites were current, communicating discoveries made within the EFRC,

highlighting the achievements and recognitions of the personnel involved in the EFRC, and providing a current list of publications. Other websites were static and appeared to be largely unchanged since the award was made.

8.12.2 Comments

There was no evidence that the EFRCs have any presence on other social media. This might be useful for some broader dissemination of information to those who extensively use that media to get information.

8.13 Effective Interactions Between BES Program Managers and EFRCs

8.13.1 Findings

Many of the interactions between program managers and EFRC directors are informal, and thus not documented in PAMS and therefore not accessible for review by the COV. However, based on discussions with DOE-BES program managers, the COV understand that the interactions are often very fruitful. Moreover, it was noted by the COV members who had prior experience with EFRCs that the interactions with the program managers were of high quality and useful.

8.14 Advisory Boards and Management Structure

8.14.1 Findings

Many EFRCs have advisory boards which lack a clear definition of their function and the EFRC leadership may not be taking full advantage of the outside perspective of people that comprise this important resource. The COV also noted that modes of implementing advisory boards are EFRC-dependent.

8.14.2 Comments

The DOE-BES Good Practices document provided to the Centers contains specifics about the purpose and nature of the advisory board.

8.14.3 Recommendations

This COV recommends that DOE-BES

- Ensure each Center is making best and appropriate use of their advisory board.

8.15 Monthly Directors' Meeting

8.15.1 Findings

The COV was unable to find detail on the regular (phone) meetings of the center directors with DOE-BES. It is hoped that these conversations are enabling strong communication and effective management with timely updates.

8.15.2 Comments

The COV suggests that DOE-BES consider the value of the monthly director's meetings and should assess the frequency of these meetings.

8.16 Impact and Standing of the EFRCs

8.16.1 Breadth and depth of EFRC awards

8.16.2 Findings

The funded EFRCs represent a considerable breadth of topics, being addressed with the engagement of numerous world-class researchers, including NAS-level directors, at a diverse set of institutions. The EFRC concept also has been a remarkable catalyst for getting universities and DOE National Laboratories to work together.

Funded centers clearly address the FOAs, and by extension, the DOE-BES mission and priority areas. Some aspects of EFRCs have additional relevance beyond the DOE-BES or even DOE missions.

There is strong evidence of uniqueness, significance, and scientific progress and impact across the portfolio, with some EFRCs having impactful publications and achieving synergy within the center. Often these EFRCs seem to have extensive publication networks within their EFRCs.

The track record of the EFRCs demonstrates that they clearly provide a mechanism to perform research that goes beyond single-PI or small-team efforts that are funded through different channels.

8.16.3 Comments

Since 2009, the program has launched the careers of many early career researchers as graduate students, postdocs, and many of these individuals are now faculty and industry leaders. The EFRC concept and the opportunities to work across institutions have exposed a large number of early career researchers to high-level interdisciplinary and collaborative research. DOE-BES should consider ways to publicize the remarkable contributions of the EFRC program to the development of the scientific workforce including, in particular, the exceptional opportunities given to students and postdocs to work within world-class teams.

8.16.4 National and international standing of the EFRCs

8.16.5 Findings

Key personnel represent scientific leaders in their respective fields. Multiple reviews of the proposals pointed to the assembly of "star-studded teams." There is also evidence the EFRCs are dynamic in PI recruitment with some renewed projects including new PIs that strengthen the EFRC capabilities.

Many of the EFRCs have a healthy mix of investigators from different career stages. This is seen as a positive and contributes to the future success of the early career scientists and engineers.

The publication information that was provided, the extensive annual reports and the mid-term review documents make it very clear that the vast majority of the EFRCs are highly productive.

We also note that many of the EFRCs are considered international leaders in key areas, represent the best places in the US to do this type of multi-disciplinary research, and fill critical voids in the scientific community. Much of this observation is confirmed in the documentation related to the reviews of proposals and the mid-term evaluations, including input from a significant number of international reviewers who assess the national and international standing of the EFRC efforts.

However, it was difficult for the COV to assess the international standing of the EFRCs with the information provided, especially when it comes to comparing their output with other efforts of similar size and scope, both within the US and internationally.

8.16.6 Comments

The extensive amounts of data collected at annual and mid-term reviews could be a significant part of any standard metrics-based benchmarking, while components of the reviewers initial and mid-term reports could be a part of a peer-reviewed benchmarking activity.

In the future, perhaps a reorganization of these components could provide enough information for a COV to draw some brief conclusions.

8.16.7 Recommendations

This COV recommends that DOE-BES

- Continue to explore light-touch approaches to benchmarking the international standing of the EFRCs, possibly as part of BESAC's ongoing analyses, or through liaison with mid-term reviewers with knowledge of the broader international community.

