Emerging Frontiers in Research and Innovation 2020 (EFRI-2020)

1. Distributed Chemical Manufacturing (DCheM)

2. Engineering the Elimination of End-of-Life Plastics (E3P)

PROGRAM SOLICITATION

NSF 19-599

REPLACES DOCUMENT(S):

NSF 19-502

National Science Foundation

Directorate for Engineering
Emerging Frontiers and Multidisciplinary Activities

Directorate for Biological Sciences

Directorate for Mathematical and Physical Sciences

Directorate for Social, Behavioral and Economic Sciences

U.S. Dept. of Energy

National Institute of Standards and Technology

Letter of Intent Due Date(s) ***(required)*** (due by 5 p.m. submitter's local time):

November 04, 2019

LOI due date

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

December 02, 2019

Preliminary Proposal Due Date

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

March 26, 2020

Full Proposal Due Date

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 January 28, 2019.

SUMMARY OF PROGRAM REQUIREMENTS

General Information

Program Title:

EMERGING FRONTIERS IN RESEARCH AND INNOVATION (EFRI): Distributed Chemical Manufacturing (DCheM) and Engineering the Elimination of End-of-Life Plastics (E3P)

Synopsis of Program:

The Emerging Frontiers in Research and Innovation (EFRI) program of the NSF Directorate for Engineering (ENG) serves a critical role in helping ENG focus on important emerging areas in a timely manner. This solicitation is a funding opportunity for interdisciplinary teams of researchers to embark on rapidly advancing frontiers of fundamental engineering research. For this solicitation, we will consider proposals that aim to investigate emerging frontiers in one of the following two research areas:

- **Distributed Chemical Manufacturing (DCheM)**
- **Engineering the Elimination of End-of-Life Plastics (E3P)**

This solicitation will be coordinated with the Directorate for Biological Sciences, the Directorate for Mathematical and Physical Sciences and the Directorate for Social, Behavioral and Economic Sciences.

EFRI seeks proposals with transformative ideas that represent an opportunity for a significant shift in fundamental engineering knowledge with a strong potential for long term impact on national needs or a grand challenge. The proposals must also meet the detailed requirements delineated in this solicitation.

FURTHER INFORMATION: The Emerging Frontiers and Multidisciplinary Activities (EFMA) Office will host an informational webinar on Wednesday, September 18, 2019 at 1:00pm Eastern to discuss the EFRI program and answer questions about the FY 2020 solicitation. Details on how to join this webinar will be posted on the EFMA website.

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.

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

- 47.041 --- Engineering
- 47.049 --- Mathematical and Physical Sciences
- 47.074 --- Biological Sciences
- 47.075 --- Social Behavioral and Economic Sciences
- 81.049 --- Office of Science Financial Assistance Program

Award Information

Anticipated Type of Award: Standard Grant or Continuing Grant

Estimated Number of Awards: 15

(4-year awards)

Anticipated Funding Amount: $30,000,000

Pending 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.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.

Who May Serve as PI:

For proposals submitted by Institutions of Higher Education, the lead Principal Investigator (PI) must be full-time, tenured or tenure-track faculty. For proposals submitted by Non-Profit, Non-Academic Organizations, the lead PI must meet all of the following requirements: (1) the PI has a continuing appointment that is expected to last the four years of an EFRI grant; (2) the appointment has substantial research responsibilities; and (3) the proposed project relates to the PI's job responsibilities as well as to the mission of the department or organization.

A minimum of one PI and two co-PIs must participate in each proposal. Either the PI or one of the co-PIs must have a full-time, tenured or tenure-track faculty appointment within a College/Department of Engineering.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI: 2

Individuals may participate as either PI or co-PI in only one proposal submitted to each topic described in this solicitation. It is the responsibility of the submitting organization to ensure that the PI and all co-PIs are participating only in one proposal per topic as either PI or co-PI and not in any others submitted in response to the same topic for this solicitation.

If an individual is listed as PI or co-PI on more than one proposal per topic submitted in response to this solicitation, all proposals in excess of the limit for any person will be returned without review in the reverse order received.

Proposal Preparation and Submission Instructions

A. Proposal Preparation Instructions

- **Letters of Intent:** Submission of Letters of Intent is required. Please see the full text of this solicitation for further information.
- **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

- **Letter of Intent Due Date(s)** ***(required)*** (due by 5 p.m. submitter's local time):

  November 04, 2019

  LOI due date

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

  March 26, 2020

  Full Proposal Due Date

Proposal Review Information Criteria

Merit Review Criteria:

National Science Board approved criteria. Additional merit review considerations 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 Office of Emerging Frontiers and Multidisciplinary Activities (EFMA) in the Directorate for Engineering provides funding opportunities for interdisciplinary teams of researchers to embark on rapidly advancing frontiers of fundamental engineering research. The Emerging Frontiers in Research and Innovation program (EFRI), the signature program of the EFMA Office, seeks proposals with potentially transformative ideas that represent an opportunity for a significant shift in fundamental engineering knowledge with strong potential for long-term impact on national needs or a grand challenge. For this solicitation, EFRI will consider proposals that aim to investigate emerging frontiers in one of the following two specific research areas: 1) Distributed Chemical Manufacturing (DCheM) and, 2) Engineering the Elimination of End-of-Life Plastics (E3P). Proposals must meet the detailed requirements delineated in this solicitation.

1. **Distributed Chemical Manufacturing (DCheM)**

   The EFRI topic Distributed Chemical Manufacturing (DCheM) aims to support fundamental research projects focusing on the development of modular process plants able to take advantage of distributed feedstocks and product delivery needs, or to address environmental remediation problems at the source. EFRI-DCheM research projects

have the potential to revolutionize the chemical process industries while promoting energy and environmental sustainability. EFRI-DCheM projects should adopt a convergent research approach that engages engineers and scientists with complementary expertise to tackle challenging problems relevant to distributed chemical manufacturing, including process intensification and modular design of chemical processes. Projects may include fundamental studies of chemical and physical transformations of matter, multi-scale modeling of complex chemical systems, real-time optimization and control algorithms, heterogeneous data fusion methods, nanomanufacturing, environmental risk assessment, and socioeconomic studies. Examples of potential DCheM applications include (but are not limited to): catalytic conversion of stranded natural gas resources or waste biomass to liquid fuels and chemicals, distributed ammonia synthesis, modular organic electrosynthesis, distributed carbon capture and sequestration, negative greenhouse gas emissions technologies, on-site/on-demand production of chemicals or pharmaceuticals, distributed seawater desalination technologies, waste-water purification, and manufacturing of fertilizers on the farm. Engaging social scientists in the interdisciplinary teams will facilitate research into the benefits of citizen ownership of distributed chemical plants and the willingness of municipalities to locate compact chemical manufacturing facilities within their jurisdictions. EFRI-DCheM projects are also envisioned as ideal platforms for innovative educational and workforce development programs, such as curriculum development and outreach activities to broaden participation of underrepresented minorities in STEM.

