FY 2015 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

Date of COV: April 22-23rd, 2015
Program/Cluster/Section: All Programs
Division: CBET
Directorate: ENG
Number of actions reviewed: 322 **Awards: 135** **Supplement Awards: 39** **Declinations: 134** **Other: 14**
Total number of actions within Program/Cluster/Division during period under review: **Awards*: 1832** **Declinations*: 8508** **Other: 163** ***Competitive Proposal Actions**

Manner in which reviewed actions were selected:

CBET has 17 programs divided into 4 clusters, Chemical and Biochemical Systems (CBS), Bioengineering and Engineering Healthcare (BEH), Environmental Engineering and Sustainability (EES), and Transport, Thermal, and Fluid Phenomena (TTF). The proposal actions, also referred to as "jackets", were downloaded by CBET staff to cover fiscal years (FYs) 2012-2014 from the Enterprise Information System (EIS) at NSF. CBET staff removed from the detailed list the following types of proposals and actions: special initiatives/cross-directorate programs not exclusively organized by CBET staff, forward-funded awards, IPA agreements, continuing grant increments, and other proposals that fall outside the scope of the COV.

COV Membership

	Name	Affiliation
COV Co-Chairs:	Dr. Linda M. Abriola	Dean of Engineering and Professor of Civil & Environmental Engineering, Tufts University
	Dr. Mary Jane Hagenson*	Vice President for Research & Technology, Chevron Phillips Chemical Co. (Retired)
COV Members:	Dr. Gretchen Bair	Associate R&D Director of External Technology, The Dow Chemical Company
	Dr. Kenneth Ball	Dean, Volgenau School of Engineering, George Mason University
	Dr. Sue Ann Bidstrup-Allen	Professor, Department of Chemical and Biomolecular Engineering, University of Pennsylvania
	Dr. Christopher Bowman	Distinguished Professor and James and Catherine Patten Endowed Chair, Department of Chemical and Biological Engineering, University of Colorado
	Dr. Jennifer S. Curtis	Distinguished Professor, Department of Chemical Engineering, University of Florida
	Dr. Joseph Freeman	Associate Professor, Department of Biomedical Engineering, Rutgers University
	Dr. Peggy Johnson	Professor and Department Head, Department of Civil Engineering, Pennsylvania State University
	Dr. Sharon Jones	Professor and Dean, Donald P. Shiley School of Engineering, University of Portland
	Dr. Kimberly Ogden	Professor, Department of Chemical and Environmental Engineering, University of Arizona
	Dr. Concetta LaMarca	Senior Research Consultant, Reaction Engineering, DuPont Engineering Research and Technology

	Dr. Martine La Berge	**Professor and Chair, Department of Bioengineering, Clemson University**
	Dr. Gintaras "Rex" Reklaitis	**Burton and Kathryn Gedge Distinguished Professor, Department of Chemical Engineering, Purdue University**
	Dr. William Tumas	**Associate Laboratory Director, Materials and Chemical Science Technology, National Renewable Energy Laboratory**
	Dr. Kyriacos Zygouraki	**A.J. Hartsook Professor, Departments of Chemical Engineering and Bioengineering, Rice University**

***NSF Engineering Advisory Committee Member**

INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, and withdrawals) that were *completed within the past three fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program(s) under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

I. Questions about the quality and effectiveness of the program's use of merit review process. Please answer the following questions about the effectiveness of the merit review process and provide comments or concerns in the space below the question**.**

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCESS	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE
1. Are the review methods (for example, panel, ad hoc, site visits) appropriate? Comments: There is clear evidence that CBET staff and reviewers are diligent and responsible in conducting proposal reviews as fairly as possible. The reviewers judge the proposals based on the proposed work, on the ability of the PI and/or co-PIs to perform the work, on the inclusion of any preliminary data and its significance, and on the appropriateness of the outreach or educational part of the Broader Impact section. A number of panels did not comment on the appropriateness of the budgets or comment on the resources available to the researchers to perform the work. The consensus of the COV is that the review methods are appropriate. The large majority of reviews were done by panels. Many of the panels utilized hybrid reviews, with a mix of ad hoc reviews considered by the panel members. In some cases, the ad hoc reviewers also served as panel members. The size of the review panels was variable, as was the number of ad hoc reviews. It was difficult for the COV to determine whether some reviews were hybrid or ad hoc since the "Review Record" or Form 7 was not uniformly	YES