9 HUBS Panel Report

9.1 DOE-BES Response to the Recommendations of the 2016 COV

This COV evaluated the responses of DOE-BES to the recommendations of the 2016 COV.

- a. The 2016 COV recommended that a final 5-year summary, written in language that is widely accessible, be required after the end of a HUB award, irrespective of renewal. The final report should focus on the “retroactive measure of transformational impact,” as urged in the Secretary of Energy Advisory Board HUBs+ report (<https://www.energy.gov/seab/downloads/report-hubs-task-force>). This recommendation was implemented by DOE-BES, e.g. in its Guidance for the JCESR-1 Final Report 2012-2018, which specified a succinct summary as a high-level executive summary, including an assessment of the impact of the project and a summary of the scientific gaps remaining at the end of the project. The resulting JCESR 5-year summary contained a high-level Executive Summary and assessment of Scientific Impact. Similarly, the JCAP FY19 Progress Report included descriptions of achievements at a high level, along with statements that convey the impact of the work.
- b. The 2016 COV also recommended that the EFRCs, HUBs and reviewers produce concise and clear report and review documents, and particularly with emphasis on executive summaries of accomplishments and impact. Although DOE-BES did take actions to address this recommendation, this COV recommends that further action is needed to streamline the reporting requirements, reduce duplication of material, and to set strict page limits.

9.2 Efficacy and Quality of Processes used for the HUB Awards Selection and BES Management Oversight

9.2.1 Findings

2020 Fuels from Sunlight. The COV found that the decision to hold a Solar Fuels Roundtable in August 2019 to obtain scientific input from the community on the changing landscape of solar energy was appropriate and needed, recognizing that it had been 14 years since the topic was addressed by the *Solar Energy* BRN Workshop in 2005. The Roundtable report provided the scientific direction (i.e., priority research opportunities) for the new proposal call for Fuels from Sunlight (DE-FOA-0002254). The FOA was considered adequate but the short timeframe between FOA release and submission deadline for pre-proposals (5 weeks) might have limited the number of responses.

The approach to the merit review of the pre-proposals and full proposals was thorough and appropriate. A two-tier process was used for the merit review of the full proposals. First *ad hoc* mail reviewers each reviewed 1-2 written proposals. Then panel reviewers studied all proposals, and participated in a virtual panel review with the representatives of the applicants to obtain answers and clarification on the proposal content. The number of reviewers per proposal for the competition was excellent (12 reviewers per proposal) considering the breadth and complexity of

the proposals. There was a very good balance between international (25%) and US domestic (75%) reviewers. However, the reviewer pool lacked Federal Laboratory representation and only one panelist had industrial expertise. It was difficult to determine if this was a consequence of conflict of interest but the COV believes that other agencies and their labs (e.g., NIST, Air Force, Navy, Army, etc.) should be included even if DOE labs are conflicted.

DOE-BES provided detailed instructions to reviewers. The questions supplied in the review template were insightful and it is clear that the reviewers were engaged and thoughtful in their feedback. Overall, the reviews were found to be well-prepared, extensive (4-5 pages each), and consistent. DOE-BES leadership accurately summarized the reviewers' comments in a briefing to the Associate Director of BES. The presentation also provided valuable analysis of the characteristics of the proposing teams, the strengths and weaknesses of the proposals, and recommendations for funding. The DOE-BES leadership is commended for considering not only the reviewers' comments but alignment of the proposed research to the scope of the proposal call when making funding recommendations.

It was stated in the initial presentation to the COV that DOE-BES was informed that panel reviewers had to remain anonymous even though the FOA indicated that the merit review panel may be conducted as in-person meetings with representatives from the applicants. This decision is at odds with precedent and does not enable the fruitful back and forth discussions between PIs and reviewer/panelists.

2018 JCESR. DOE-BES convened a *Next Generation Electrical Energy Storage* BRN in March 2017 for a community assessment of the current status of electrical energy storage and identification of top priority basic science gaps and opportunities. With the ending of JCESR's first five years in 2018, the BRN was particularly timely. This timing also reflects the careful strategy DOE-BES uses to focus the community and inform DOE-BES. The BRN report identified five priority research directions which were all addressed in JCESR's renewal proposal in 2018.

The FY18 appropriations provided guidance to move forward with the review and renewal process for JCESR. Using input from the 2017 Assessment of JCESR and science gaps identified in the *Next Generation Electrical Energy Storage* BRN report, DOE-BES requested a renewal proposal from JCESR. DOE-BES worked closely with JCESR to define a second phase program with formidable strategic goals. A review panel was convened after the renewal proposal was submitted by JCESR. The COV noted that the number of reviewers for the renewal review was five: considering the breadth and complexity of the proposal the number was viewed as less than ideal even for a renewal. All reviewers were US domestic reviewers, but the reviewer pool was balanced between national laboratory and academic institutions. It was difficult to determine if the limited number of reviewers was a consequence of conflicts of interest for too many potential reviewers, but some leading international and industry experts should have been included to fill out important areas in, for example, theory and computation.