2. **Engineering the Elimination of End-of-Life Plastics (E3P)**

   The EFRI topic "Engineering the Elimination of End-of-Life Plastics" (E3P) supports interdisciplinary research to create a scientific foundation for viable solutions to the capture, management, and elimination of end-of-use plastics. Plastics are an integral component of modern life, permeating the food and health industries and enhancing consumer safety, wellness, and convenience. However, while plastic materials have been instrumental in societal advancement, they also pose a global environmental hazard. The inherent durability of plastics leads to accumulation in landfills and the environment, where they contaminate waterways and animal life. The increasing rate of production of plastic products and packaging by industrialized societies is predicted to result in exponentially increasing accumulation in the absence of interventions. This EFRI topic seeks to establish the requisite knowledge and methods to enable technologies that depolymerize and recapture value from end-of-life plastic materials, toward the long-term goal of creating a circular economy for plastics.

   Realizing the vision of a world in which plastic materials no longer languish in landfills and the environment will require innovation to create value for end-of-life plastics and to address current challenges in recycling, valorization, and separations. Mixed plastic waste streams contain a variety of polymers, additives, contaminants, and non-polymeric waste, complicating downstream processing. Mechanical recycling is effective for some conventional plastics but has attendant challenges, including inadequate *in situ* blend characterization, high-throughput sensing/sorting methods, and reduced functional properties of the recycled product. Chemical recycling offers many promising advantages, including the ability to generate entirely new value-added products, but the recalcitrance of polymeric bonds and unique process requirements pose significant implementation challenges. Notwithstanding recent demonstrations of chemical recycling technologies, new approaches enabling complete depolymerization of mixed plastic waste streams, or degradation into environmentally benign components, coupled with reintegration of depolymerized products into the value chain, are needed to achieve the promise of a world without plastic waste. Furthermore, understanding how to efficiently separate polymers and polymer-derived species in downstream chemical processes and from water sources will be critical. We envision these needs can best be met through convergent, fundamental research in catalyst and biocatalyst design, chemical and polymer process design, materials science and engineering, and advanced manufacturing. It is expected that transformative research in this topic will take a holistic, systems-level approach driven by strong interdisciplinary collaborations.

ENHANCING DIVERSITY IN ENGINEERING - THE BROADENING PARTICIPATION PLAN

The Directorate for Engineering (ENG) promotes diversity in all aspects of its programs. In keeping with ENG's priority to broaden the participation of underrepresented groups (see detailed definition below) in Engineering, the Office of Emerging Frontiers and Multidisciplinary Activities is addressing the need to enhance diversity in all fields of Engineering by **requiring all EFRI projects to include a "Broadening Participation Plan"** as part of the EFRI 2020 Solicitation. One goal is to increase the participation of underrepresented groups in the field of engineering and in engineering research. This requirement will not only promote diversity in the human resources engaged in these EFRI projects but will also expand diversity of thought, ideas, and approaches brought together by EFRI in defining and solving important research questions.

The term "underrepresented groups" refers to and includes the following: women, persons with disabilities, and ethnic and racial groups which are in the minority in engineering, including African Americans, Hispanics, Native Americans, Alaska Natives, and Pacific Islanders.

The Broadening Participation Plan must be described as part of Broader Impacts of the proposal both in the Project Summary and in the Project Description. Proposers should include a preliminary version of the Broadening Participation Plan in their preliminary proposal and a detailed version in their full proposal (if invited to submit). The Plan may include, but is not limited to, any of the following menu of activities as appropriate for your project and the circumstances of your organization(s):

- PI, Co-PI, or other SENIOR PERSONNEL - Inclusion of persons from underrepresented groups as PI, co-PI, and/or other senior personnel, as appropriate for the project;
- STUDENTS AND POST-DOCTORAL RESEARCHERS - Inclusion of persons from underrepresented groups as undergraduate student(s), graduate student(s), and post-doctoral researcher(s);
- RESEARCH EXPERIENCES FOR UNDERGRADUATES (REU) - A plan to apply for supplement(s) to engage undergraduate researchers, using REU supplement(s);
- RESEARCH EXPERIENCE AND MENTORING (EFRI-REM) - A plan to apply for post-award supplement(s) to enhance research goals through diversification of the EFRI research teams;
- MINORITY-SERVING INSTITUTIONS - Engaging faculty and/or student researchers at minority serving institutions in the research project;

- COMMUNITY COLLEGES - Engaging faculty and/or student researchers at community colleges in the research project;
- RESEARCH EXPERIENCES FOR TEACHERS (RET) - A plan to apply for post-award supplement(s) to engage teachers and/or Community College Faculty through the RET program;
- RESEARCH EXPERIENCES FOR HIGH SCHOOL STUDENTS - Provide research opportunities for members of underrepresented groups at the high school level;
- EXISTING INSTITUTIONAL PROGRAMS - Enhance/collaborate with existing diversity programs at your home organization and/or nearby organizations;
- MENTORING - Senior Personnel serve as role models and mentors for an underrepresented student population;
- TUTORING OPPORTUNITIES - Provide tutoring opportunities for underrepresented middle school, high school, and undergraduate students;
- K-12 OUTREACH - Outreach activities that will interest and attract underrepresented K-12 students to engineering undergraduate programs.

The EFMA Office encourages the proposers to be creative in the planning of activities to attract and retain members of underrepresented groups to the fields of engineering and engineering research when developing their Broadening Participation Plans.

II. PROGRAM DESCRIPTION

The required elements listed below for each topic (Research Thrusts, Programmatic Considerations) are expected to be addressed in both preliminary proposals and full proposals.

1. **Distributed Chemical Manufacturing (DCheM)**

   The potential for a dramatic transformation in the chemical process industries is emerging from the rapid development of process intensification. This can potentially yield substantial economic and environmental benefits in combination with advanced manufacturing by significantly reducing the size of chemical process plants. Distributed Chemical Manufacturing (DCheM) aims to revolutionize the chemical process industries by enabling the development of intensified and, where appropriate, modular process plants, which take advantage of distributed resources and/or address distributed environmental remediation needs. DCheM will provide a path for the introduction of numerous new process technologies that will stimulate the US economy while promoting energy and environmental sustainability. Modular processes offer flexibility in dealing with variability in both the supply rate and quality of feedstock, as well as facilitating on-stream maintenance, regeneration, and replacement of component modules.

