

Environmental Convergence Opportunities in Chemical, Bioengineering, Environmental, and Transport Systems (ECO-CBET)

PROGRAM SOLICITATION

NSF 20-517



National Science Foundation

Directorate for Engineering
Division of Chemical, Bioengineering, Environmental and Transport Systems

Preliminary Proposal Due Date(s) (required) (due by 5 p.m. submitter's local time):

February 12, 2020

February 12, Annually Thereafter

Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

May 14, 2020

April 30, Annually Thereafter

IMPORTANT INFORMATION AND REVISION NOTES

Any proposal submitted in response to this solicitation should be submitted in accordance with the revised *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) (NSF 19-1), which is effective for proposals submitted, or due, on or after February 25, 2019.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

Environmental Convergence Opportunities in Chemical, Bioengineering, Environmental, and Transport Systems (ECO-CBET)

Synopsis of Program:

Creating solutions to pressing environmental and sustainability challenges will require input and imaginative approaches from various fields, perspectives, and disciplines. The National Academies of Sciences, Engineering and Medicine (NASEM), in their report "[Environmental Engineering for the 21st Century: Addressing Grand Challenges](#)," identified five critical challenges we must address as a society:

- Sustainably supply food, water, and energy
- Curb climate change and adapt to its impacts
- Design a future without pollution and waste
- Create efficient, healthy, and resilient cities
- Foster informed decisions and actions

The report further states, "The challenges provide focal points for evolving environmental engineering education, research, and practice toward increased contributions and a greater impact. Implementing this new model will require modifications in educational curriculum and creative approaches to foster interdisciplinary research on complex social and environmental problems." This solicitation aims to address these grand challenges by supporting a collaborative research model that seamlessly integrates sustainability, environmental engineering, and process science and engineering.

Accordingly, the Environmental Convergence Opportunities in Chemical, Bioengineering, Environmental, and Transport Systems (ECO-CBET) solicitation will support activities that confront vexing environmental engineering and sustainability problems by uncovering and incorporating fundamental knowledge to design new processes, materials, and devices from a systems-level perspective. Projects should be compelling and reflect sustained, coordinated efforts from interdisciplinary research teams. A key objective of the solicitation is to encourage conversations and robust collaborations amongst the chemical process, transport phenomena, bioengineering, and environmental and sustainability research communities such that unanticipated solutions may arise. Furthermore, training the future workforce to actively engage and be successful in interdisciplinary research will be necessary to continually innovate given the scope of the environmental problems faced by our global community.

Process science and engineering, in the context of this solicitation, is broadly defined, including all programmatic interests of the National Science Foundation (NSF) Directorate for Engineering's (ENG) Division of Chemical, Bioengineering, Environmental, and Transport Systems (CBET). The interests are outlined in the "core" program descriptions:

Chemical Process Systems (CPS) Cluster

- [Catalysis](#)
- [Electrochemical Systems](#)
- [Interfacial Engineering](#)
- [Process Systems, Reaction Engineering, and Molecular Thermodynamics](#)

Engineering Biology and Health (EBH) Cluster

- [Biophotonics](#)
- [Biosensing](#)
- [Cellular and Biochemical Engineering](#)
- [Disability and Rehabilitation Engineering](#)
- [Engineering of Biomedical Systems](#)

Environmental Engineering and Sustainability (EES) Cluster

- [Environmental Engineering](#)
- [Environmental Sustainability](#)
- [Nanoscale Interactions](#)

Transport Phenomena (TP) Cluster

- [Combustion and Fire Systems](#)
- [Fluid Dynamics](#)
- [Particulate and Multiphase Processes](#)
- [Thermal Transport Processes](#)

Teams should be constructed in such a manner that expertise is complementary and distinct, drawing from the program descriptions as inspiration; non-traditional collaborations between research communities is highly encouraged. There should be at least three named investigators to ensure a diversity of perspectives. Teams may also wish to consider, as appropriate, incorporating individuals with expertise in manufacturing or social sciences.

While this solicitation is not restricted to a specific environmental engineering and sustainability research topic, the 2020 fiscal year solicitation emphasizes research topics related to: 1) greenhouse gas mitigation and 2) managing the nitrogen cycle. Assuming sufficient funding is provided in the NSF budget, it is anticipated this competition will continue annually. Research topic priorities are subject to change in subsequent years. Awards are expected to range from \$1,500,000 to \$1,700,000 over four years. Budgets should be commensurate with the scope of the proposed research. Pending the availability of funds, awards have the potential to be renewed once for a total of eight years of support. Renewal of awards will be subject to a competitive merit review process.

Cognizant Program Officer(s):

Please note that the following information is current at the time of publishing. See program website for any updates to the points of contact.