DOE-BES provided high quality instructions to reviewers, preparing reviewers with clear review criteria and an organized review agenda that elicited excellent, extensive, and consistent reviewer comments. A shortcoming was that the review format had no ranking in terms of quality. Subsequently, DOE-BES leadership provided significant guidance to the applicant to address

shortcomings in the proposal. The DOE-BES briefings summarized the action items and the reviewers' comments along with a valuable analysis of the strengths and weaknesses of the proposal and recommendations for funding.

The international representation and connectivity of JCESR are very important. Assessing the posture of JCESR research on an international scale - a DOE-BES and COV challenge - may be facilitated because of JCESR's extensive use of major DOE-BES facilities at ANL and elsewhere; The COV believes that international representation is important in DOE-BES reviews, particularly those as large as a HUB.

JCESR uses three advisory committees - governance, institutional leadership, and energy storage advisory committees, with membership of the third composed of half or more from industry. Without relevant documents, the COV cannot evaluate the extent and quality of feedback JCESR is getting from its advisory committees. The COV recognizes that advisory boards need to have confidence that they may speak frankly, honestly, and privately in giving advice to the HUB, but it is a worthy question how a HUB might respect this feedback and still convey some sense of the activity level, contributions, and benefits that arise from an advisory board.

9.2.2 Comments

2020 Fuels from Sunlight. With regard to the Fuels from Sunlight FOA, the COV is concerned that there was insufficient time between the release of the FOA and the pre-proposal deadline for proper development of teams and proposals. Release of the Roundtable brochure (January 2020) defining priority research opportunities and the release of the proposal call (FOA, February 18, 2020) left only 5 weeks until the deadline for pre-proposals (March 24, 2020). Furthermore, this short time frame may have disadvantaged all but the most experienced teams from submitting compelling pre-proposals. The COV appreciates that DOE-BES does not have full control of the timetable related to the release of a FOA. DOE-BES should continue to apprise the community as soon as possible about the scientific directions that may lead to new proposal calls, providing as much time in the schedule as possible for teams to form and develop innovative ideas.

With the award of two new Fuels from Sunlight HUBs, the funding level of HUBs considered by this COV varies substantially, from \$8 to \$24M/year. It was unclear how DOE will tailor the metrics and expectations to the size of the HUB. In addition to publications, expectations for generation of intellectual property and industrial engagement should be defined. Since a solar fuels industry currently does not exist, these HUBs have an opportunity to make scientific advances to lower the barrier for industry to engage in these technologies. In addition, HUBs will be the training grounds for this new industry in energy sustainability. Thus, workforce development should be considered as a metric for assessing the impact of the HUBs.

The level of funding of one of the HUBS at \$8M raises an important question about the distinction between such a HUB and two well-funded EFRCs. Answering this question was outside the scope of this COV, but the question may be worth some consideration by DOE-BES Management.

9.2.3 Recommendation

This COV recommends that DOE-BES:

- Retain the flexibility to convene review panels as DOE-BES sees fit to enable thorough and complete reviews that provide them with the input needed to make award decisions.
- Convene review panels that provide a broad range of perspectives particularly including topical representation but also industrial and international representation.
- Encourage HUBs to use external advisory boards as venues for advice from academia, national laboratories and industry (as JCESR has).

9.3 Oversight and Management of HUBs

9.3.1 Findings

JCAP. The comprehensive HUB Oversight Plan as presented in 2016 after the Fuels from Sunlight Hub competition process was an impressive and comprehensive description of the approach DOE-BES uses to manage the HUB. This facilitated management of the HUB with few if any surprises, particularly as the JCAP administrative staff were responsible for following the plan's goals and milestones.

On-site JCAP reviews in 2017, 2018, and 2019 were very well managed by DOE-BES, from prescribing the requirements of the review document to providing reviewers with context and criteria for the reviews. Review teams of 5-6 highly qualified members sometimes included an international member. The reviews themselves were extensive (4-5 pages per reviewer), thorough, very positive overall, and carefully written, suggesting that reviewers regarded JCAP and DOE-BES highly. DOE-BES' orientation stated that critiques from previous reviews should be addressed in the review document. Review documents appropriately included comments addressing concerns from prior reviews. Given the extensive feedback from all reviewers on a handful of review criteria, it would be helpful to ask them for brief indication of rating for the different criteria and overall - either a short summary, or a simple rating like E/VG/G/M.

DOE-BES Program Managers prepare an analysis of the reviews for their management which included summaries of reviewer perceptions and conclusions, enhanced by reviewer quotes. The review documents had no Table of Contents and only a crude Navigation Pane, making it difficult to find specific topics or to see the overall document organization - a shortcoming which DOE-BES instructions can easily overcome.

