DE-FOA-0002657: Request for Information on Biomass Conversion Research, Development, and Analysis Programs

DATE: 2/1/2022
SUBJECT: Request for Information (RFI)

Description

The U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE) Bioenergy Technologies Office (BETO) is requesting information and feedback on several priority areas relating to activities in the Conversion Research and Development (R&D) Program:

- Improved Robustness of Microbial Cells (Category 1)
- Improved Robustness of Catalytic Processes (Category 2)
- State of Technology (SOT) Analyses in the BETO Research Portfolio (Category 3)

Background

DOE has funded R&D seeking to advance technologies enabling the sustainable production of price-competitive biofuels and bioproducts. These technologies focus on developing drop-in biofuels capable of being used as sustainable aviation, marine and diesel fuels. These bioenergy technologies can enable a transition to a clean energy economy, create high-quality jobs, support rural economies, and spur innovation in renewable energy and chemicals production – the bioeconomy.

The Conversion Technologies subprogram pursues applied R&D to generate knowledge that supports industry efforts to demonstrate and deploy technologies for converting biomass feedstocks into transportation fuels and co-produced bioproducts. Conversion research explores concepts in both biological (using biological organisms) and thermochemical (using heat, pressure, and chemical processes) routes to convert biomass, waste feedstocks, and other complex organic polymers into "drop-in" biofuels (sustainable aviation fuels, marine fuels, and legacy fuels such as diesel), fuel components, and chemical intermediates. The Conversion R&D Program funds R&D in several activity areas.

- Bio-processing R&D: The goal of this activity is to reduce the time and cost for developing and implementing biological conversion of biomass and other materials into useful fuels and products.
- Catalyst R&D: The goal of this activity is to significantly reduce the time and cost required to develop new catalysts for converting organic molecules derived from

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biomass and other relevant feedstocks via inorganic catalysis into fuels, chemical intermediates, and products.

- Co-products R&D: This activity focuses on employing the rich, functional nature of biomass to produce value-added and performance-advantaged bioproducts to enhance the economic feasibility of biorefineries, supporting lower carbon alternatives for the chemical industry.
- Deconstruction and Synthesis R&D: This activity examines and develops more efficient and effective technologies to convert biomass to fuels and products via well-defined conversion technology pathways. This activity also investigates more energy efficient and cost-effective techniques for disassembling biomass feedstocks, separating the constituents, and identifying catalytic, biochemical, and hybrid pathways for synthesizing desired end products using the organisms and catalysts developed elsewhere in the Program.

Purpose

The purpose of this RFI is to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders on issues related to Microbial Cell and Catalyst Robustness, and State-of Technology Analyses.

In the Conversion R&D Program, process robustness has been identified as a key challenge that must be addressed prior to scale-up. This includes the development of more robust organisms and catalytic processes for the conversion of sustainable feedstocks and intermediates into biofuels and bioproducts. The Program is interested in feedback on barriers, capabilities, tools, and other general information needed to prioritize future research and development programs in the areas of organism (Category 1) and catalyst development (Category 2).

The Conversion R&D Program funds techno-economic and life-cycle analysis to track progress of particular process “pathways” and unit operations. The Program is interested in feedback on which analyses are most useful to the broader bioenergy research and industrial community (Category 3).

For full descriptions and background on these Categories of Interest, please see the respective Categories below.

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This is solely a request for information and not a Funding Opportunity Announcement (FOA). EERE is not accepting applications.

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications at this time. EERE may issue a FOA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA. There is no guarantee that a FOA will be issued as a result of this RFI. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of EERE funded awards, will be subject to Congressional appropriations and direction.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

Confidential Business Information

Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery two well-marked copies: one copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Evaluation and Administration by Federal and Non-Federal Personnel

Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to EERE providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Categories and Questions

Category 1: Improving Robustness of Microbial Cells

The bioprocess industry relies heavily on microbial conversion of a feedstock into a product reproducibly, consistently, and over extended periods of time. However, performance of these microorganisms has been shown to suffer from variability in a few important ways. Two key types of variability include cell-to-cell variability and batch-to-batch variability. Many studies have explored the mechanisms of cell-to-cell variability, and several groups have developed creative solutions to reduce variability. Batch-to-batch variability is widely acknowledged but fewer studies have been published describing this effect, in part possibly due to the lack of incentive to publish negative data. Ultimately, gaps remain in understanding why microbial performance varies and how organisms can be engineered for improved robustness.

For the purpose of this RFI, the term "robustness" will be used to describe an engineered microorganism or process optimizations that can avoid cell-to-cell production variability, maintain stable production over an extended period of time, and/or perform reproducibly between batches. This RFI seeks to explore two related issues: cell-to-cell and batch-to-batch variability, and stable production for an extended period of time. It will be important to explore whether reducing variability has an impact on increasing the duration of performance of microbial systems, where long-running continuous systems could provide discrete cost and process advantages over batch systems. In order to improve robustness, it is critical to understand barriers facing improved strain performance and reliability.