- Christina Payne, telephone: (703) 292-2895, email: cpayne@nsf.gov
- Bruce K. Hamilton, telephone: (703) 292-7066, email: bhamilto@nsf.gov
- Robert McCabe, telephone: (703) 292-4826, email: RMCCABE@nsf.gov
- William Olbricht, telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Steven W. Peretti, telephone: (703) 292-7029, email: speretti@nsf.gov
- Catherine Walker, telephone: (703) 292-7125, email: cawalker@nsf.gov

Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):

- 47.041 --- Engineering

Award Information

Anticipated Type of Award: Continuing Grant

Estimated Number of Awards: 5 to 7

The number of awards will depend on the availability of funds and the quality of the proposals. The awards will be 4-year awards and may be renewable for an additional four years, depending on the availability of funds and a competitive merit review process.

Anticipated Funding Amount: \$8,500,000

Estimated program budget, number of awards and average award size/duration are subject to the availability of funds.

Eligibility Information

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.

Who May Serve as PI:

PIs or co-PIs must hold primary, full-time, paid appointments in research or teaching positions at US-based campuses/offices of institutions eligible to submit to this solicitation (see above).

A minimum of one PI and two co-PIs must participate in each proposal. Each PI is expected to contribute distinct expertise relevant to the program clusters of the Division of Chemical, Bioengineering, Environmental, and Transport Systems. The four program clusters are: [Chemical Process Systems](#), [Engineering Biology and Health](#), [Environmental Engineering and Sustainability](#), and [Transport Phenomena](#). Information about programs belonging to each cluster can be found on the [CBET website](#). Where appropriate, PIs with expertise in manufacturing and/or social sciences should also be considered.

If there are strong collaborations with industry, the Grant Opportunities for Academic Liaison with Industry (GOALI) (NSF *Proposal and Award Policies and Procedures Guide* (PAPPG) [Chapter II, Section E.4](#)) mechanism can be used in conjunction with this solicitation.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

There are no restrictions or limits.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Not required
- **Preliminary Proposals:** Submission of Preliminary Proposals is required. Please see the full text of this solicitation for further information.
- **Full Proposals:**
 - Full Proposals submitted via FastLane: *NSF Proposal and Award Policies and Procedures Guide*(PAPPG) guidelines apply. The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.
 - Full Proposals submitted via Grants.gov: *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov* guidelines apply (Note: The *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

B. Budgetary Information

- **Cost Sharing Requirements:**

Inclusion of voluntary committed cost sharing is prohibited.
- **Indirect Cost (F&A) Limitations:**

Not Applicable
- **Other Budgetary Limitations:**

Not Applicable

C. Due Dates

- **Preliminary Proposal Due Date(s) (required)** (due by 5 p.m. submitter's local time):

February 12, 2020

February 12, Annually Thereafter

- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):

May 14, 2020

April 30, Annually Thereafter

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review criteria apply. Please see the full text of this solicitation for further information.

Award Administration Information

Award Conditions:

Additional award conditions apply. Please see the full text of this solicitation for further information.

Reporting Requirements:

Standard NSF reporting requirements apply.

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I. INTRODUCTION

The Environmental Convergence Opportunities in Chemical, Bioengineering, Environmental, and Transport Systems (ECO-CBET) solicitation seeks to engage the research communities represented among the programmatic clusters of CBET - [Chemical Process Systems](#), [Engineering Biology and Health](#), [Transport Phenomena](#), and [Environmental Engineering and Sustainability](#) - in the development of innovative, fundamentally driven approaches to tackle pressing environmental challenges. Projects are expected to advance and apply fundamental processes, mechanisms, and theories to yield systems-level understanding and tools. Highly collaborative projects that pair environmental engineering and sustainability experts with complementary researchers from other process science disciplines, e.g., heat and mass transfer, catalysis, biotechnology, process design and control, etc, are sought. Experts in manufacturing and/or social sciences may also provide unique perspectives that serve to expand the technological and societal impact of the research. The goals of the solicitation include:

- Encouraging new ways of thinking about environmental problems through atypical scientific collaborations and leveraging this diversity of perspectives to create innovative, holistic solutions;
- Integrating fundamental chemical process, transport, and bioengineering science with environmental engineering and sustainability research toward reducing and mitigating pollution and waste; and
- Training a future workforce prepared to develop and apply fundamental knowledge and approaches to solve environmental and sustainability problems.