The JCAP annual reports are overwhelming, over 300 pages, the bulk of which is simply content that appears largely duplicated each year. Duplicative material, if needed, should be kept disconnected as an Appendix. The requirement for quarterly reports and monthly phone conferences pose a workload that seems somewhat overbearing. The COV feels that streamlining the reporting requirements to obtain the necessary information in an efficient, easy to access report would benefit the program.

JCESR. At a high level, JCESR underwent a significant change in emphasis with its 2018 renewal, moving to a stronger focus on fundamental science and prioritizing grid storage over transportation as its primary use-inspired motivation. The COV supports this change in vision, particularly given

the significant discussions between JCESR and DOE-BES to develop the mission and plans for the renewal. The guidance given to JCESR regarding the preparation of their renewal proposal was clear and well considered, providing well-defined criteria for the assessment. The COV wondered whether the number and depth of exchanges between DOE-BES and JCESR before the proposal submission may have blurred the line between management and oversight. However, after talking with DOE-BES staff, the COV understands and concurs with the DOE-BES view that the JCESR renewal was a joint effort which contributes to good management and the attainment of joint goals and objectives.

The COV found that the oversight of JCESR was well documented, clearly laying out the roles, responsibilities, authorities, accountabilities, and performance metrics for the JCESR participants and DOE. The Oversight Plan includes periodic teleconferences (on at least a monthly basis with JCESR management), DOE internal coordination (including EERE and ARPA-E), quarterly written progress reports, programmatic change controls, an initial HUB review in the first year, annual HUB review in years 2-5, coordination of HUB public affairs with DOE, and informal, annual, on-site visits and monthly monitoring. The instructions from DOE-BES regarding the management expectations of JCESR were found to be highly detailed, organized, and well considered.

JCESR's Quarterly Reports and Milestone Schedule are replete with excellent scientific content, highlights, and budget and personnel information. The quality of the written reports is high and the COV finds that the introduction of a detailed list of outside collaborations indicating domestic and international collaborators was useful for assessing the impact of the HUB on an international scale. While the 2016 COV found the biweekly teleconferences and templated reports to be an improvement over previous management practices, this 2020 COV found the reports may now be too lengthy and repetitive to fully digest the changes, quarter-after-quarter. Quarterly reports of ~75 pages per report require significant attention and resources to produce. Shorter reports with greater focus on changes may be more efficient and effective. Given the full complement of formal and informal meetings, reports, visits, and other communications, JCESR is under a heavy reporting burden. Thus, the COV urges DOE-BES to consider ways to alleviate some of this burden without sacrificing the quality of their management and oversight. One proposed way to reduce reporting burden would be to rely on automated reference collection.

9.3.2 Comments

JCAP/FS. Descriptions of JCAP and follow-on Fuels from Sunlight (FS) HUBs emphasize the vision of direct creation of fuels from sunlight, i.e., an intimate integration of photon capture, charge management and transport, and electrochemical conversion of feedstocks to fuels. The potential benefits to society could be enormous, but the COV understands that no such industry exists today. While that is an impediment for connecting JCAP or the new FS HUBs to industry, the COV believes such a connection to be important. With ~50 invention disclosures, JCAP clearly has potential for technology impact. Indeed, JCAP had such a mission. The 2016 DOE Oversight Plan states "*The HUB is expected to foster and encourage robust interactions with private industry beyond the scope of the research and development directly funded through the DOE JCAP award. These interactions should aim at accelerating technological innovation and reducing barriers to the movement of new technologies to the marketplace.*" The COV feels that

increasing representation from industry is a worthy exercise, e.g. as advisory board or review panel members.

JCESR. Unlike JCAP and the FS HUBs, JCESR should benefit from a vibrant energy storage community even if at-scale grid storage has not yet been achieved. The COV was not convinced that JCESR was receiving and/or acting on sufficient feedback from the energy storage industry, which could be highly beneficial not only for their science and technology transfer but for workforce development.

9.3.3 Recommendations

The COV recommends that DOE-BES:

- Consider ways to streamline the reporting requirements without sacrificing the quality of their management and oversight. Additionally, the HUB reporting requirement should be commensurate with the size and scope of the particular effort – especially now the HUBs are funded from \$8 - \$24 M per year.
- Work to ensure the number of reviewers is commensurate with the size and scope of HUB awards. The challenges associated with finding a sufficient number of highly-qualified reviewers who do not have a conflict of interest is recognized as is the distinction between a renewal and a re-competition.
- Consider how to ensure a connection to industry and technology for the new LiSA and CHASE HUBs. This connection is important for technology perspective and to interact with students whose future careers lie there. The COV recognizes that this is a challenge where an industry does not yet exist, but industry perspectives could be provided from those in related industries.