completed. One column on the form should have either an “R” for “Reviewer”, a “P” for “Panelist”, or a “B” for “Both”, but oftentimes had none of these symbols, or a “1” or a “2” which were not defined. Likewise, the column for Reviewed (R), Not Reviewed (N), COI (C), or Late (L) often had other symbols or none at all. The Reviewer Rating column was also inconsistently filled in. Very few of the jackets that were reviewed received fair to poor ratings. Most jackets (both funded and non-funded) received rankings that ranged from good to excellent. Guidelines are unclear for differentiating between E, VG, G, F, P ratings and how these ratings translate to HR, R, NR decisions.	
2. Are both merit review criteria addressed a) In individual reviews? In general, the individual reviews do a very good job addressing both merit review criteria. b) In panel summaries? The panel summaries address both merit review criteria, although not as consistently as the individual reviews. Some panels appear to give greater consideration to Broader Impacts, while others appear to give greater consideration to Intellectual Merit. c) In Program Officer review analyses? The Program Officers address both merit review criteria, although not as much detail is given for Broader Impacts. Comments: The Broader Impact criterion may benefit from more explanation and description, and clearer guidance as to how it should be assessed. There is evidence of a wide range of interpretation among both PIs and reviewers about what constitutes broader impact and how it should be weighted in the proposal ratings. In some cases it is viewed as technical impact beyond the immediate project. In others, outreach to underrepresented groups or K-12 students. In addition the Broader Impact criterion appears to be used by reviewers more as a tie-breaker rather than a more substantial and equally weighted criterion. Not all of the reviewers addressed the strengths and weaknesses of the	 YES YES YES

proposal, despite templates that instruct reviewers to assess strengths and weaknesses for both merit review criteria. Also, if there are no weaknesses for a specific review criterion, this should be explicitly stated.	
3. Do the individual reviewers giving written reviews provide substantive comments to explain their assessment of the proposals? Comments: Most of the reviewers gave very detailed and substantial comments. However, some of the assessments were superficial and left the impression that the proposal either was not read carefully or the reviewer was not an expert in the field. A common example of a superficial assessment is summarizing the goals and objectives of the proposal without any meaningful critique. In these cases, another review should be obtained, especially if there are only three reviews (or fewer). Alternatively, affected proposals could be assigned to a panel for a more thorough review or considered by the PD for final funding decisions.	YES
4. Do the panel summaries provide the rationale for the panel consensus (or reasons consensus was not reached)? Comments: The panel summaries are typically a nearly verbatim compilation of the individual reviewer comments, with consensus being implied. However, in cases where individual reviewer comments reflect some disagreement on proposal ratings and merit, it is not clear how or whether consensus is reached. It is noted that at least in a few cases, the panel summary stated that there were “no weaknesses noted”, while there were in fact some weaknesses noted in at least one individual review. Contradictory statements such as these should be avoided.	YES
5. Does the documentation in the jacket provide the rationale for the award/decline decision? Comments: In some cases, especially for proposals that were awarded, the rationale was very detailed and well documented. In other cases, especially for proposals that were declined, the explanation was very scant. Minimal	YES

documentation seems to be more pervasive in declined proposals. A number of them gave no detail, but rather just stated that the program director agrees with the reviewers. In several cases, the reviewers recommended the proposal for funding, but the Program Officer declined it without any explanation other than a generic standardized statement. These types of cases, in particular, would benefit from more detailed documentation. In addition to the written commentary feedback, the breakdown of all proposals into HR, R, NR really helps put any feedback into perspective. Since the proposal process is so competitive, it is not always clear from the written feedback which proposal will be funded. Therefore for an R (or even a HR) proposal that is not funded, it is assumed that funds simply ran out first. However, the rationale for funding and the reason why a recommended proposal is not funded should be documented. Furthermore, since the COV is only reviewing a sample of all CBET proposals, we cannot comment further on situations where an R rated proposal was funded over a HR proposal. If this in fact does occur, the methodology for making these decisions should be reviewed and critically assessed by CBET.	
6. Does the documentation to the PI provide the rationale for the award/decline decision? Comments: The rationale for the award or decline decision was generally included in the documentation to the PI. The feedback to the PI is nearly identical to the internal documentation, only with identifying information of the reviewers removed. Thus, many of the COV comments in Question 5 also are germane to this question. In particular, the PO comments could be more detailed for proposals that are declined funding.	YES
7. Additional comments on the quality and effectiveness of the program's use of merit review process: Some EAGER proposals had levels of funding that were significant (up to $200,000), raising the question of whether ad hoc reviews should be obtained or if the cap for funding EAGERs without external reviews should be lowered.	

II. Questions concerning the selection of reviewers. Please answer the following questions about the selection of reviewers and provide comments or concerns in the space below the question**.**