II. PROGRAM DESCRIPTION

The Environmental Convergence Opportunities in Chemical, Bioengineering, Environmental, and Transport Systems (ECO-CBET) solicitation will support activities that substantially advance our capabilities to address environmental and sustainability grand challenges by integrating the expertise and fundamental advancements of chemical processes, transport phenomena, and bioengineering. The proposed research is expected to be compelling and broad reaching, going well beyond that typically supported by any single CBET core program. This solicitation is an opportunity to build and sustain collaborative bridges with research communities across the programmatic clusters of CBET, which include - [Chemical Process Systems](#), [Engineering Biology and Health](#), [Environmental Engineering and Sustainability](#), and [Transport Phenomena](#). Teams are expected to work cooperatively over the life of the project to understand and address the proposed challenge. Sustained open dialogue will be necessary to fully benefit from the unique skills and perspective each member brings to the table. Teams are also encouraged to apply, and further develop, advanced research tools required to address problems of the magnitude represented by global environmental and sustainability challenges. Training the future workforce to step outside the bounds of their discipline to solve a pressing engineering problem is also integral to the objectives of the solicitation.

We anticipate that the intentional and coordinated integration of fundamental knowledge from the chemical process, transport, and bioengineering communities with that of the environmental engineering and sustainability communities will engender creative approaches to long-standing challenges. To achieve this integration, this solicitation will support projects that leverage techniques, tools, theories, and approaches relevant to the disparate CBET research communities to address an environmental or sustainability challenge. Integration of manufacturing research and/or social science considerations, where appropriate, may contribute to the overall impact of the project. Again, a primary goal of the solicitation is to provide sustained research funding in support of truly collaborative teams working at the forefront of solving environmental and sustainability grand challenges in an effort that is more than the sum of individual contributions. Successful applicants will take a holistic, systems-level approach driven by strong interdisciplinary collaborations.

We envision supporting projects that are more than a "patch" or incremental advance to an existing technology and encourage investigators to approach environmental engineering and sustainability problems with fresh perspectives. For example, novel approaches to process design and control may lead to improved manufacturing efficiency and reduced environmental impact. Fundamental understanding of thermal transport processes could result in waste heat reduction, management, or re-use. Understanding catalytic materials and adsorption processes will be valuable in improving the overall energy balance of alternative energy production, carbon capture and sequestration processes, and improved recyclability or biodegradability of waste. Similarly, cellular and biochemical engineering insights could lead to improvements in sustainable crop production or improved monitoring of human impacts on the environment. In other words, there are seemingly endless opportunities for engaging the chemical process, transport, and bioengineering communities in the study and solution of environmental and sustainability challenges. Investigators should describe a clear vision for how the project outcomes will promote or facilitate solutions to an environmental challenge; as an innovative process design that can be applied at scale; or as a controllable, engineered system that can be deployed in the field.

Proposals that address one of the two strategic challenges described below are particularly encouraged (though not required) for this competition. However, any creative and transformative ideas that couple the process, bioengineering, and transport sciences to other environmental and sustainability challenges, as described above, are welcome.

Greenhouse Gas Mitigation – Transformative, high-risk/high-reward approaches are sought to economically and sustainably capture, contain, and/or convert greenhouse gases, such as CO₂, methane, nitrous oxide, and chlorofluorocarbons, from industrial process streams or directly from air.

Managing the Nitrogen Cycle – Transformative, high-risk/high-reward approaches are sought to prevent runoff and leaching of nitrates into drinking water reservoirs or into the ecosystems of receiving waters; to prevent denitrification of soil nitrogen by microorganisms and release of nitrous oxide (N₂O) into the atmosphere; or to economically and more sustainably synthesize ammonia than current processes.

In addition to innovative research, projects are expected to engage and train students to step outside the bounds of their discipline to conduct collaborative and convergent research. Educational and outreach activities targeting any educational level are welcome. The outcome of the activities should be students who are prepared to enter the workforce and work collaboratively to solve environmental and sustainability challenges of global concern.

III. AWARD INFORMATION

Awards are expected to range from \$1,500,000 to \$1,700,000 for a duration of four years. The budget must be commensurate with the scope of the project and thoroughly justified in the proposal. Pending competitive merit review and availability of funds, awards may be renewable for a total of eight years of support.

Anticipated funding amount is pending availability of funds.

IV. ELIGIBILITY INFORMATION

Who May Submit Proposals:

Proposals may only be submitted by the following:

- Institutions of Higher Education (IHEs) - Two- and four-year IHEs (including community colleges) accredited in, and having a campus located in the US, acting on behalf of their faculty members. Special Instructions for International Branch Campuses of US IHEs: If the proposal includes funding to be provided to an international branch campus of a US institution of higher education (including through use of subawards and consultant arrangements), the proposer must explain the benefit(s) to the project of performance at the international branch campus, and justify why the project activities cannot be performed at the US campus.

Who May Serve as PI:

PIs or co-PIs must hold primary, full-time, paid appointments in research or teaching positions at US-based campuses/offices of institutions eligible to submit to this solicitation (see above).