   Research Thrusts

   Each proposal submitted in response to this topic of the EFRI solicitation is encouraged to address at least two of the three thrusts outlined below:

   Thrust 1: Fundamental Chemical and Physical Transformations of Matter.

   Successful implementation of DCheM concepts will require fundamental understanding of chemical and physical processes at the molecular scale, including reaction kinetics and transport phenomena, development of new materials, such as catalysts, mass separation agents and electrochemical materials, and/or integration of alternative activation methods for chemical reactions (e.g., low-temperature plasmas, microwaves, or electrical energy).

   Thrust 2: Process Integration and Advanced Manufacturing.

   Successful implementation of DCheM processes at commercial scales will require the development and integration of multifunctional process units (e.g., membrane reactors, reactive distillation and extraction units, modular organic electrosynthesis units, fluidized-bed and multiphase reactors, etc.), advanced spatial and temporal process intensification strategies, and/or microfluidic and microchemical systems. Studies that evaluate the benefits of integration on process performance (e.g., efficiency, selectivity, environmental sustainability, and process economics), scale up or scale down of process units, optimization of reactor geometries and the manufacturability of novel designs and components, including the application of advanced manufacturing techniques, are relevant to this thrust.

   Thrust 3: Process Modeling, Optimization and Control.

   Efficient operation of DCheM processes will require the development of real-time learning and decision-making algorithms, real-time optimization and control methods, predictive multi-scale process models, reduced order models, resilient (semi)autonomous and/or reconfigurable process systems, new sensors and/or sensor networks, machine learning tools, and advanced data analytics.

   Application Examples

   Specific examples where DCheM research projects may have an impact include (but are not limited to):

   - **Natural Gas to Liquid Technologies**

     The abundant domestic shale oil resources provide a technological and economic advantage to the U.S. Yet utilization of stranded natural gas resources in remote locations and biogas produced in animal farms remains a challenge due to high transportation costs and the difficulty of activating alkanes, especially methane. As a result, gas is often flared contributing to carbon dioxide emissions. The release of methane

gas in the arctic due to thawing permafrost is a problem with potentially severe environmental consequences that must be addressed. Distributed/modular process units can take advantage of such feedstocks and sources to produce high-value-added liquid fuels and chemicals and achieve a positive environmental impact.

- **Valorization of Waste Biomass and Recycled Plastics**

  New methods to efficiently deconstruct carbon-containing solids and selectively synthesize high-value-added products enable the use of diverse feedstocks (e.g., waste biomass, waste food, or recycled plastics) resulting in positive environmental and societal benefits. Techniques such as pyrolysis are energy-demanding, lack selectivity and produce mixtures of molecules that require challenging and expensive separations. The low energy density in some feedstocks (e.g., due to high water content in biomass) and short lifetime (e.g., in the case of food waste) require distributed manufacturing solutions that are close to the production site. DCheM research projects can lead to breakthroughs in carbon engineering with significant economic and environmental benefits.

- **Modular Organic Electrosynthesis**

  Organic electrosynthesis has recently emerged as a promising method for biomass conversion because it enables complex conversions in the aqueous phase at low temperature and prevents thermal degradation. There is potential for significant advantages when organic electrosynthesis is coupled with biocatalysis or pyrolysis in hybrid processes. Modular organic electrosynthesis can yield new conversion pathways for complex molecules and emerging oxygenated feedstocks, such as carbon dioxide and biomass, and supply new molecules from biomass using renewable electricity.

- **Distributed Ammonia Synthesis**

  Ammonia synthesis requires high temperatures and pressures, and utilizes hydrogen produced from methane steam reforming, which is extremely energy intensive and inefficient. About 2% of all carbon dioxide emissions are attributed to ammonia plants. In addition, over-fertilizing the soil results in more than 50% of the fertilizer finding its way into the water ecosystem, with a tremendous environmental impact. The availability of renewable electricity from solar and wind provides an opportunity to develop new distributed manufacturing technologies for producing ammonia in remote locations and fertilizers on the farm to improve fertilizing strategies.

- **Carbon Dioxide Capture and Conversion**

  Carbon dioxide is produced over a multitude of scales, ranging from large, concentrated sources (e.g., power plants) to small, diluted streams (e.g., transportation units). Efficient capture of carbon dioxide and its conversion to useful chemicals and fuels requires the development of new materials, including catalysts and adsorbents, and new approaches, such as plasma-assisted conversion and electrocatalysis. Large-scale implementation of such technologies will require the development of integrated modular systems, including intensified reactors, separations, and heat and mass transfer elements, that can ideally tap into renewable energy to carry out these transformations at various scales.

- **Water Purification and Desalination**

  The perpetual availability of clean water is a critical societal challenge. Many biological and agricultural processes require large amounts of water. Excessive use of fertilizers threatens the purity of vast watersheds that serve large populations. Desalination of seawater is a very energy-intensive operation. Distributed chemical processing and separations, including the use of molecularly engineered materials and the integration of renewable energy into water treatment processes, may provide innovative solutions that overcome these challenges.

- **Hydrogen Production from Renewable Energy Resources**

  Production of hydrogen at or near the site of use can eliminate the need for storage and transportation and can take advantage of renewable energy sources. DChEM technologies can enable water splitting for hydrogen production by using renewable energy in electrocatalytic or photo-electrocatalytic systems that are essential for many chemical transformations, such as distributed ammonia synthesis, carbon dioxide utilization, and upgrading of fuels and chemicals.

- **Distributed Power Generation and Storage in Chemicals**

  Storing renewable energy into chemicals, whose energy density can be up to 100 times higher than that of conventional Li-based batteries, is an appealing scenario. These chemicals can be used whenever needed or can produce electricity in fuel cells. Development of improved batteries, membranes for fuel cells and flow batteries, and superior catalysts for electrocatalytic transformations are essential to realize this opportunity. At the systems level, fundamental studies will be needed to integrate power generation, storage, and smart grids, especially microgrids.

- **On-Demand Production of Specialty Chemicals and Pharmaceuticals**

  DCheM processes can enable on-site/on-demand production of low-volume specialty chemicals, especially for materials that are hazardous to transport due to high toxicity or flammability. DCheM systems can also address the increasing emphasis on continuous manufacturing, modularization, and process intensification in the pharmaceuticals industry.

In addition to innovative research, the EFRI-DChEM projects will serve as ideal platforms for pursuing innovative

educational and workforce development programs, such as curriculum development and outreach activities that increase awareness and broaden participation of underrepresented minorities in STEM careers.