SELECTION OF REVIEWERS	**YES , NO, DATA NOT AVAILABLE, or NOT APPLICABLE**
1. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments: Overall the program does make use of reviewers having appropriate expertise and/or qualification. The reviewers selected seemed well qualified to assess the merit of the proposals reviewed. Each panel reflected a breadth of experience, with at least one senior more prominent researcher in the field, complemented by talented young researchers and occasionally non-academic reviewers. There was a mix of disciplines as appropriate to the focus of the proposal. The assignment of panel members to provide written reviews likewise was generally appropriate with at least one member clearly expert in the area. Detailed comments about impact of the work and about potential pitfalls in the research plans indicated that the reviewers were well selected for their respective proposals. The selection of reviewers by geographic region does seem to be generally proportional to the relative number of research-intensive universities in that region. It should be emphasized that the collective COV comments on the appropriateness of reviewers are based on a high level evaluation of reviewers' backgrounds based on acquaintance with that individual or by recourse to their individual websites. Not all reviewers had descriptive web sites but the information available did indicate that these individuals generally had relevant expertise and research programs. The chart that shows the background of the reviewers is helpful along with information about where the reviewers publish. The PDs should stress that all reviewers provide information on their expertise when they are part of a panel. Among the jackets involving proposals reviewed by only the program director, decision was made without external review (reviewed by Program Director only). In most cases, a thorough review was provided by the PD, justifying the	YES

recommendation to fund or not fund. However, to insure consistency between PDs, it would be desirable that a sufficient level of justification be provided for all such funding decisions.	
2. Did the program recognize and resolve conflicts of interest when appropriate? Comments: Based on the information provided it appears that the program recognizes and resolves conflicts of interest when appropriate. The PDs all included statements regarding the handling of potential COIs and, from the jackets reviewed, all protocols were followed. Individual reviewer's forms generally indicated no conflicts. In cases where a conflict did exist, the panelists and/or PD's with COI left the room when the proposals were discussed.	YES
Additional comments on reviewer selection: The COV concludes that NSF has made considerable efforts to ensure a diverse make-up of the panels particularly relative to ethnicity and gender. Not all panels had representatives outside of academia. The COV urges NSF to continue to be inclusive in review panels and strive for diversity. The size of review panels appears to vary with panels as small as 4 members and as large as 27. It is not clear how panel size was determined, and the COV questions whether very large panels can be as effective as those of more moderate size. The COV recommends that CBET conduct a review of panel size and effectiveness across the division.	

III. Questions concerning the management of the program under review. Please comment on the following:

MANAGEMENT OF THE PROGRAM UNDER REVIEW
1. Management of the program. Comments: **Strategic Management of Research Portfolio:** A key component of CBET's continued success is the pursuit of crosscutting research. CBET Program Directors (PDs) should be allowed considerable latitude in determining their research portfolio while being constantly alert to emerging and frontier areas. In its response to the 2012 COV report, CBET indicated that it had developed a strategic plan that formed the basis of a road map for all programs while allowing PDs wide latitude. The 2015 COV review revealed that while a strategic plan exists at the Foundation and Division levels, no detailed strategic roadmap has been finalized for CBET. The 2015 COV strongly recommends that CBET document this planning process. Such a planning process should be ongoing and transparent with input from stakeholders along with the assessment of programmatic success. This issue is further elaborated in #3. **Recruitment and Mentoring of Program Directors:** The current PDs appear to be well qualified. However the process for recruitment and mentoring of PDs was not clearly defined. Since roughly half of the PD's are rotating positions, CBET would benefit from increased procedures and documentation on this critical staffing process. **Management of the Review Process:** In general, the quality of the reviews and the review process is high and provides scientific justification for the funding decisions. The PDs in CBET appear to do an outstanding job of getting the proposals reviewed and decisions made in a timely manner, despite the large increase in proposals received. Based on the information provided, there is no indication of any systematic bias or flaws in the decision-making process. Generally, the reviews correlate well with the final decisions that are made, and the summary reviews often address differences of opinions that may arise between individual reviewers. It is noted that in more than one case, proposals from the recommended (R) category were funded over those in the highly recommended (HR) category. This strategy is acceptable and aligns with

giving the PDs latitude as long as any HR proposals that may be displaced include a comparative justification in the summary.

The COV noted that the second question of Criterion #3 (i.e. plan for assessment of success) was not always addressed. The COV strongly recommends that all proposals clearly describe not only what they propose and how they plan to do it, but also how they will know if they succeed and what technological or other benefits to society could accrue if the project is successful. A template may address this issue. In general, increased focus is recommended on discerning measures of success for all proposals.

Situations were noted where two out of the three reviews are strongly positive but devoid of substantive arguments about the merits of the proposal, while the third reviewer presented a detailed critique raising significant concerns about the main hypotheses of the proposal, its research methods or both. In such cases, the PD should follow a clearly defined process to reconcile these conflicting opinions. This discussion and its conclusions should be carefully documented in the Review Analysis statement. When there is significant disagreement among the reviewers, the PDs should be encouraged to invite the PIs to provide responses to the critical reviews.

The COV did not receive information about the guidelines and procedures for addressing reviews that are inappropriate for one reason or another. Since this situation is inevitable, this process should be reviewed and documented.

The COV noted situations where feedback to the PI was not specific enough for the PI to understand how to improve his/her proposal for better chances of success at a later date. The COV recommends that reviewers and panel summary writers address all elements of the intellectual merit and broader impact of the proposal, and provide more specific feedback to the PI, especially in the cases where the proposal is not recommended for funding.