A minimum of one PI and two co-PIs must participate in each proposal. Each PI is expected to contribute distinct expertise relevant to the program clusters of the Division of Chemical, Bioengineering, Environmental, and Transport Systems. The four program clusters are: [Chemical Process Systems](#), [Engineering Biology and Health](#), [Environmental Engineering and Sustainability](#), and [Transport Phenomena](#). Information about programs belonging to each cluster can be found on the [CBET website](#). Where appropriate, PIs with expertise in manufacturing and/or social sciences should also be considered.

If there are strong collaborations with industry, the Grant Opportunities for Academic Liaison with Industry (GOALI) (NSF *Proposal and Award Policies and Procedures Guide* (PAPPG) [Chapter II, Section E.4](#)) mechanism can be used in conjunction with this solicitation.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI:

There are no restrictions or limits.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Preliminary Proposals (required): Preliminary proposals are required and must be submitted via the NSF FastLane system, even if full proposals will be submitted via Grants.gov.

Preliminary proposals should provide a brief overview of the project focusing on its transformative aspects. They should include sufficient information to allow assessment of the main ideas and approaches and of the responsiveness of the project to the solicitation goals. As appropriate, rudimentary assessment of the ultimate technological feasibility of the project (consistent with factors such as thermodynamic and kinetic limitations, materials synthesizability and stability, and overall energy balance) is encouraged. Review of the preliminary proposals will emphasize the potential transformative impact of the proposed idea and the application of fundamental principles and concepts to solve a pressing environmental engineering/sustainability challenge.

Preliminary Proposal Preparation Instructions:

Preliminary proposals must be submitted via FastLane in accordance with the instructions below. Preliminary proposals that are not compliant with this solicitation will be returned without review. It is the submitting institution's responsibility to ensure that the proposal is compliant with all applicable requirements. Preliminary proposals should not include separate subaward budgets but should include planned levels for subawards on the budget justification page. Preliminary proposals must contain the items listed below and must strictly adhere to the specified page limitations. No additional information may be provided as an appendix or by links to web pages. Figures and tables must be included within the applicable page limit. All elements of the proposal, including legends and tables, must meet all formatting requirements for font size and characters per inch as specified in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG).

Preliminary proposals must include the following items:

Cover Sheet: Select the solicitation number from the pull-down list. Check the box indicated for preliminary proposal. Entries on the Cover Sheet are limited to the principal investigator and a maximum of four co-principal investigators. A minimum of two co-principal investigators must be identified. Additional project leaders or senior personnel can be listed on the project summary page and entered into FastLane as senior personnel. At the preliminary proposal stage, avoid the inclusion of individuals without a substantive project role.

Title of Proposed Project: The title for the proposed project must begin with "ECO-CBET Preliminary Proposal:". The title must state clearly and succinctly the major theme(s) of the project.

Project Summary: The project summary may not exceed one page in length and must consist of three parts:

1. In the Overview section, include the title of the project, the name of the PI, the lead institution, and a list of co-PIs and senior personnel together with their institutions;
2. Provide a succinct summary of the *intellectual merit* of the proposed project. This should include the transformative nature of the proposed research and the significant leap or paradigm shift in fundamental engineering knowledge it will provide; and
3. Describe the *broader impacts* of the proposed work, including the potential long-term impact on national needs or a grand challenge.

Preliminary proposals that do not separately address in the project summary both intellectual merit and broader impacts will be returned without review.

Project Description: The project description of the preliminary proposal is limited to five pages and should include the following three sections:

1. **Vision and Goals** – Describe the vision and specific goals of the proposed research;
2. **Approach and Methodology** – Describe the approach and methodology that will be used to achieve the vision and goals; and
3. **Transformative Impact** – Describe the transformative aspects of the project, including how the collaboration of experts from different disciplines will enable a significant advancement of fundamental engineering knowledge and will have strong potential for long-term impact on a national need or grand challenge. Include a succinct statement of your anticipated Broader Impacts.

Biographical sketches: The standard NSF two-page biographical sketches must be provided for the PI, co-PIs and other senior personnel listed on the project summary page.

Budget: The preliminary proposal must include a budget for each of the four years proposed. FastLane will automatically provide a cumulative budget. Preliminary proposals should not include separate subaward budgets. However, the budget justification should include planned levels for subawards to any partner institution. Enter the anticipated total level of subaward support on line G5, Subawards.

Current and Pending Support for the PI, co-PIs, and senior personnel must be included.

In the **Supplementary Documentation** section, include the following:

List of **key personnel involved** (maximum one page), with a description of the expertise each person brings to the project and how this expertise will be applied to achieve convergent research. Each of the key personnel should be named as either PI, co-PI, or Senior Personnel. Avoid listing personnel who do not substantively contribute to the project goals.