9.4 Impact and Standing

9.4.1 Findings

JCAP. JCAP and the newly funded LiSA and CHASE HUBs are led by top research institutions in the world with a number of the participants having outstanding international research reputations. Many of the players from JCAP are also participating in the LiSA HUB.

The COV found that the emphasis of JCAP-I changed after the first five years from hydrogen production, with notable device orientation, to the more scientifically challenging goals of CO₂ reduction and oxygen evolution for JCAP-II. Water splitting is a crowded field and the shift to the more challenging problems is supported by the COV.

JCAP is having a significant impact not only from the standpoint of scientific output but also in workforce development. The 619 publications are in a good mix of journals including society journals with >50% being in high impact journals. The JCAP team is well cited. Typically, at any one time ~50 graduate students, ~40 postdocs, and ~6 undergraduate were involved in JCAP projects. There are 140 alumni who are having significant impact in the US and internationally. About 29% of JCAP alums have been hired in faculty positions predominantly in the US but also

around the world, ~36% in industry, ~4% in permanent positions in national labs and ~20% as postdocs in academia or national labs. One has created a new startup company.

JCESR. The COV bases its assessment of impact and standing on the reviews of experts in connection with the 2018 renewal, as well as on the annual and quarterly reports and high-impact publications generated by JCESR. The 2017 review of JCESR specifically addressed the question of whether JCESR’s scientific results were strongly impacting the energy storage community, concluding that JCESR had significant impact in a number of areas. The COV agrees with the assessment of the 2017 review and views that JCESR is pursuing a scientifically exciting, high risk research portfolio requiring significant effort due to the multiplicity and variety of technical challenges. Innovation and risk are balanced, and the likelihood of scientific advancement is high.

Examples of the novelty and impact of the work being pursued include:

- Computational materials genome for electrolytes and multivalent electrodes;
- New concepts in flow batteries;
- Understanding sparingly solvated Li-S systems;
- Data-driven machine learning materials science, which is likely to gain further in significance and use; and,
- Dynamic interface characterization using major user facilities.

JCESR is an international leader in important areas, particularly electrolyte discovery and development and conceptualization of solvation as a key to electrochemical properties. The important benefits of JCESR’s work are shared through a public portal at the Materials Project hosted by UC Berkeley. JCESR-II is continuing to pursue the full five-component spectrum of primary research directions identified in the 2017 *Next Generation Energy Storage* BRN report, resulting in significant breadth of scientific activities. The depth of the portfolio varies area to area, and is particularly strong in the primary research directions linking complex phenomena across time and space.

9.4.2 Comments

JCAP/FS. Funding reductions have had and will continue to have a significant adverse effect on the productivity and impact of the JCAP, CHASE and LiSA HUBs. JCAP funding went from its original \$25M/year to \$15M/year for the first and second 5-year phases respectively. It was not clear to the COV what mechanism was used to do this, nor the extent to which the modality of such “smaller” Hubs may differ: at some point, smaller HUBs resemble large EFRC’s.

JCAP has had significant industrial partnerships with Panasonic, Toyota Central Research and development Laboratory, Sempra Energy – Southern California Gas Company, Honda Research Institute (USA), Siemens, and Toyota Motor Engineering and Manufacturing North America (TEMA). While this is commendable, it is surprising that energy and catalysis companies have not been involved.

Appendix I. Charge to the Committee of Visitors



MIT School of Science

Marc A. Kastner

Donner Professor of Physics, Emeritus, Former Dean of Science mkastner@mit.edu

February 4, 2020

Professor Ian Robertson
Dean, College of Engineering
University of Wisconsin
Madison, Wisconsin 53706

Dear Prof. Robertson:

The Basic Energy Sciences Advisory Committee (BESAC) has been charged by the Department of Energy Office of Science to assemble a Committee of Visitors (COV) to review the management processes for the following two programs within the Basic Energy Sciences (BES) Energy Frontier Research Centers (EFRC) and Energy Innovation Hubs (Hubs) programs. Thank you for agreeing to chair this BESAC COV panel. Under your leadership, the panel should provide an assessment of the processes used to solicit, review, recommend, and document proposal actions and monitor active projects and programs.

The panel should assess the operations of the program elements during the fiscal years 2017 through 2020. The panel may examine any files from this period for both DOE laboratory projects and university projects. The COV is being asked to review both procurement and management activities for the EFRC program and the BES-supported Hubs for Fuels from Sunlight and for Batteries and Energy Storage.

BES will provide background material on these program elements prior to the meeting. The COV is scheduled to take place October 14–16, 2020 at the Rockville Hilton Hotel. A presentation to BESAC to summarize the COV is requested for the Spring 2021 meeting (not yet scheduled). Following acceptance of the report by the full BESAC committee, the COV report with findings and recommendations will be presented to the Director of the Office of Science.