EFRI-DCheM Programmatic Considerations

Interdisciplinary Research: DChEM will provide an opportunity for convergent research conducted by interdisciplinary teams of engineers and scientists using principles from diverse fields, including catalysis, reaction engineering, molecular separations, electrochemical systems, transport phenomena, particulate and multiphase processes, environmental engineering, process control and optimization, multi-scale modeling of complex systems, low-temperature plasma science, organic electrosynthesis, materials science, smart/additive (nano)manufacturing, sensor networks, and data science. Engaging social scientists in the interdisciplinary research teams will enable studies of the benefits of citizen ownership of distributed chemical plants and the willingness of communities, especially smaller towns, to locate compact chemical manufacturing facilities within their communities along with the employment opportunities those facilities will provide.

Responsible Innovation : The proposed research activities are expected to create socially responsible innovations for solving complex problems with positive societal and environmental impact. EFRI-DCheM projects are expected to yield economic benefits, reduce financial risks, and increase energy and environmental sustainability. EFRI-DCheM teams are expected to identify ethical, social, economic, health, legal, safety, and environmental considerations that are relevant to proposed projects. Submitted proposals must discuss how challenges resulting from these considerations will be addressed, within the context and scope of the project description. Collaboration with ethicists, social scientists, and economists is encouraged, as appropriate.

2. **Engineering the Elimination of End-of-Life Plastics (E3P)**

Only a small fraction of the plastic produced to date has ever been recycled. The remainder has either been disposed of as landfill, incinerated, or otherwise lost to the environment at the end of the product's useful life. Managing end-of-life plastic waste is a particularly challenging problem given the many available polymer types and formulations and the associated complexity of recycling mixed waste streams, many of which are also contaminated with non-polymeric materials. In addition to the technological challenges, the relatively low cost of virgin plastic production continues to disincentivize recycling and valorization of plastic materials. The goal of this EFRI topic is to develop new engineering approaches for the elimination of, and reclamation of value from, end-of-life plastic materials.

Effective management of end-of-life plastic waste will require transformative strategies for chemical and/or biological depolymerization and valorization. Novel methods and processes, particularly those enabling integration of depolymerization and valorization strategies within existing plastics manufacturing and recycling frameworks, will also be necessary. To achieve this requires:

robust physical systems and materials for plastic lifecycle management, including sensors for detection and characterization of composition and reaction dynamics, and mass separating agents for capture of plastic materials and plastic-derived molecules;

development of novel catalysts and reaction engineering, either chemical or biological, enabling complete depolymerization and/or valorization of plastic waste; and

systems-level integration of new plastic remediation and valorization technologies into manufacturing infrastructures, including improving efficiency and economic viability of existing recycling, remediation, and valorization technologies.

Research Thrusts

Each proposal submitted in response to this topic of the EFRI solicitation must address at least two of the three thrusts outlined below:

Thrust 1: Depolymerization of plastic materials

This research thrust focuses on developing foundational knowledge of how to effectively depolymerize end-of-life plastic materials. The goal is to engender transformative approaches capable of depolymerizing plastics into molecular components for future use or for environmentally benign disposal (i.e., elimination). Approaches with the potential to simultaneously target several polymer types are particularly encouraged.

Chemical recycling has emerged as a promising complement to mechanical recycling, enabling the near-complete depolymerization of polymers to their monomeric components. Many fundamental challenges remain, however, before this technology can be deployed at scale. For example, chemical recycling must operate under extremely non-ideal process conditions, including taking a diverse, solid polymer feedstock rife with impurities and efficiently converting it to a saleable product. Enabling this technology will require innovations in the areas of catalysis, chemical reaction engineering, materials science and engineering, and process and advanced manufacturing systems. Development and characterization of robust catalysts capable of selective bond activation would substantially enhance bond cleavage and functionalization capabilities. Advances in chemical reaction engineering, including novel reactor designs for processing polymers in liquid states and deploying heterogeneous catalysts, could improve reaction rates and energy efficiency while reducing solvent requirements. The use of models and theories, integrated with experiments, to understand complex reaction networks, catalytic mechanisms, and macromolecular thermodynamics and transport properties would provide unique insights into depolymerization processes that could serve as the basis for new hypotheses and approaches.

Recent discoveries of naturally evolved, plastic-degrading microbes suggest biological routes to industrial-scale plastic depolymerization may be feasible. Since commercial-scale plastic manufacturing was established in the 20th

century, microbes have evolved that are capable of depolymerizing the increasingly abundant polymers as sources of energy. Leveraging modern synthetic biology tools and directed molecular evolution, one can imagine the advent of microbial systems tailor-made to efficiently depolymerize mixed polymer waste streams under ambient conditions. Alternatively, designer enzymatic cocktails akin to those employed in biomass conversion processes may be capable of selectively attacking recalcitrant polymeric bonds. Protein engineering may be used to introduce beneficial features, for example, enhancing turnover, protein stability, or selectivity. Regardless of approach, fundamental understanding of the underpinnings of the biological depolymerization processes will be important in facilitating design of new biotechnological pathways.

This thrust is not intended to be overly prescriptive. Concepts that advance the goal of near-complete depolymerization of end-of-life plastic materials to their basic molecular components are sought. For example, multi-step transformations involving cascades of chemocatalytic, biocatalytic, and noncatalytic systems may be necessary to achieve energy-efficient, reliable routes to depolymerization. While not the primary focus of the thrust, novel approaches that produce substantial improvements to thermal depolymerization technologies may be considered. In general, investigators are urged to consider how their proposed approach can be integrated within existing recycling infrastructure or will be broadly scalable.

Thrust 2: Valorization of plastic materials and plastic-derived molecules

This research thrust focuses on understanding how to effectively reclaim value from energy- and chemical-rich plastic waste. The goal is to develop pathways and systems for plastics and depolymerization products to re-enter the value chain, incentivizing collection and recycling of plastic waste. Valorization processes will likely be closely coupled with an upstream depolymerization, but any engineering approach to transformation - chemical, biological, physical - that may result in a value-added product from end-of-life plastic materials will be considered.

Transformation to valuable products will require formulation of new chemical, biological, and physical processes and understanding of the attendant mechanisms. Similarly to depolymerization, valorization of plastic waste may require development of purpose-designed chemical or biological catalysts capable of transforming monomers, functionalized molecules, and macromolecules under non-ideal process conditions. Transformations that make use of existing components in depolymerized mixtures to obtain higher or equal value products or produce easily separable intermediate product streams are particularly desirable. Theories, models, and tools capable of design and prediction of new routes to polymeric products and monomers could revolutionize approaches to managing end-of-life plastic materials. Reaction design for polymer-to-polymer synthesis with limited physical property deterioration may also offer new opportunities for end-of-life plastic valorization. Deploying modeling approaches, such as density functional theory, molecular dynamics simulation, and kinetic network modeling, in combination with experiments should provide a means to understand and control molecular interactions between catalysts and mixture components, to understand complex reaction networks, as well as to predict structure-processing-property relationships for potential products. Advances in reactive polymer processing methods, advanced manufacturing systems, and systems-level integration with existing infrastructure may be necessary to achieve the full potential of these approaches. Consideration of the economic viability and environmental implications of the derived value-added products is highly encouraged.