Distribution of Proposal Load and Success Rates:

CBET has the highest proposal burden relative to the number of full time staff, along with the lowest proposal funding success rate of the divisions in the ENG directorate. Many R and some HR proposals are not being funded and this is a loss for the scientific community and society.

The number of proposals submitted to the four clusters of CBET increased by more than 10% between 2012 and 2014. During this same period, proposals for the CBS (Chemical and Biological Systems) cluster increased by more than one third, with a corresponding drop in success rate of approximately 5%. A drop of more than 5 percentage points is very significant for the already low success rates of a major CBET cluster and should be addressed. EES (Environmental Engineering and Sustainability) had the second largest increase in total proposals submitted at just below 11% and saw its success rate decrease by approximately 2% between 2012 and 2014. Similar situations exist for other CBET clusters. The differences for individual programs were even more dramatic. In 2014, the Catalysis and Biocatalysis program (1403) saw a nearly two thirds increase in submitted proposals over the corresponding 2012 number, while the Process and Reaction Engineering (1403) and Fluid Dynamics (1443) programs saw increases of approximately 40% over the same period.

CBET is severely challenged to manage this increased influx of strong proposals in these critical areas while maintaining flat budgets overall. The COV believes this is an issue that will persist and as was suggested earlier, a well-documented directorate and division-wide strategic plan that is consistent with NSF's strategic plan should be put in place to streamline the funding and selection process.

Proposal Processing Time:

CBET has done an excellent job of processing proposals, with the average processing time in 2014 remaining almost unchanged since 2012 at about 5 months, despite a more than 10% increase in proposals received. Since the 2012 COV review, CBET has moved to a single submission window for unsolicited proposals that helped to streamline the review process. It was noted that a couple of programs were lagging the others in conducting timely reviews.

The COV recommends continued evaluation and development of new methods to expedite and streamline the proposal review process, including use of virtual panels.

2. Responsiveness of the program to emerging research and education opportunities.

Comments:
The COV commends CBET for its efforts to explore future directions. CBET sponsored nine workshops in 2013 and 2014 aimed at soliciting input on future directions worthy of research support. Workshop topics ranged from mapping of the human brain and advanced bio-manufacturing, to process intensification and the water-energy nexus. Bringing together academic researchers and industrial practitioners, these workshops served to identify past successes and outline future research opportunities in their thematic areas. Research challenges and potential solutions were summarized in journal publications and/or reports that were widely disseminated. These are highly meritorious efforts and should continue.

The COV encourages CBET to continue these excellent efforts and to work with the Directorate to develop a hierarchy for decision making on future directions options and efforts, in keeping with NSF and national priorities. Such efforts may result in more funding directed to CBET.

3. Program planning and prioritization process (internal and external) that guided the development of the portfolio.

Comments:

The 2012 COV report identified "structural impediments" to the development of a strategic vision for CBET. The 2015 COV notes that continued efforts to clarify and document decision making are required for setting the funding priorities for CBET. We strongly encourage CBET to develop a decision making framework with specific goals and metrics to determine its success. This documentation is particularly important in times of constrained resources.

The COV believes that CBET's funding strategy will benefit from a documented and transparent strategic planning process. In addition, we recommend that CBET develop a robust process to evaluate the indicators of success and use that information to inform the ongoing continuous evaluation of funding priorities.

It is very important that young investigators (but also senior ones who enter another research area) can propose a new idea that conforms to the mission and the research portfolio of the Division. Arguments against "dilution of impact" should not lead to the other extreme where funding priorities imposed by strict roadmaps become the main determining factor in a decision. CBET should maintain a balance and judge every proposal on its own merits, assuming of course that it fits within the strategic focus areas of the Division and Directorate.

CBET has done a good job in sponsoring workshops and discussions about future directions (as described above), but the results of these longer range efforts would benefit from increased documentation. The information on CBET's portfolio model (the two slides provided) is a nice illustration of a cyclic process, but CBET did not present specific examples of the implementation of that process cycle with evidence as to how an area was identified that subsequently resulted in more proposals being funded in that area, particularly within the regular award process as opposed to separate RFPs.

It is important for CBET to stay abreast of the latest developments in its focus areas and future directions. Additional funding for workshops and PD visits to universities and research centers is encouraged, as well as new methods, such as virtual conferencing, to gather critical new ideas and enhanced interaction.

4. Responsiveness of program to previous COV comments and recommendations.

Comments:
The recommendations from the previous COV were followed, with continued efforts needed on the CBET-specific strategic plan.

The COV commends CBET for conducting workshops in 2013 and 2014 to inform the research community of emerging research opportunities and help CBET sharpen its focus. In addition, CBET has partnered with the Department of Energy, the Electric Power Research Institute (EPRI), and other government agencies to address critical fundamental and applied research challenges associated with vehicle applications, electric power plants, combustion engines, and hydrogen production.