The Basic Energy Sciences Advisory Committee has given the panel the following charge:

1. For both EFRCs and Hubs, assess the efficacy and quality of the processes used to:
 - (a) solicit, review, recommend, and document proposal actions; and
 - (b) monitor active projects and programs.
2. Within the boundaries defined by DOE missions and available funding, comment on how the award process has affected:
 - (a) the breadth and depth of portfolio elements; and
 - (b) the national and international standing of the portfolio elements.

If you have any questions regarding BESAC or its legalities, please contact Katie Runkles (301-903-6529; katie.runkles@science.doe.gov). Logistical support for the meeting will be provided by Kerry Hochberger (301-903-7661; kerry.hochberger@science.doe.gov). Technical questions



Massachusetts Institute of Technology
77 Massachusetts Avenue, Building 13-2142, Cambridge, MA
02139-4307

related to the programs being reviewed should be referred to Andy Schwartz (301-903-3535 or andrew.schwartz@science.doe.gov).

Sincerely,

A handwritten signature in black ink that reads "Marc Kastner". The signature is written in a cursive, flowing style.

Marc Kastner, Chair
Basic Energy Sciences Advisory Committee

cc: H. Kung
L. Horton
B. Garrett
A. Schwartz
K. Runkles
K. Hochberger

Appendix II. Members of The COV and Their Affiliation

Name		Institution	Title
Ian	Robertson	Univ. Wisconsin-Madison	Grainger Dean of the College of Engineering
Polly	Arnold OBE FRS	LBL UC Berkeley	Director, Chemical Sciences Division Professor of Chemistry
Hans	Christen	ORNL	Director, Neutron Scattering Division
Gary	Rubloff	Dept. of Materials Science and Engineering Univ. of Maryland	Distinguished University Professor and Minta Martin Professor of Engineering,
Phil	Britt	ORNL	Acting Associate Laboratory Director for Physical Sciences
James	Coleman NAE	Dept. of Electrical Engineering Univ. Texas at Arlington	Presidential Distinguished Professor,
Mike	McKittrick	DOE-AMO	R&D Consortia Program Manager
Abbas	Ourmazd	Dept. of Physics Univ. of Wisconsin-Milwaukee	Distinguished Professor
Frances	Ross	Dept. of Materials Science and Engineering MIT	Ellen Swallow Richards Professor
Carol	Bessel	NSF	Deputy Division Director (acting), Division of Industrial Innovation & Partnerships
Patricia	Dove	Dept. of Geosciences and Dept. of Chemistry. Virginia Tech	University Distinguished Professor and C.P. Miles Professor of Science
Greg	Girolami	Department of Chemistry University of Illinois	William and Janet Lycan Professor
Shirley	Meng	Dept. of NanoEngineering Univ. California- San Diego	Professor, Zable Endowed Chair in Energy Technologies
Chris	Palmstrom	Dept. of Materials and Dept. of Electrical & Computer Engineering, Univ. California-Santa Barbara	Distinguished Professor
Nag	Patibandla	Applied Materials	VP, Advanced Deposition Products; Office of the CTO
Yue	Qi	Engineering, Brown University	Joan Wernig Sorensen Professor of Engineering
Theresa	Windus	Dept. of Chemistry Ames/Iowa St University	Distinguished Professor

Appendix III. Agenda for the Virtual Meeting

DRAFT AGENDA
 Basic Energy Sciences Advisory Committee
 Committee of Visitors for the
 Energy Frontier Research Centers & Energy Innovation Hubs

Virtual Meeting
 October 13-16, 2020
 Zoom sessions will be reserved for 11AM – 4PM each date (all times EDT)

<https://www.zoomgov.com/j/1606625691?pwd=UzZHNIRVUGJMcUJuVmdOWU9kRzdsUT09>

Meeting ID: 160 662 5691
 Passcode: 686279

Preliminary Activities (prior to COV)

Dates	Activity	Description
Week before COV	Background material available to COV	Uploaded into PAMS COV module
10/5/20, 4-5pm EDT	Pre-COV Meetings:	Zoom, SharePoint (ORISE)
10/7/20, 11am-12pm EDT	Zoom intro, PAMS intro, SharePoint intro	PAMS (BES)

ALL TIMES EASTERN DAYLIGHT TIME

Tuesday, October 13, 2020

Time	Activity	Description	Participants
10:45 AM	Zoom Login		All
11:00 AM	Welcome and Charge to the Committee	Marc Kastner (MIT) Chair, Basic Energy Sciences Advisory Committee	All
11:10 AM	Introductions		All
11:25 AM	COV presentations/Q&A: <ul style="list-style-type: none"> • Basic Energy Sciences welcome/overview (10min) • EFRCs (20min) • Batteries Hub (10min) • Solar Fuels Hub (10min) 	Presenters: <ul style="list-style-type: none"> • Linda Horton, Associate Director, Office of Basic Energy Sciences • Andy Schwartz, Robin Hayes • John Vetrano, Craig Henderson • Gail McLean, Chris Fecko 	All
12:35 PM	Instructions and Review of Schedule	Ian Robertson (Univ. of Wisconsin) COV Chair	All
12:50 PM	Break and move to breakout sessions		