Thrust 3: Enabling processes that eliminate plastic waste

This research thrust focuses on establishing fundamental knowledge and new approaches for the separation of plastics and plastic-derived molecules from chemical process streams and water sources, and for real-time detection of chemical properties and reaction dynamics, broadly defined. The goal is to promote development of innovative materials, methods, tools, and physical systems that complement processes for the elimination of end-of-life materials and valorization of polymeric products. Proposals responding to this thrust may focus on a single enabling process. Truly transformative approaches to other complementary processes, such as compatibilization, may also be considered.

Innovative separation methods will be required to eliminate end-of-life plastic materials from landfills and the environment. At the front end, developing approaches for chemical separation of multi-layer packaging could offer new opportunities for management of this otherwise non-recyclable material. Integrated with depolymerization and valorization processes, design and discovery of mass separating agents capable of low-energy, selective removal of target product streams or monomers will substantially improve process sustainability. Materials capable of withstanding extreme temperatures would be particularly advantageous. Low-energy solvent- or electrochemical-based approaches could also be employed to selectively target produced chemicals. Similarly, membranes capable of high-throughput separation of micro- and nano-scale plastic particles from water and process effluent streams could play an important role in eliminating unwanted plastic materials from the environment. Application of such materials and methods for plastic and plastic-derived molecule separations, even beyond those listed here, is expected to lead to transformative processes for chemical recycling, valorization, and environmental remediation.

Efficient handling and processing of complex plastic waste materials will require the development and application of new methods for real-time detection of chemical properties and reaction dynamics. Reliable, high-throughput analytical techniques for the characterization of municipal mixed waste streams would revolutionize operations at material recovery facilities and simplify downstream processing. For example, integration of spectroscopic methods with artificial intelligence/machine learning or even development of new sensing technologies could provide new opportunities to efficiently sort materials by chemical composition. Further downstream, development of real-time *in situ* reaction monitoring and control capabilities will facilitate effective depolymerization and valorization. To achieve this may require novel sensors and reactor designs as well as theories and models that integrate reaction and transport phenomena in polymer melts with control theory.

EFRI-E3P Programmatic Considerations

Interdisciplinary Research:

This field will benefit tremendously from research that draws on many disciplines, including engineering, chemistry, materials science, biology, and social sciences. Proposals must include one investigator from an appropriate engineering discipline, and it is strongly encouraged that proposals also include a participant from an appropriate physical or biological science discipline. Inclusion of investigators from relevant social science disciplines (e.g., ethicists, behavioral scientists, economists) is also strongly encouraged. Projects should be designed to leverage interdisciplinary expertise bridging engineering, chemical, biological, social, and other specialties to build new knowledge at the intersection of the disciplines, but fully informed by each.

Proposed projects must address at least two of the three thrusts.

Responsible Innovation: It is expected that the proposed scientific and technical activities will create socially responsible innovations for solving complex problems. It is therefore crucial that project teams are mindful of the ethical, social, economic, health, legal, and environmental implications surrounding innovations for depolymerization and valorization of end-of-life plastic products. Submitted proposals must describe these potential implications, how anticipated and unanticipated implications will be addressed, and integrate these considerations, where applicable, within the context and scope of the research. Substantial collaborations with ethicists, environmental scientists, behavioral scientists, and/or economists are encouraged, if applicable.

III. AWARD INFORMATION

The anticipated budget for this program solicitation is $30,000,000 in FY 2020, pending the availability of funds. Each award will be funded as a Standard Grant or Continuing Grant. The anticipated number of awards for this solicitation is up to 15 awards. Each project team may receive support of up to a total of $2,000,000 spread over four years. It is not expected that all awards will receive the maximum amount; the size of awards will depend upon the type of research program proposed.

If a proposal involves multiple organizations, it must be submitted as a single proposal with subawards: separately submitted collaborative proposals are not permitted.

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.
- Non-profit, non-academic organizations: Independent museums, observatories, research labs, professional societies and similar organizations in the U.S. associated with educational or research activities.

Who May Serve as PI:

For proposals submitted by Institutions of Higher Education, the lead Principal Investigator (PI) must be full-time, tenured or tenure-track faculty. For proposals submitted by Non-Profit, Non-Academic Organizations, the lead PI must meet all of the following requirements: (1) the PI has a continuing appointment that is expected to last the four years of an EFRI grant; (2) the appointment has substantial research responsibilities; and (3) the proposed project relates to the PI's job responsibilities as well as to the mission of the department or organization.

A minimum of one PI and two co-PIs must participate in each proposal. Either the PI or one of the co-PIs must have a full-time, tenured or tenure-track faculty appointment within a College/Department of Engineering.

Limit on Number of Proposals per Organization:

There are no restrictions or limits.

Limit on Number of Proposals per PI or Co-PI: 2

Individuals may participate as either PI or co-PI in only one proposal submitted to each topic described in this solicitation. It is the responsibility of the submitting organization to ensure that the PI and all co-PIs are participating only in one proposal per topic as either PI or co-PI and not in any others submitted in response to the same topic for this solicitation.

If an individual is listed as PI or co-PI on more than one proposal per topic submitted in response to this solicitation, all proposals in excess of the limit for any person will be returned without review in the reverse order received.

V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

A. Proposal Preparation Instructions

Letters of Intent *(required)* :

A one-page Letter of Intent is required. The letter should be submitted via FastLane no later than the date specified in this solicitation. The subject heading of the letter should include a brief title of the proposal and the name of the lead organization. Each letter must include the following:

1. THE TITLE - Title of the EFRI proposal, preceded by the words **" EFRI DCheM :" or " EFRI E3P :"**.
2. THE TEAM - Names, departmental and organizational affiliation, and expertise of the Principal Investigator and at least two co-Principal Investigators.
3. THE SYNOPSIS (GOALS) - Brief description of the specific goals of the proposal (maximum of 250 words).

These letters of intent are not used as pre-approval mechanisms for the submission of preliminary proposals and no feedback is provided to the submitters, *however letters of intent are required for all submitted preliminary proposals to this solicitation.* The letters of intent are not reviewed but are used to assess the overall response to the solicitation. They help NSF anticipate review requirements for preliminary proposals. For more information on letters of intent, please review the *NSF Proposal & Award Policies & Procedures Guide* (PAPPG).