The change to a single window seems to have helped maintain proposal processing time despite a more than 10% increase in proposals received from 2012 to 2014. However, the COV believes that the CBET funding levels remain too low and has concerns that the strongest PIs may seek funding elsewhere. Increased CBET funding would help to insure that CBET continues to play a leading role within NSF and the Engineering Directorate while fulfilling its mission to "transform the frontiers of science and engineering".

The COV believes that CBET would benefit from a template of strengths and weaknesses for both review criteria that panel reviewers must use.

IV. Questions about Portfolio. Please answer the following about the portfolio of awards made by the program under review.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE, OR DATA NOT AVAILABLE
1. Does the program portfolio have an appropriate balance of awards based on the following considerations: ▪ -disciplines and sub-disciplines of the activity? ▪ -geographical distribution of Principal Investigators? ▪ -types of institutions? ▪ -for new investigators? ▪ -underrepresented groups? Comments: Overall, the COV concluded, based on compiled data, that the program appears to have a good balance of awards across disciplines, geographies, institutional type, PI experience, and other demographic considerations. In addition, the connectivity map of collaborative projects among university departments provided to the COV shows strong collaborations among disciplines. Overall, there appears to be a good balance among the engineering, math and science disciplines represented by the Principal Investigators (PIs). The COV was unable to comment about sub-disciplines, as there was not enough information provided. Geographically, there was a reasonable distribution of institutions particularly given the distribution of research institutions. The geographical distribution of awards appears to be consistent with the distribution of research-intensive Ph.D. institutions, with some regional variation by discipline and sub-discipline. All regions of the US were represented and at least one grant was given to each state. The largest number of grants went to the 4 states (CA, TX, NY, PA) with the highest number of high or very high research active universities. The number of awards to PIs from "Master's only" universities and 4-year institutions is representative of the number of proposals submitted from those institutions. The information provided by CBET shows that more than 25% of awards go to new investigators, although the fraction of new awards varied widely among the various programs. While the number of new PIs awarded NSF	- APPROPRIATE

funding was viewed as positive and speaks well to bringing in new talent and ideas, there is some concern about the sustainability of roughly 25% of awards going to new awardees, particularly in the likely continuing flat budget environment. While NSF continues to make efforts in inclusivity to assure that all scientists and engineers from under-represented groups are encouraged to participate, the assessment of grants awarded to under-represented groups is still low but is reflective of the demographics in engineering departments. Very small numbers of awards were made to individuals with disabilities and/or from African-Americans, Hispanics, and multi-racial groups. The award rates seem to match the demographics of submitted proposals for most groups; however, the COV observed that the total number of awards and success rates for proposals from African Americans were actually considerably lower than the other groups. This situation warrants further study and assessment. The COV highly recommends that NSF provide statistical analyses of the raw data so that future COVs can better interpret the balance of awards based on the various considerations.	
2. Are awards appropriate in size and duration for the scope of the projects? Comments: The COV highly recommends a re-assessment by CBET of the size and duration of their awards. In particular, the committee is concerned that the typical size of award around $100K/year has not changed for quite a long time, is lower than the average NSF and Engineering Directorate award, and has not kept pace with the rising costs of academic research due to increases in stipends, tuition, overhead, materials and supplies. There was some concern within the COV whether the size of CBET awards is still sufficient for transformative research. This suggestion was made by the previous COV but does not appear to have been addressed. However, this COV is concerned about the downside (even lower success rates) of any significant increases in the average amount of individual awards while the CBET budget remains flat. A balance must be maintained between award amount and funding highly meritorious proposals in traditional and emerging areas. Development of key success metrics could guide this effort. The majority of the awards are for 3 years. By design, EAGER and RAPID awards are of shorter duration and CAREER awards are for 5 years. If NSF intends to establish, build and sustain effective collaborations between PIs	APPROPRIATE

and industry, it may want to assess the appropriate duration for GOALI and related programs. The appropriateness of the duration should be tied directly to an assessment of the program success against CBET metrics.	
3. Does the program portfolio include awards for projects that are innovative? Comments: Overall, the proposed work was deemed to be innovative, and the program portfolio is diverse and addresses a number of topics that are novel. Many of the awarded proposals had new and innovative methods, hypotheses, or techniques as indicated by the reviewers and panel summaries. In general, PIs emphasized what is new and unique in the proposed research whether bringing innovative approaches to current problems or addressing novel problems. The research highlights from the CBET website reveal that CBET has funded some truly innovative projects in areas of critical national importance. COV members identified a number of specific innovative examples during their review. For example, a number of projects explored the study and use of various micro- and nanotechnologies in a variety of settings, ranging from combustion systems, computational design and synthesis of materials, cancer therapies, biomass conversion and renewable energy, and improved and safer batteries. The COV recommends that results oriented data be provided on the number and quality/impact of publications and patents for CBET as well as a comparison/benchmark with other NSF programs.	APPROPRIATE
4. Does the program portfolio include inter- and multi-disciplinary projects? Comments: Given the size of the awards, the degree of inter- and multi-disciplinary interactions is impressive with an array of interactions between co-PIs in different disciplines for many of the funded awards. Projects combine engineering, biology, medicine and physiology, chemistry, physics, micro- and nanotechnology, and other subjects. Corresponding to the multidisciplinary nature of the research, many of the integrated educational programs are themselves multidisciplinary in nature, and even involve students from different majors and disciplines. The funded proposals generally include the rationale for bringing together investigators with different backgrounds to tackle the research activity. The connectivity map provided to the COV showing the departmental affiliations of PIs indicates significant inter- and multi-disciplinary collaborations for the funded projects. NSF should assure that its review process continues to foster collaborative multi-disciplinary proposals.	APPROPRIATE