In the **Single Copy Documents** section, include the following:

Collaborators and Other Affiliations Information: Proposers should follow the guidance specified in Chapter II.C.1.e of the NSF PAPPG. Grants.gov Users: The COA information must be provided through use of the COA template and uploaded as a PDF attachment.

Preliminary proposals will be reviewed by panels of outside experts. Based on the reviews, a limited number of PIs will be invited to submit full proposals. By mid-March 2020, invited proposers should expect to receive an invitation to submit a full proposal.

Full Proposal Preparation Instructions: Proposers may opt to submit proposals in response to this Program Solicitation via FastLane or Grants.gov.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG). The complete text of the PAPPG is available electronically on the NSF website at: https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg. Paper copies of the PAPPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov. Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.
- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the *NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov*. The complete text of the *NSF Grants.gov Application Guide* is available on the Grants.gov website and on the NSF website at: (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

Collaborative Proposals. All collaborative proposals submitted as separate submissions from multiple institutions must be submitted via the NSF FastLane system. PAPPG Chapter II.D.3 provides additional information on collaborative proposals.

See PAPPG Chapter II.C.2 for guidance on the required sections of a full research proposal submitted to NSF. Please note that the proposal preparation instructions provided in this program solicitation may deviate from the PAPPG instructions.

Based on the review of preliminary proposals, a limited number of teams will be invited to submit a full proposal.

The review of invited full proposals will include *ad hoc* and/or panel reviews. The following exceptions and additions to the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG) or NSF Grants.gov Application Guide apply to full proposals submitted to this solicitation:

Full proposals will be accepted only from PIs who have submitted preliminary proposals in the current review cycle and who were invited to submit a full proposal. Submission of full proposals by PIs whose preliminary proposals received a review recommendation of 'Not Invited' will be returned without review.

Cover Sheet: Select the solicitation number from the pull-down list. Entries on the Cover Sheet are limited to the principal investigator and a maximum of four co-principal investigators. A minimum of two co-principal investigators must be identified. Additional project leaders or senior personnel should be listed on the project summary page and entered into FastLane as senior personnel. When preparing the Cover Sheet for full proposals, please provide the related preliminary proposal number.

Title of Proposed Project: The title for the proposed project must begin with "ECO-CBET:". The title must state clearly and succinctly the major theme(s) of the project. Titles of proposals involving **GOALI**, must begin with "ECO-CBET: **GOALI**:"

Project Summary (one-page limit): The Project Summary consists of an overview, a statement on the intellectual merit of the proposed activity, and a statement on the broader impacts of the proposed activity. Provide the following information:

1. In the *Overview* section provide the title of the project, the name of the PI, the lead institution, and a list of co-PIs and senior personnel together with their institutions;
2. A succinct summary of the *intellectual merit* of the proposed project. This should include the transformative nature of the proposed research, and the significant leap or paradigm shift in fundamental engineering knowledge; and
3. The *broader impacts* of the proposed work, including the potential long-term impact on a national need, a grand challenge, or both.

Proposals that do not contain the Project Summary, including an overview and separate statements on intellectual merit and broader impacts, will not be accepted by FastLane or will be returned without review.

Project Description: Prepare the project description as described in the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG).

Budget: Develop a realistic project budget that is consistent with the proposed activities. Provide detailed budget justifications separately for each institution. Proposed budgets should include funds for travel by the PI and co-PIs to attend a reverse site visit at NSF headquarters held at the end of the second year of the award.

Current and Pending Support information must be provided for the PI and each of the co-PIs and Senior Personnel listed in the Project Summary page.

Facilities, Equipment, and Other Resources: Provide a description of available facilities and priorities for its use, if applicable. For projects requiring additional equipment, justify the need for these resources in the context of the innovative work proposed.

In the **Supplementary Documentation** section, include the following:

1. Provide a **list of key personnel** involved (maximum three pages), with a description of the expertise each person brings to the project and how this expertise will be applied to achieve convergent research. Each of the key personnel should be named as either PI, co-PI, or Senior Personnel.
2. Provide a detailed **management plan** (maximum three pages) including means of communication, data tracking, management of personnel within the project group, management of intellectual property resulting from the project, and timeline of activities. The management plan should also describe how students will be trained to engage in and sustain collaborative relationships across a variety of disciplines;
3. **Letters of Collaboration:** For proposals involving collaborations with researchers not listed as co-PIs, proposers should include letters confirming the collaborations. Letters of collaboration should be limited to stating the intent to collaborate and should not contain endorsements or evaluation of the proposed project. Details about collaborative work to be done under this project should be included within the 15 pages of the Project Description, not in the letter(s) of collaboration.
4. Proposals that include support for post-doctoral researchers must provide a **postdoctoral researcher mentoring plan**; and
5. Proposals must include a **Data Management Plan** (maximum two pages). The data management plan must include a description for the management, dissemination, and archiving of all digital products generated by the proposed work including data, software, and digital designs. The **Data Management Plan** should describe the management of digital assets and intellectual property rights, including plans for sharing data, code, digital designs, information, and materials resulting from the award. Data and other digital products should be identified, and the following described for each of them:
 - o The types of data, samples, physical collections, software, curriculum materials, and other materials to be produced during the project;
 - o Metadata to be collected and disseminated with primary data;
 - o The standards to be used for data and metadata format and content;
 - o Policies for access and sharing including provisions for appropriate protection of privacy, confidentiality, security, intellectual property, or other rights or requirements;
 - o Policies and provisions for re-use, re-distribution, and the production of derivatives;
 - o Release considerations: Timetable, Constraints, Responsible person(s), Public repository used;
 - o License for use (emphasis on open source licenses such as MIT and GPL); *All software and code must be in a versioned code repository (e.g., GitHub/BitBucket) and released immediately. Code must be well documented for others to reuse;*

In the **Single Copy Documents** section, include the following:

Collaborators and Other Affiliations Information: Proposers should follow the guidance specified in Chapter II.C.1.e of the NSF PAPPG. Grants.gov Users: The COA information must be provided through use of the COA template and uploaded as a PDF attachment. Please note that failure to submit a COA document for each PI, co-PI and other senior personnel may result in a proposal being returned without review.

Please submit these documents even if the information is unchanged since submission of the preliminary proposal.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

Budget Preparation Instructions:

The NSF ECO-CBET Management Team will schedule reverse site visits with each project team following the second year of the award. The meetings will take place at NSF Headquarters in Alexandria, VA. Proposal budgets should include funds to support the attendance of each PI and co-PI at this meeting.

C. Due Dates

- **Preliminary Proposal Due Date(s) (required)** (due by 5 p.m. submitter's local time):
 - February 12, 2020
 - February 12, Annually Thereafter
- **Full Proposal Deadline(s)** (due by 5 p.m. submitter's local time):
 - May 14, 2020
 - April 30, Annually Thereafter

D. FastLane / Research.gov / Grants.gov Requirements

For Proposals Submitted Via FastLane:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: <https://www.fastlane.nsf.gov/a1/newstan.htm>. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov. The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

For Proposals Submitted Via Grants.gov:

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. Comprehensive information about using Grants.gov is available on the Grants.gov Applicant Resources webpage: <https://www.grants.gov/web/grants/applicants.html>. In addition, the NSF Grants.gov Application Guide (see link in Section V.A) provides instructions regarding the technical preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: support@grants.gov. The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

Submitting the Proposal: Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

Proposers that submitted via FastLane may use Research.gov to verify the status of their submission to NSF. For proposers that submitted via Grants.gov, until an application has been received and validated by NSF, the Authorized Organizational Representative may check the status of an application on Grants.gov. After proposers have received an e-mail notification from NSF, Research.gov should be used to check the status of an application.

VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

Proposals received by NSF are assigned to the appropriate NSF program for acknowledgement and, if they meet NSF requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF either as *ad hoc* reviewers, panelists, or both, who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts of interest with the proposal. In addition, Program Officers may obtain comments from site visits before recommending final action on proposals. Senior NSF staff further review recommendations for awards. A flowchart that depicts the entire NSF proposal and award process (and associated timeline) is included in PAPPG Exhibit III-1.

A comprehensive description of the Foundation's merit review process is available on the NSF website at: https://www.nsf.gov/bfa/dias/policy/merit_review/.

Proposers should also be aware of core strategies that are essential to the fulfillment of NSF's mission, as articulated in *Building the Future: Investing in Discovery and Innovation - NSF Strategic Plan for Fiscal Years (FY) 2018 – 2022*. These strategies are integrated in the program planning and implementation process, of which proposal review is one part. NSF's mission is particularly well-implemented through the integration of research and education and broadening participation in NSF programs, projects, and activities.

One of the strategic objectives in support of NSF's mission is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions must recruit, train, and prepare a diverse STEM workforce to advance the frontiers of science and participate in the U.S. technology-based economy. NSF's contribution to the national innovation ecosystem is to provide cutting-edge research under the guidance of the Nation's most creative scientists and engineers. NSF also supports development of a strong science, technology, engineering, and mathematics (STEM) workforce by investing in building the knowledge that informs improvements in STEM teaching and learning.