Letter of Intent Preparation Instructions:

When submitting a Letter of Intent through FastLane in response to this Program Solicitation please note the conditions outlined below:

- Submission by an Authorized Organizational Representative (AOR) is required when submitting Letters of Intent.
- A Minimum of 2 and Maximum of 4 Other Senior Project Personnel are permitted
- A Minimum of 0 and Maximum of 3 Other Participating Organizations are permitted
- Submission of multiple Letters of Intent is not permitted

Preliminary Proposals *(required):* Preliminary proposals are required and must be submitted via the NSF FastLane system.

Preliminary proposals should provide a brief overview of the project focusing on its transformative aspect. They should include sufficient information to allow assessment of the main ideas and approaches and how proposed projects are appropriate for the EFRI program as opposed to existing programs. Review of the preliminary proposals will include particular emphasis on the transformative nature and impact of the proposed idea.

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 organization's responsibility to ensure that the proposal is compliant with all applicable requirements. If there are multiple organizations involved in a preliminary proposal, it must be submitted as a single proposal with subawards and not as separately submitted collaborative proposals. 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 EFRI program 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 should be listed on the project summary page and entered into FastLane as senior personnel.

Title of Proposed Project: The title for the proposed EFRI project must begin, as appropriate, with either " EFRI DCheM Preliminary Proposal:" or " EFRI E3P Preliminary Proposal:" . The title must state clearly and succinctly the major emerging frontier in research and innovation that is the focus for 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 organization, and a list of co-PIs and senior personnel together with their organizations;
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.

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 in approximately one page;
2. **Approach and Methodology** - Describe the approach and methodology that will be used to achieve the vision and goals in approximately three pages; and
3. **Transformative Impact** - In approximately one page, describe the transformative aspects of the project, including how the synergy of experts from different disciplines will achieve 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 preliminary Broadening Participation Plan.

References Cited: Indicate with an asterisk any cited publications that resulted from prior research funded by NSF for the PI or co-PI (s).

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 organization. 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 succinct description of what each person uniquely brings to the project and how their expertise will be integrated to foster synergy.

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.

A **Powerpoint Slide** must be submitted by E-mail:

Proposers **must send the following document via email within 24 hours of submission of their proposal**. After receipt of the proposal number from FastLane, send an email with a single PowerPoint slide attached, summarizing the vision of the EFRI proposal to - efri2020@nsf.gov. The subject heading of the email should note the proposal number, the PI, and the lead organization. This will be used during review panel discussions.

Remember to email this PowerPoint slide to: efri2020@nsf.gov; **do not use FastLane**.

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 the end of January 2020, invited proposers should expect to receive an invitation from the EFRI program to submit a full proposal.

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

- 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) 292-7827 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) 292-7827 or by e-mail from nsfpubs@nsf.gov.

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 PIs will be invited to submit a full proposal. If multiple organizations are involved in an invited full proposal, it must be submitted as a single full proposal with subawards, and not as separately submitted collaborative proposals.

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 Program:

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 EFRI program 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. Additional project leaders or senior personnel should be listed on the project summary page and included in the proposal as senior personnel. When preparing the Cover Sheet for full proposals, please list the related preliminary proposal number.

Title of Proposed Project: The title for the proposed EFRI project must begin with **"EFRI DCheM:" or "EFRI E3P:"**. The title must state clearly and succinctly the major emerging frontier in research and innovation that is the focus for the project.

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 organization, and a list of co-PIs and senior personnel together with their organizations;
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. Include a summary of your Broadening Participation Plan.

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 (maximum 15 pages) must include the following subsections:

1. **Intellectual Merit:** Describe the vision and goals of the proposed research, approaches and methodologies to attain the goals, and the expected outcomes, following the guidance provided in the NSF Proposal & Award Policies & Procedures Guide (PAPPG).
2. **Broader Impacts:** Please follow the guidance provided in the NSF Proposal & Award Policies & Procedures Guide (PAPPG) to prepare the Broader Impacts section. The following solicitation-specific information should also be included:
    i. The Broader Impacts section should include a subsection labeled " Key Anticipated Outcomes " that describes how the proposed project will lead to a significant shift in fundamental engineering knowledge and will have strong long-term potential for significant impact on a national need or a grand challenge.
    ii. The Broader Impacts section should also describe ways in which education and outreach are integrated within the research program to effectively achieve societal impact. Concisely articulate unifying and integrative aspects of the proposed research as well as the innovative ideas of the research.
    iii. The Broader Impacts section must include a Broadening Participation Plan . The plan must aim to broaden participation of underrepresented groups in engineering research. For more information see: Enhancing Diversity in Engineering at the end of Introduction, Section I. If needed, you may include additional information, up to five pages, about your Broadening Participation Plan as a Supplementary Document.
3. **Results from Prior NSF Support:** Please follow the guidance provided in the NSF Proposal & Award Policies & Procedures Guide (PAPPG) for reporting results from prior NSF support.

References Cited: Indicate with an asterisk any cited publications that resulted from prior research funded by NSF for the PI, or co-PIs.

Biographical Sketches for key personnel (PI, co-PIs, and each of the senior personnel listed on the Project Summary page). Use the standard PAPPG format.

Budget: Develop a realistic project budget that is consistent with the proposed activities. Provide detailed budget justifications separately for the lead organization's budget (up to five pages of budget justification), and for each subawardee budget (up to five pages of budget justification for each subaward). Proposed budgets must include funds for travel by at least one PI and at least one graduate student or researcher to attend an annual EFRI grantees' meeting.

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 EFRI 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 what each person uniquely brings to the project and how their expertise will be integrated to foster synergy;
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;
3. **Mechanisms for sharing the outcomes** of the research with the scientific community, e.g., publications, web sites, *etc*. (maximum two pages). The description should be specific and should describe what, how, and when the community would have access to the outcomes of the project. This is particularly important for projects that will produce tangible research tools and resources;

produce tangible research tools and resources;

4. Proposals that include support for post-doctoral researchers must provide a **postdoctoral researcher mentoring plan;**
5. **Broadening Participation Plan** - You may include additional information, up to five pages, about the Broadening Participation Plan in the Supplementary Documentation section; and
6. 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 (e.g., models for 3D printers). Proposers who feel that the plan cannot fit within the limit of two pages may provide additional detail in an additional Supplementary Document.