The multi-disciplinary nature of CBET may stem from the breadth of fields it spans and its organizational structure not being solely aligned by disciplines. This structure provides an important link between universities that are aligned by discipline and key problems including those from mission funding agencies (which are often aligned by end use, such as solar).	
5. Is the program relevant to national priorities, agency mission, relevant fields and other constituent needs? Include citations of relevant external reports. **Comments:** The CBET program is extremely relevant to national priorities, agency mission, relevant fields, and other constituent needs. The CBET programs support innovative research and education in fields of chemical engineering, biotechnology, bioengineering and environmental engineering and in areas that involve transformation and/or transport of matter and energy by chemical, thermal or mechanical means. The breadth of these programs cuts across the entirety of NSF with projects that are highly relevant to national priorities and needs. There is clear alignment with major initiatives in the US and the NSF mission as documented by the workshop reports, the cross-agency collaborations, and the research highlights. CBET is to be commended for initiating collaborative efforts with other national funding agencies, including EPRI and DOE to support multidisciplinary grants in key research areas. CBET has partnered with DOE or the Electric Power Research Institute (EPRI) in four separate proposal calls between 2012-2014 to address critical fundamental and applied research challenges associated with vehicle applications, electric power plants, combustion engines and hydrogen production. Examples of high impact projects include work that could lead to waterless power plant cooling and enhanced efficiencies, leading to water and energy conservation and reduced emissions. Two projects in the combustion area could lead to reduced fuel consumption and reduced pollutant emissions and better air quality, as well as a reduction in greenhouse gas emissions. Another project could lead to a breakthrough in the design of electric batteries and an alternative to lithium-ion batteries, leading to more widespread use of electric vehicles and safer power supplies for consumer electronics. Other projects could lead to new and more effective cancer therapies, and rehabilitation of stroke victims suffering from loss of speech. Another project supports the NSF initiative of “Materials by Design” and the computational design and synthesis of nanostructures with pre-engineered properties.	APPROPRIATE

NSF in general, and CBET in particular, are in a unique position to encourage cross-agency and university-industry partnerships and has a number of funding modalities to create and lead new initiatives. It is important not to lose focus on traditional areas that provide the foundation for new initiatives. For example, a balance of projects focused on traditional energy and renewal energy is critical as both are relevant to national priorities. The Special Funding project on advanced combustion is a good example. With input from a distinguished group of technological thinkers from around the world, the National Academy of Engineering has recently identified the Grand Challenges for Engineering in the 21st Century. Organized around broader thematic themes like Sustainability or Health, several of these Grand Challenges can be addressed by research that has been supported for a long time by CBET. For example, CBET's Mission Statement encompasses the following Grand Challenges: - Make solar energy economical, - Develop carbon sequestration methods, - Provide access to clean water, - Engineer better medicines, and - Reverse-engineer the brain. The CBET focus areas align with research agendas emanating from this and other national committees. CBET coordinated 9 workshops in a number of key areas relevant to national priorities between 2012-2014. The topics for the workshops supported were broad and relevant. The reports that were in the format of publications were the most informative and the COV recommends that NSF require this type of report in the future. CBET should ensure the participation of some early career faculty in workshops. It is also clear that CBET is helping educate the next generation of Ph.D's in science and engineering as well as educating the general public about scientific advances.	
6. Does the program portfolio include projects that integrate research and education? **Comments:** A key part of the NSF strategy per the strategic plan is to "seamlessly integrate the education of future scientists, engineers, and educators into the broad portfolio of research." The CBET program requires an integration of research and education, which is further encouraged by the inclusion and	APPROPRIATE

adherence to the Broader Impacts review criteria. The integration of education with research is especially prominent in the CAREER and Research Experiences for Undergraduates (REU) programs. The CAREER awards were designed to include an educational component. Many of the unsolicited proposals also include an educational component that is in line with the amount of funding. Some projects propose to develop means to transmit the research findings into pre-college classrooms. Significant outreach in many proposals also serves as education development.	
7. Additional comments on the quality of the projects or the balance of the portfolio **Comments:** There was great balance with respect to the topics of the proposals. They ranged from materials, to imaging, to robotics, to modeling. A wide variety of awards were also included (unsolicited, CAREER, GOALI, and REUs). CBET presented examples of initiating new programs and sun setting of others, indicating responsiveness to emerging research areas. Review of funded proposals reveals a distribution of awards targeted to the development of new faculty, support for potentially transformative research, high risk/rewards efforts, as well as collaboration among universities and research organizations.	