NSF's mission calls for the broadening of opportunities and expanding participation of groups, institutions, and geographic regions that are underrepresented in STEM disciplines, which is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

A. Merit Review Principles and Criteria

The National Science Foundation strives to invest in a robust and diverse portfolio of projects that creates new knowledge and enables breakthroughs in understanding across all areas of science and engineering research and education. To identify which projects to support, NSF relies on a merit review process that incorporates consideration of both the technical aspects of a proposed project and its potential to contribute more broadly to advancing NSF's mission "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." NSF makes every effort to conduct a fair, competitive, transparent merit review process for the selection of projects.

1. Merit Review Principles

These principles are to be given due diligence by PIs and organizations when preparing proposals and managing projects, by reviewers when reading and evaluating proposals, and by NSF program staff when determining whether or not to recommend proposals for funding and while overseeing awards. Given that NSF is the primary federal agency charged with nurturing and supporting excellence in basic research and education, the following three principles apply:

- All NSF projects should be of the highest quality and have the potential to advance, if not transform, the frontiers of knowledge.
- NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These "Broader Impacts" may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. The project activities may be based on previously established and/or innovative methods and approaches, but in either case must be well justified.
- Meaningful assessment and evaluation of NSF funded projects should be based on appropriate metrics, keeping in mind the likely correlation between the effect of broader impacts and the resources provided to implement projects. If the size of the activity is limited, evaluation of that activity in isolation is not likely to be meaningful. Thus, assessing the effectiveness of these activities may best be done at a higher, more aggregated, level than the individual project.

With respect to the third principle, even if assessment of Broader Impacts outcomes for particular projects is done at an aggregated level, PIs are expected to be accountable for carrying out the activities described in the funded project. Thus, individual projects should include clearly stated goals, specific descriptions of

the activities that the PI intends to do, and a plan in place to document the outputs of those activities.

These three merit review principles provide the basis for the merit review criteria, as well as a context within which the users of the criteria can better understand their intent.

2. Merit Review Criteria

All NSF proposals are evaluated through use of the two National Science Board approved merit review criteria. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two merit review criteria are listed below. **Both** criteria are to be given **full consideration** during the review and decision-making processes; each criterion is necessary but neither, by itself, is sufficient. Therefore, proposers must fully address both criteria. (PAPPG Chapter II.C.2.d(i). contains additional information for use by proposers in development of the Project Description section of the proposal). Reviewers are strongly encouraged to review the criteria, including PAPPG Chapter II.C.2.d(i), prior to the review of a proposal.

When evaluating NSF proposals, reviewers will be asked to consider what the proposers want to do, why they want to do it, how they plan to do it, how they will know if they succeed, and what benefits could accrue if the project is successful. These issues apply both to the technical aspects of the proposal and the way in which the project may make broader contributions. To that end, reviewers will be asked to evaluate all proposals against two criteria:

- **Intellectual Merit:** The Intellectual Merit criterion encompasses the potential to advance knowledge; and
- **Broader Impacts:** The Broader Impacts criterion encompasses the potential to benefit society and contribute to the achievement of specific, desired societal outcomes.

The following elements should be considered in the review for both criteria:

1. What is the potential for the proposed activity to
 - a. Advance knowledge and understanding within its own field or across different fields (Intellectual Merit); and
 - b. Benefit society or advance desired societal outcomes (Broader Impacts)?
2. To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?
3. Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?
4. How well qualified is the individual, team, or organization to conduct the proposed activities?
5. Are there adequate resources available to the PI (either at the home organization or through collaborations) to carry out the proposed activities?

Broader impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to, the project. NSF values the advancement of scientific knowledge and activities that contribute to achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education.

Proposers are reminded that reviewers will also be asked to review the Data Management Plan and the Postdoctoral Researcher Mentoring Plan, as appropriate.

Additional Solicitation Specific Review Criteria

The following additional criteria will be used to evaluate all proposals:

- **Responsiveness:** Does the proposed research effectively integrate chemical process, transport, and/or bioengineering science to solve a problem of environmental engineering or sustainability relevance? How effectively does the proposed research use convergent processes with iterative feedback among tasks?
- **Collaboration Management Plan:** How will collaboration lead to new knowledge and creative approaches? How will the team assess the success of their collaborative processes and make changes as necessary?
- **Expertise:** To what extent is the proposed activity comprised of a multidisciplinary group of scientists and engineers appropriate to the project? Have the team members been selected to provide distinct, complementary expertise to the project?
- **Feasibility:** Do the envisioned technologies, processes, and/or approaches have long-term potential to become industrially and/or environmentally feasible, including sustainability issues and life cycle implications?

In the case of renewal proposals, reviewers will also evaluate:

Progress made during the previous award (as described in the Results from Prior NSF Support section of the proposal).