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:

- The types of data, samples, physical collections, software, curriculum materials, and other materials to be produced in the course of the project;
- Metadata to be collected and disseminated with primary data;
- The standards to be used for data and metadata format and content;
- Policies for access and sharing including provisions for appropriate protection of privacy, confidentiality, security, intellectual property, or other rights or requirements;
- Policies and provisions for re-use, re-distribution, and the production of derivatives;
- Release considerations: Timetable, Constraints, Responsible person(s), Public repository used;
- 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;
- Other digital products including (but not limited to) 3D models for printing, circuit boards designs, phenotyping data, image data, and machine learning models must be included in the data management plan;
- Letters of commitment (uploaded as supplementary document(s)) should be provided from databases or stock centers that agree to distribute project outcomes, including the actions planned and funds needed (if any) for the distribution; and
- In the case of a multi-institutional proposal, the lead organization is responsible for coordinating and managing the intellectual property resulting from the award.

PIs should consult with current data standardization procedures as described by public sites such as DataONE and follow the "The Fair Guiding Principles for Data Management and Stewardship" and those articulated in "Best Practices for Scientific Computing".

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.

A **Powerpoint Slide** must be submitted by E-mail:

Proposers **must send the following document via email within 24 hours of submission of their proposal.** After receipt of the proposal number from FastLane, send an email with a single **PowerPoint slide** attached, summarizing the vision of the EFRI proposal to efri2020@nsf.gov. The subject heading of the email should note the proposal number, the PI, and the lead organization. This will be used during review panel discussions.

Remember to email this slide to efri2020@nsf.gov no later than 24 hours after the proposal submission deadline; **do not use FastLane**.

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

Pre-submission Check List:

- No principal investigator (PI) or co-principal investigator (co-PI) is listed as a principal investigator or co-principal investigator on any other EFRI proposal submitted to a single topic;
- The Lead PI or one of the project co-PIs *must* be full-time faculty within an engineering college or department;
- If the proposal has multiple organizations, it must not be submitted as a separately submitted collaborative proposal but as a single proposal with subawards;
- Proposal has a minimum number of 3 PI/co-PIs and a maximum of 5 PI/co-PIs;
- Total budget does not exceed $2,000,000 and is spread over 4 years;
- **Broadening Participation Plan:** All proposals must describe a plan (both in the Project Summary and the Project Description) that promotes the participation of underrepresented groups in engineering;
- Post-doctoral Researcher Mentoring Plan: Each proposal that requests funding to support post-doctoral researchers must include, as a supplementary document, a description of the mentoring activities that will be provided for such individuals;
- **Data Management Plan:** All proposals must describe plans for data management and sharing of the products of research, or explain the absence of the need for such plans;
- A **list of key personnel involved** (maximum three pages), with a description of what each person uniquely brings to the project is provided in the Supplementary Documents section;
- **Collaborators and Other Affiliations (COA)** information is provided in the Single Copy Documents section using the NSF template; and
- Immediately after submission, an E-mail is sent to: efri2020@nsf.gov with a one-page project summary as a PowerPoint slide. The subject heading of the email should note the proposal number, the PI and the lead

organization.

This checklist is provided to aid in the preparation of the proposal. The burden to ensure that the proposal is complete and meets all solicitation requirements remains with the Principal Investigator.

B. Budgetary Information

Cost Sharing:

Inclusion of voluntary committed cost sharing is prohibited.

C. Due Dates

- **Letter of Intent Due Date(s)** ***(required)*** (due by 5 p.m. submitter's local time):

  November 04, 2019

  LOI due date

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

  December 02, 2019

  Preliminary Proposal Due Date

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

  March 26, 2020

  Full Proposal Due Date

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

For Proposals Submitted Via FastLane or Research.gov:

To prepare and submit a proposal via FastLane, see detailed technical instructions available at: https://www.fastlane.nsf.gov/a1/newstan.htm. To prepare and submit a proposal via Research.gov, see detailed technical instructions available at: https://www.research.gov/research-portal/appmanager/base/desktop?_nfpb=true&_pageLabel=research_node_display&_nodePath=/researchGov/Service/Desktop/ProposalPreparationandSubmission.html. For FastLane or Research.gov user support, call the FastLane and Research.gov Help Desk at 1-800-673-6188 or e-mail fastlane@nsf.gov or rgov@nsf.gov. The FastLane and Research.gov Help Desk answers general technical questions related to the use of the FastLane and Research.gov systems. 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 or Research.gov 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

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

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

In addition to the two NSF review criteria (intellectual merit and broader impacts), the following criteria will be used in the review of all EFRI proposals. For the preliminary proposals the review criteria will place greater emphasis on the transformative nature and impact of the proposed idea.

- ***TRANSFORMATIVE*** - Does the proposed research represent an opportunity for a significant leap or paradigm shift in fundamental engineering knowledge?
- ***NATIONAL NEED/GRAND CHALLENGE***- Is there potential for making significant progress on a current national need or grand challenge?
- Responsiveness to "Programmatic Considerations" for **EFRI-DCheM and EFRI-E3P** proposals as delineated in Section II. Program Description.
- **Broadening Participation Plan** - Does the plan actively promote, increase, and enhance the participation of underrepresented groups in the field of engineering and in engineering research?
- Effectiveness of the proposed **Management Plan**.

B. Review and Selection Process

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

Inter-Agency Involvement: The Department of Energy (DOE) and the National Institute of Standards and Technology (NIST) are collaborating agencies for the FY 2020 solicitation. Representatives from DOE and NIST will be permitted to view preliminary and full proposals, recommend reviewers, and attend review panels as observers, and receive unattributed proposal reviews.

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 is striving to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. The time interval begins on the date of receipt. The interval ends when the Division Director accepts the Program Officer's recommendation.

A summary rating and accompanying narrative will be completed and submitted by each reviewer. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers, 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.

decision to award or decline funding.

In developing its recommendations for awards, review panels as well as NSF staff will consider: the relative merit of the EFRI proposals using the criteria listed above, the potential national impact of the proposed activity, the balance of awards among scientific fields, geographical distribution, and the combined ability of the proposals to meet the objectives of the EFRI Office. The EFRI Office will not normally award more than one proposal from any one lead institution in this competition.

In all cases, 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 and 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.

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 PI and one graduate student or one researcher to attend an annual EFRI grantees' meeting. Awardees will be required to attend and present their research results and plans annually at an annual EFRI grantees' conference for the duration of their award.