1:00 PM	Panel breakout sessions	<ul style="list-style-type: none"> • Further Q&A about background info with BES staff, as needed • BES staff provide introduction to electronic files in PAMS • Panel co-chairs give instructions, assignments to panelists • COV members begin work on reviewing material; BES staff available in the zoom sessions to address questions and assist with PAMS 	COV, BES, ORISE
1:45 PM	Panel breakout sessions continue	Zoom continues for discussions among COV members; BES staff out of zoom breakout sessions, but available by zoom (in DOE Breakout room), email or phone to address questions	COV only (DOE staff available in the DOE Breakout Room)
2:30 PM	Break		
2:45 PM	Panel breakout sessions continue	BES staff in breakout rooms at beginning to answer any questions.	COV only (DOE staff available in the DOE Breakout Room)
3:30 PM	Check-in Meeting between Chair and co-chairs (panel breakout sessions can continue)	Discuss relative progress in panels and observations from discussions and panel check lists/reports; consider any course corrections	COV Chair and Co-chairs BES leadership if requested
4:00 PM	Adjourn breakout sessions for the day	Zoom ends for the day; panelists can continue to work offline; BES staff available to address questions	

Wednesday, October 14, 2020 [All times EDT]

Time	Activity	Description	Participants
11:00 AM	Executive session for all COV (if needed) Panels breakout sessions reconvene	COV members continue reading, discussing, and completing panel check lists and panel reports; BES staff available by zoom, email or phone to address questions	COV only (DOE staff available in the DOE Breakout Room)
12:45 PM	Break		
1:00 PM	Panel breakout sessions continue		COV only (DOE staff available in the DOE Breakout Room)
2:30 PM	Break		
2:45 PM	Executive Session for all COV – report outs from panels leads on the panel reports	COV discusses output from panels and decides if other work is needed (reading new material, bringing new eyes to old material, ...)	COV only (DOE staff available in the DOE Breakout Room)
3:30 PM	Executive Session for Chair and Co-chairs	Discuss initial panel reports and path forward	COV Chair and co-chairs
3:45 PM	Check-in Meeting with BES Leadership	Brief discussion of progress and opportunity to ask questions and obtain clarification on any issues	COV Chair, co-chairs, BES leadership
4:00 PM	Adjourn for the day	Zoom ends for the day, panelists can continue to work offline, BES staff available by email or phone	

Thursday, October 15, 2020 (Details to be updated based on prior day progress) [All times EDT]

Time	Activity	Description	Participants
11:00 AM	COV Executive Session (if needed)	Discuss plan for the day – more time for additional reads to resolve any issues arising from panel reports or move on to finalizing panel reports, summary report and presentation	COV
11:30 AM	Panel breakout sessions (details to be determined by COV co-chairs based on previous progress)	Continue reading/writing if to finalize/update panel reports; BES staff available by zoom, email or phone to address questions	COV
12:45 PM	Break		
1:00 PM	Panel breakout sessions (details to be determined by COV co-chairs based on previous progress)	Continue reading/writing if to finalize/update panel reports; BES staff available by zoom, email or phone to address questions	COV
2:45 PM	Break		
3:00 PM	COV Executive Session	Discuss panel reports, identify key findings and recommendations	COV
4:00 PM	Adjourn for day		

Friday, October 16, 2020 (Details to be updated based on prior day progress) [All times EDT]

Time	Activity	Description	Participants
11:00	Writing Session – completion of report		
TBD	Break		
TBD	COV Executive Session		COV
TBD	Closeout Session with COV and BES	Presentation of key findings and recommendations	COV, BES
TBD	Discussion of Download Clean-up	BES will discuss removal of downloaded files from computers	COV, BES
No later than 4PM	Adjourn		

Appendix IV. Checklists for the Panels

Checklist for EFRC

Checklist for COV Review -- EFRC Selection Process	
	Comments
I. Efficacy and Quality of Processes used for EFRC Selection (a) Solicit, review, recommend, and document proposal actions	
FOAs: Adequate information for potential proposers?	
2018 FOA (broad topical breadth) 2020 FOA (more limited breadth)	
Review process: Consider, for example:	
Overall review process? Pre-proposals process implemented in 2018? Sufficient number of reviews? Qualified reviewers? Quality of reviews (consistent with criteria)?	
Documentation: Consider, for example:	
Summaries of proposals, reviews, and recommendations? Award documentation? Revised budgets? Revised scope?	
II. Impact and Standing of the EFRCs (a) Breadth and depth of awards: Consider, for example:	
Overall quality of awarded EFRCs? Balance of innovation, risk, and interdisciplinary research? Scientific diversity? Institutional diversity? Other?	