OTHER TOPICS (Section V)

1. Please comment on any program areas in need of improvement or gaps (if any) within program areas.

   The COV did not identify any significant gaps within the program areas. As discussed above, CBET is a very interdisciplinary and broad division. Its program areas encompass a wide range of topics and are organized very effectively, clustered in broad application areas rather than disciplines. This organization is also flexible, allowing new areas to emerge or areas to be combined. Historically, clusters and program areas have evolved, as proposal submission numbers fluctuate and new research thrusts are identified.

   The COV lauds the division for its efforts to develop a comprehensive portfolio assessment process. This process will be crucial to the support of division planning and prioritization in the future, including identifying new areas for workshops and investments. Broadly speaking, there is a clear need for sustained strategic planning across the division. As described to the COV, it appears that the current strategic planning and assessment process is organized primarily around budget planning. This approach to strategic planning appears to have been successful in producing new initiatives, sun setting others, and developing cross-division collaborations. However, it is not well described or codified in any document or flow chart. This makes assessment of the process and continuous improvement difficult. Thus, looking forward, the COV recommends that CBET put additional effort into documenting its planning and portfolio assessment processes, facilitating further discussion and refinement.

   One example of the need for strategic planning relates to planning for the CBS Cluster. This cluster is currently significantly smaller than the others in the division with respect to both funding and number of PDs and is also facing a critical transition period as one of its long serving PDs retires. It will be important, as a part of its strategic planning process, that CBET consider how to strengthen this cluster to assure its long term success.

   Given the breadth of the program portfolio and the dynamic process of identifying new areas for funding (e.g., the water-energy-food nexus), the COV also suggests that CBET devote effort to considering what may be an appropriate balance between the funding of more “traditional” areas (e.g., reaction engineering) to “emerging areas” (e.g., earth systems engineering). Obviously, both traditional and emerging areas are vital to the sustained health of the US scientific/engineering enterprise. It is crucial that CBET continue to fund proposals that are the most innovative and have the highest potential for impact, regardless of how they may be labeled or categorized.

2. Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

CBET has been most effective in its identification and support of innovative and impactful research projects across a diversity of program areas. In addition, the PDs and their staffs have been extraordinarily efficient in handling the large division proposal load. The COV wishes to make one general observation, however, which relates to performance assessment. In its efforts to evaluate specific performance metrics, the COV had access to few statistical analyses, i.e., the data presented to the COV were primarily raw (number) data. It was not clear to the COV whether CBET (or NSF) has defined procedures to routinely analyze and report metrics of interest, e.g., as relate to geographic and demographic breakdowns of proposals and success rates, or publications resulting from NSF funded research. There also does not appear to be a routine procedure to capture and report funding for CBET program areas that is derived from external sources (e.g., other government agencies). Better approaches to data analysis would facilitate tracking of metrics, which would, in turn, provide CBET a stronger foundation for self-assessment and benchmarking against other divisions within NSF.

3. Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

The move to web-based submission of project final reports creates an excellent opportunity for CBET and other NSF divisions to capture project data and develop and track metrics to assess project success for both of its review criteria (intellectual merit and broader impacts). These metrics could span such areas as quality of scholarship, discoveries/innovations, follow-on research, career development, etc. During the CBET review process, the only information shared with the COV on project success was primarily anecdotal in nature and project-specific, e.g., specific examples of PI awards, tech transfer activities, and high impact publications. No, more general, project success metrics were described or reported. Although we recognize that data capture and analysis will not be trivial to implement, the COV strongly believes that an investment of effort in this area will reap substantial benefits. We recommend that a standardized data mining procedure be developed and associated project success metrics be created and tracked across the directorate.

Although evidence of research quality and impact was presented and discussed at the COV review, it was less clear from the information provided how CBET tracks and reviews the impact of project elements associated with the integration of education with research. Many of the division's funded proposals incorporate educational outreach objectives as part of their plans to address the broader impact criterion. However, there does not seem to be methodology developed for determining "success" resulting from the considerable funding and efforts spent on this key criterion. The COV recommends that NSF consider this concern as it reviews the broader impact criterion overall. Given the relatively small size of the average research award, it is also recommended that CBET consider developing guidance on the appropriate balance

between project funds (and effort) spent on these educational integration activities versus funds spent on project research.