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:

- Sohi Rastegar, Office Head, ENG/EFMA, telephone: (703) 292-8305, email: srastega@nsf.gov
- Louise R. Howe, telephone: (703) 292-2548, email: lhowe@nsf.gov
- TOPIC 1, Distributed Chemical Manufacturing (DCheM), telephone: (703) 292-2894, email: tmountzi@nsf.gov
- Triantafillos J. Mountziaris, telephone: (703) 292-2894, email: tmountzi@nsf.gov
- Carole J. Read, telephone: (703) 292-2418, email: cread@nsf.gov
- Robert McCabe, telephone: (703) 292-4826, email: RMCCABE@nsf.gov
- William Olbricht, telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Karl J. Rockne, telephone: (703) 292-5356, email: krockne@nsf.gov
- Khershed P. Cooper, telephone: (703) 292-7017, email: khcooper@nsf.gov
- Brigid A. Mullany, telephone: (703) 292-4453, email: bmullany@nsf.gov
- TOPIC 2, Engineering the Elimination of End-of-Life Plastics (E3P), telephone: (703) 292-2895, email: cpayne@nsf.gov
- Christina Payne, telephone: (703) 292-2895, email: cpayne@nsf.gov
- Bruce K. Hamilton, telephone: (703) 292-9054, email: bhamilto@nsf.gov
- William Olbricht, telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Steven W. Peretti, telephone: (703) 292-7029, email: speretti@nsf.gov
- Khershed P. Cooper, telephone: (703) 292-7017, email: khcooper@nsf.gov
- David Rockcliffe, telephone: (703) 292-7123, email: drockcli@nsf.gov
- Suk-Wah Tam-Chang, telephone: (703) 292-8684, email: stamchan@nsf.gov

For questions related to the use of FastLane or Research.gov, contact:

- FastLane and Research.gov Help Desk: 1-800-673-6188

  FastLane Help Desk e-mail: fastlane@nsf.gov.

  Research.gov Help Desk e-mail: rgov@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.

The following Program Officers may also be contacted for content-specific questions on the EFRI 2020 topics.

TOPIC 1: Distributed Chemical Manufacturing (DCheM),

- Topic Coordinator: Triantafillos J. Mountziaris, Program Director, ENG/CBET, telephone: (703) 292-2894, email: tmountzi@nsf.gov
- Robert McCabe, Program Director, ENG/CBET, telephone: (703) 292-4826, email: rmccabe@nsf.gov
- Carole Read, Program Director, ENG/CBET, telephone: (703) 292-2418, email: cread@nsf.gov
- Christina M. Payne, Program Director, ENG/CBET, telephone: (703) 292-2895, email: cpayne@nsf.gov
- Catherine Walker, Associate Program Director, ENG/CBET, telephone: (703) 292-7125, email: cawalker@nsf.gov
- James Jones, Program Director, ENG/CBET, telephone: (703) 292-4458, email: jwjones@nsf.gov
- Steven Peretti, Program Director, ENG/CBET, telephone: (703) 292-7029, email: speretti@nsf.gov
- William Olbricht, Program Director, ENG/CBET, telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Karl Rockne, Program Director, ENG/CBET, telephone: (703) 292-5356, email: krockne@nsf.gov
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- José Lage, Program Director, ENG/CBET, telephone: (703) 292-4997, email: jlage@nsf.gov
- Harsha Chelliah, Program Director, ENG/CBET, telephone: (703) 292-7062, email: hchellia@nsf.gov
- Nora Savage, Program Director, ENG/CBET, telephone: (703) 292-7949, email: nosavage@nsf.gov
- Shahab Shojaei-Zadeh, Associate Program Director, ENG/CBET, telephone: (703) 292-8045, email: sshojaei@nsf.gov
- Khershed Cooper, Program Director, ENG/CMMI, telephone: (703) 292-7017, email: khcooper@nsf.gov

- Bruce Kramer, Program Director, ENG/CMMI, telephone: (703) 292-5348, email: bkramer@nsf.gov
- Alexis Lewis, Program Director, ENG/CMMI, telephone: (703) 292-2624, email: alewis@nsf.gov
- Brigid A. Mullany, Program Director, ENG/CMMI, telephone: (703) 292-4453, email: bmullany@nsf.gov
- Anthony Kuh, Program Director, ENG/ECCS, telephone: (703) 292-2210, email: akuh@nsf.gov
- John N. Parker, Program Director, SBE/SES, telephone: (703) 292-5034, email: joparker@nsf.gov
- Kenneth Moloy, Program Director, MPS/CHE, telephone: (703) 292-8441, email: kmoloy@nsf.gov
- Vyacheslav Lukin, Program Director, MPS/PHY, telephone: (703) 292-7382, email: vlukin@nsf.gov
- Melissa Klembara, Technology Manager, US DOE Advanced Manufacturing Office, email: melissa.klembara@ee.doe.gov

TOPIC 2: Engineering the Elimination of End-of-Life Plastics (E3P),

- Topic Coordinator: Christina M. Payne , telephone: (703) 292-2895, email: cpayne@nsf.gov
- Bruce K. Hamilton, Program Director, ENG/CBET, telephone: (703) 292-9054, email: bhamilto@nsf.gov
- T. J. Mountziaris, Program Director, ENG/CBET, telephone: (703) 292-2894, email: tmountzi@nsf.gov
- William Olbricht, Program Director, ENG/CBET, telephone: (703) 292-4842, email: wolbrich@nsf.gov
- Steven W. Peretti, Program Director, ENG/CBET, telephone: (703) 292-7029, email: speretti@nsf.gov
- Carole J. Read, Program Director, ENG/CBET, telephone: (703) 292-2418, email: cread@nsf.gov
- Karl J. Rockne, Program Director, ENG/CBET, telephone: (703) 292-5356, email: krockne@nsf.gov
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- Brigid A. Mullany, Program Director, ENG/CMMI, telephone: (703) 292-4453, email: bmullany@nsf.gov
- David Rockcliffe, Program Director, BIO/MCB, telephone: (703) 292-7123, email: drockcli@nsf.gov
- Anne-Marie Schmoltner, Program Director, MPS/CHE, telephone: (703) 292-4716, email: aschmolt@nsf.gov
- Suk-Wah Tam-Chang, Program Director, MPS/CHE, telephone: (703) 292-8684, email: stamchan@nsf.gov
- Andy Lovinger, Program Director, MPS/DMR, telephone: (703) 292-4933, email: alovinge@nsf.gov
- Melissa Klembara, Technology Manager, US DOE Advanced Manufacturing Office, email: melissa.klembara@ee.doe.gov
- Nichole Fitzgerald, Technology Manager, US DOE Bioenergy Technologies Office, email: nichole.fitzgerald@ee.doe.gov
- Kathryn L. Beers, Group Leader, NIST, email: kathryn.beers@nist.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 (FASED) 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
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Office of the General Counsel
National Science Foundation
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