B. Review and Selection Process

Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review.

Reviewers will be asked to evaluate proposals using two National Science Board approved merit review criteria and, if applicable, additional program specific criteria. A summary rating and accompanying narrative will generally be completed and submitted by each reviewer and/or panel. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF strives to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. Large or particularly complex proposals or proposals from new awardees may require additional review and processing time. The time interval begins on the deadline or target date, or receipt date, whichever is later. The interval ends when the Division Director acts upon the Program Officer's recommendation.

After programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review

of business, financial, and policy implications. After an administrative review has occurred, Grants and Agreements Officers perform the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments, obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

Once an award or declination decision has been made, Principal Investigators are provided feedback about their proposals. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers or any reviewer-identifying information, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

VII. AWARD ADMINISTRATION INFORMATION

A. Notification of the Award

Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process.)

B. Award Conditions

An NSF award consists of: (1) the award notice, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award notice; (4) the applicable award conditions, such as Grant General Conditions (GC-1)*; or Research Terms and Conditions* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award notice. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

*These documents may be accessed electronically on NSF's Website at https://www.nsf.gov/awards/managing/award_conditions.jsp?org=NSF. Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-8134 or by e-mail from nsfpubs@nsf.gov.

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

Special Award Conditions:

Awardees must include in the proposal budget funds for travel by the PI and each co-PI to attend a two-year reverse site visit at NSF. Awardees will be required to attend and present their research results and future plans.

C. Reporting Requirements

For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer no later than 90 days prior to the end of the current budget period. (Some programs or awards require submission of more frequent project reports). No later than 120 days following expiration of a grant, the PI also is required to submit a final project report, and a project outcomes report for the general public.

Failure to provide the required annual or final project reports, or the project outcomes report, will delay NSF review and processing of any future funding increments as well as any pending proposals for all identified PIs and co-PIs on a given award. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through Research.gov, for preparation and submission of annual and final project reports. Such reports provide information on accomplishments, project participants (individual and organizational), publications, and other specific products and impacts of the project. Submission of the report via Research.gov constitutes certification by the PI that the contents of the report are accurate and complete. The project outcomes report also must be prepared and submitted using Research.gov. This report serves as a brief summary, prepared specifically for the public, of the nature and outcomes of the project. This report will be posted on the NSF website exactly as it is submitted by the PI.

More comprehensive information on NSF Reporting Requirements and other important information on the administration of NSF awards is contained in the NSF *Proposal & Award Policies & Procedures Guide* (PAPPG) Chapter VII, available electronically on the NSF Website at https://www.nsf.gov/publications/pub_summ.jsp?ods_key=pappg.

VIII. AGENCY CONTACTS

Please note that the program contact information is current at the time of publishing. See program website for any updates to the points of contact.

General inquiries regarding this program should be made to:

- Christina Payne, telephone: (703) 292-2895, email: cpayne@nsf.gov
- Bruce K. Hamilton, telephone: (703)292-7066, email: bhamilto@nsf.gov
- Robert McCabe, telephone: (703) 292-4826, email: RMCCABE@nsf.gov
- William Olbricht, telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Steven W. Peretti, telephone: (703) 292-7029, email: speretti@nsf.gov
- Catherine Walker, telephone: (703) 292-7125, email: cawalker@nsf.gov

For questions related to the use of FastLane contact:

- FastLane Help Desk: 1-800-673-6188
- FastLane Help Desk e-mail: fastlane@nsf.gov.

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: support@grants.gov.

IX. OTHER INFORMATION

The NSF website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this website by potential proposers is strongly encouraged. In addition, "NSF Update" is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF [Grants Conferences](#). Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. "NSF Update" also is available on [NSF's website](#).

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this mechanism. Further information on Grants.gov may be obtained at <https://www.grants.gov>.

ABOUT THE NATIONAL SCIENCE FOUNDATION

The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 55,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Arctic and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

Facilitation Awards for Scientists and Engineers with Disabilities (FASSED) provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See the *NSF Proposal & Award Policies & Procedures Guide* Chapter II.E.6 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at <https://www.nsf.gov>

- **Location:** 2415 Eisenhower Avenue, Alexandria, VA 22314
- **For General Information** (NSF Information Center): (703) 292-5111

- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**
 Send an e-mail to: nsfpubs@nsf.gov
 or telephone: (703) 292-7827
- **To Locate NSF Employees:** (703) 292-5111

PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See [System of Record Notices](#), NSF-50, "Principal Investigator/Proposal File and Associated Records," and NSF-51, "Reviewer/Proposal File and Associated Records." Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton
 Reports Clearance Officer
 Office of the General Counsel
 National Science Foundation
 Alexandria, VA 22314

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