A healthy fraction of the total funds in the CBET division are being awarded to new researchers each year. Most of these awards are early career awards, which have longer durations than other investigator awards and carry sizeable commitments of resources. While COV applauds CBET's efforts to support young investigators, it is not clear that this level of funding will be sustainable, if the health of the entire research ecosystem is to be maintained. Thus, it will be important that CBET consider the role that early career awards should play in the division and to assess the success of the CAREER program. To this end, program metrics must be defined that are aligned with program goals. In pursuit of its program goals, the division may also want to consider other, shorter duration, funding vehicles that can serve to develop and support new talent, e.g. small research initiation grants.

The large CBET proposal burden was identified in the previous CBET COV report as a major issue that needed to be addressed. The COV notes that, since that report was written, CBET has undertaken a number of changes to streamline the proposal review process, including the adoption of a single submission window. While the number of submitted proposals did decrease somewhat in response to these changes, it has since begun to rise again, and the proposal workload is still extremely large in comparison with most divisions across the directorate and NSF as a whole. Although virtual panels have been employed in some instances (for small programs), the proposal submission and review process has remained relatively unchanged over many years. Although we recognize that all approaches have flaws, the COV suggests that CBET consider and pilot alternative methods to select projects for funding. Given the low funding success rate dictated by the large proposal volume, the COV believes that researchers may also be receptive to such alternative approaches. This will be particularly true for approaches that reduce the burden on the proposer, such as those incorporating pre-proposal submission and screening. Over time, sharing of experiences and best practices among the divisions in the directorate may lead to a better model.

4. Please provide comments on any other issues the COV feels are relevant.

The Engineering Directorate and CBET benefit greatly from talented faculty and staff who bring fresh energy, expertise and insight to the division as they fill rotator positions. Within CBET, the Division Director, as well roughly half of the 17 Program Directors are rotator positions. This creates a dynamic environment and broadens participation within the CBET Division.

The COV understands and greatly values these positive aspects of rotator positions, but also notes that business continuity can be negatively impacted by changes in leadership and prolonged vacancies, which occasionally occur. In times of turnover, strategic planning and continual improvement efforts can take a back seat to more tactical issues.

The COV recommends that CBET develop and document a Business Continuity Plan to enhance management of the process to fill rotator positions. This plan would review the current

process for managing staff turnover and include on-boarding documents to familiarize new rotators with CBET procedures and policies. We also encourage CBET to review new models for structuring rotator positions that will make such positions even more attractive so that delays in filling vacancies can be avoided.

5. NSF would appreciate your comments on how to improve the COV review process, format and report template.

The COV review process was generally very well organized and supported by CBET. A great deal of useful information and data were collected on the COV website and a number of pre-review conference calls with CBET staff and COV members helped set the stage well. The previous COV report suggested that the COV members felt that they did not have sufficient time to complete their tasks prior to the visit. In the present review, this issue was rectified; pre-visit workflow deadlines were suggested by CBET and adopted by the co-chairs. These deadlines helped to facilitate workflow and reduce COV member stress in the ramp-up to the visit. During the visit, CBET staff members were very responsive in gathering the additional information and data requested by the COV. Presentations by the Director and cluster PDs in the introductory session were well conceived and delivered and provided an excellent overview of the division and its work. The consistent format was greatly appreciated and made the presentations easy to follow.

The COV has a number of recommendations that may help improve future reviews:

- The orientation provided to the COV members was primarily focused on the pre-meeting tasks and processes. While this was very helpful in ensuring a good workflow prior the visit, the COV recommends that the orientation also include a detailed explanation of the agenda and purpose for the onsite meeting. This would enable the COV to make more efficient use of its time at the meeting. It is also recommended that a flow chart/timeline of the complete report development process be added to the orientation materials to help facilitate post-site visit workflow.

- The COV website could be substantially improved by better organization and labeling of documents. It was difficult to locate information and to assess what information was present, which was wasteful of COV member time.

- As discussed above, data provided to the COV were primarily raw data. Some data were presented in figures that were difficult to interpret. The COV strongly recommends that CBET improve presentation and labeling of these data and provide analyses of the raw data to help facilitate the COV evaluation.

- It would be very helpful to have more general information on the division prior to the visit. The COV recommends that materials on clusters, including goals, themes, and overviews of funded project areas be distributed in advance.

- Because of regular turnover, many of the current PDs and CBET staff did not have prior experience with a COV review. It appears that the process would benefit from the

development and dissemination of standard guidelines for COV across the directorate, so that there is no need to reinvent the process.

- The COV believes that the review process would be more useful to the division if it were informed by a self-study. Thus, the COV recommends that the Directorate consider developing a self-study template for its divisions. Implementation of self-studies would provide a better context for assessment of division success and achievement of goals

- Due to scheduling conflicts, the COV meeting was held off-site in a hotel. Unfortunately, the hotel conference facilities were inadequate to support the needs of the COV. For example, there were no projectors available in breakout rooms, no printers, and the meeting space was too cramped to comfortably house the COV. The COV strongly recommends that future visits be held at NSF, to ensure a supportive infrastructure.

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SIGNATURE BLOCK:

For the 2015 CBET COV

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