Checklist for COV Review -- General EFRC Management	
	Comments
I. Efficacy and Quality of Processes used for EFRC Management Oversight (b) BES management of EFRCs	
General Management approach: consider, for example:	
Communication to and among EFRCs:	
Interaction between BES and EFRCs? Management reference documents? Guidance for Reviews and Reporting?	
Web resources: BES website, community website? Technical summaries?	
PI Meetings	
Annual Reports:	
Instructions? Quality of report?	
Peer reviews:	
Management reviews (2017 and 2019): Consider, for example:	
Guidance provided and documentation received? Reviewers qualified? BES feedback-EFRC response?	
Midterm reviews (2018, 2020): Consider, for example:	
Guidance provided and documentation received? Reviewers qualified? BES guidance-EFRC response?	
II. Impact and Standing of the EFRCs (b) National and international standing of EFRCs	
Are the EFRC PIs leaders in their fields? Are the EFRCs having impact?	

Checklist for Solar Fuels Panel

Checklist for COV Review -- Selection Process	
	Comments
I. Efficacy and Quality of Processes used for Award Selection: Are the approaches for soliciting, reviewing, and selecting awards appropriate?	
Solicitation and Review Process:	
Consider for example: adequacy of information provided in the FOA; approach for merit review; scientific qualifications of reviewers; adequacy of information provided to reviewers and to applicants; and consistency of reviews and recommendation(s) with priorities and criteria stated in the FOA.	
Documentation:	
Consider for example the quality and completeness of information provided in the debriefs, selection statements, and declination memos.	
II. Impact and Standing of Awards: Is the quality and potential for impact of selected projects appropriate?	
Quality of Awards:	
Consider for example if the award decisions, including project selection and funding level, are justified by the quality of the proposals, including the importance of scientific goals, the balance of innovation and risk, the novelty of scientific and technical approaches, the competency of personnel.	
Potential for Impact in Energy Science:	
Consider for example: potential and/or actual impact of awards; uniqueness, significance, and potential for scientific progress; the stature of the principal investigators in their fields; the leadership position in the nation; and the relevance to the DOE's mission	

Checklist for COV Review -- JCAP Management	
	Comments
III. Efficacy and Quality of Processes used for JCAP Management Oversight: Are the processes being used effectively for program management?	
Annual and Quarterly Reports:	
Consider for example guidance on the format and content of reports.	
2017 On-Site Review	
Consider for example: adequacy of notification and guidance for review document; qualifications of the reviewers; adequacy of information provided to reviewers; format of review; appropriateness of BES guidance letter and JCAP response.	
2018 On-Site Review	
Consider for example: adequacy of notification and guidance for review document; qualifications of the reviewers; adequacy of information provided to reviewers; format of review; appropriateness of BES guidance letter.	
2019 On-Site Review	
Consider for example: adequacy of notification and guidance for review document; qualifications of the reviewers; adequacy of information provided to reviewers; format of review; appropriateness of BES guidance letter.	

Checklist for JCESR

Checklist for COV Review -- JCESR 2018 Renewal	
	Comments
I. Efficacy and Quality of Processes used for renewal: Are the approaches for soliciting, reviewing, and evaluating the proposal appropriate?	
Solicitation and Review Process:	
Consider for example: adequacy of information provided to JCESR; approach for merit review; scientific qualifications of reviewers; adequacy of information provided to reviewers and to JCESR; and consistency of reviews with recommendation(s)	
Documentation:	
Consider for example the quality and completeness of information provided in the debriefs and guidance letters	
II. Impact and Standing of Awards: Is the quality and potential for impact of the award appropriate?	
Quality of Awards:	
Consider for example if the award has high quality, including the importance of scientific goals, the balance of innovation and risk, the novelty of scientific and technical approaches, and the competency of personnel.	
Potential for Impact in Energy Science:	
Consider for example: potential and/or actual impact of award; uniqueness, significance, and potential for scientific progress; the stature of the principal investigators in their fields; the leadership position in the nation and the world; and the relevance to the DOE's mission	
Checklist for COV Review -- JCESR Management	
	Comments
III. Efficacy and Quality of Processes used for JCAP Management Oversight: Are the processes being used effectively for program management?	
Annual and Quarterly Reports:	
Consider for example guidance on the format and content of reports.	
(d) 2017 Assessment	
Consider for example: adequacy of notification and guidance for review document; qualifications of the reviewers; adequacy of information provided to reviewers; format of review; appropriateness of BES guidance letters and JCESR responses.	
(e) 2019 On-Site Science and Management Review	
Consider for example: adequacy of notification and guidance for review document; qualifications of the reviewers; adequacy of information provided to reviewers; format of review; appropriateness of BES guidance letter and JCESR response.	