Production of renewable fuels and chemicals in a biorefinery represents a cornerstone of BETO's approach to meet the demand for non-petrochemical derived chemicals and fuels, and provides a clear path to sustainable and carbon neutral transportation and chemical production industries. This RFI seeks to gain additional perspectives relating to microbial robustness, and how microbial performance affects the ability to commercialize bioprocesses. EERE specifically seeks information identifying the critical technology gaps and research needs required to enable more robust microorganism engineering in core BETO mission areas. Some example research needs include but are not limited to:

- identify BETO-relevant industrial processes that are impacted by poor microbial host robustness;
- improve the understanding of microbial performance and variability at a single cell resolution;
- understand why organisms lose viability or productivity during a fermentation; and

- develop approaches to improve microbial production and to increase the duration of productivity.

Responses to this Category may address one or more of the following questions:

Barriers to Robust Microbial Cells

1. What are the critical technical hurdles for developing robust microbial strains?
2. Has strain performance variability affected the ability to take a technology to scale or market? If so, how?
    a. To what degree has cell-to-cell variability impacted the successful development of a bioprocess?
    b. In what ways has batch-to-batch variability impacted the successful development of a bioprocess?
3. What are the gaps in knowledge surrounding cell-to-cell variability?
4. What are the gaps in knowledge surrounding batch-to-batch variability?
5. Is there another type of variability not captured above that has affected the performance of a bioprocess cultivation? If so, please describe.
6. In what instances may strain robustness introduce a barrier to bioprocess development? In what instances is robustness not a barrier?

Tools and Capabilities for Robust Microbial Cells

7. How is strain variability characterized, and at what stage of process development?
8. Is a lack of fundamental understanding of strain variability limiting to strain engineering? If so, please explain.
9. To what degree is access to solutions to increase robustness a barrier to development?
10. Are there standard methods to identify and rectify a lack of strain robustness? If yes, what are key process and performance parameters in comparing technologies against one another?
11. What are the most effective tools currently to improve strain robustness, and are there any tradeoffs associated with implementing those tools?

General Bioenergy-related Strain Engineering Challenges

12. Please provide any additional input or information regarding other strain engineering challenges related to the BETO mission not covered by the questions about Barriers and Tools and Capabilities above.

Category 2: Improving Robustness of Catalytic Processes

BETO is requesting input on catalytic process development, catalyst durability and accelerated aging/stress testing, and catalyst scale-up/manufacturing related to production of sustainable aviation, marine, and diesel fuels.

Specifically, BETO seeks information to help identify and understand additional areas of research, capabilities, and yet-to-be-addressed challenges associated with developing novel catalysts used in technology development and engineering solutions for the efficient conversion of biomass such as lignocellulosic, waste, and algal feedstocks to produce mostly biofuels and bioproducts. BETO supports the development of catalysis for biomass conversion to fuels and co-products through many independent projects and the ChemCatBio Consortium with its mission to help accelerate the development of catalytic technologies that convert biomass and waste resources into renewable fuels and chemicals. The conversion technologies of interest including but not limited to heterogeneous catalysis for thermochemical processes and alternative upgrading strategies.

Responses to this Category may address one or more of the following questions:

Barriers to Robust Catalytic Processes

1. What challenges have you met in scaling up a catalyst? At what stage have you moved from a powder catalyst to an engineered catalyst that can fit the industry demand? What adjustments were needed to bridge the gap between a research catalyst and an engineered catalyst? Are there BETO capabilities or research areas that can improve the speed and predictability of catalyst scaleup? If so what are they?
2. What are the major challenges and barriers that exist for the small-scale production of representative novel catalysts for biomass conversion? What information is needed to overcome these challenges?
3. When a catalyst manufacturer was involved, how did the interaction inform the catalyst development? Was it beneficial to have such interaction early in the process of catalyst development?
4. What are the most important impurities in real bio-derived streams that are impacting catalyst stability and durability?
5. How should efforts toward removal of the impurities and development of more robust catalysts be balanced? What mitigation approaches require further investigation?

6. How do you optimize time-on-stream (500+ hours?) in studies to determine catalyst stability for model biostreams? How does this vary for real biostreams?
7. What critical operations need additional investigation to further improve the viability of byproduct streams (e.g., light gases that may need upgrading towards fuel products)?
8. Is there a need for improved hydrotreating catalysts to remove any residual heteroatoms, metals, or organics that could impede certification of SAF, renewable diesel or marine fuels? Is there a need for developing new or modified catalysts for refinery co-processing operations? If so, can you identify some of these needs?
9. What critical material attributes or critical process performance measures are needed to provide confidence to stakeholders in moving to the next stage of development for your process or technology?

Tools and Capabilities for Robust Catalytic Processes

10. Please describe the use of accelerated aging and stress testing that have been applied in your catalyst development program. What challenges and barriers exist in improving catalyst lifetime and durability? What capabilities are most valuable in this task?
11. What testing protocols are most useful in assessing catalyst durability and stability at early stages of development?
12. Can investigating catalyst stability be done mostly using a mechanistic approach to deactivation or is testing the catalyst for longer time-on-stream (500 + hrs.) still required?
13. What characterization and simulation techniques have you applied in your catalyst development? What challenges have you met in using these tools to further catalyst development?
14. Please describe your approach to selecting a benchmark catalyst for the conversion of biomass. What information was most valuable in your benchmarking activities (e.g., insight into fundamental chemistry, process parameter boundaries, etc.)?
15. Would you be interested in collaborating with National Laboratories, especially ChemCatBio consortium, in developing catalysts for conversion of biomass to fuel? If yes, which research areas of the consortium might be of most interest to you?

General Information about Catalytic Pathways

16. If you are actively engaged in developing a biomass to fuels/products technology, please describe your efforts in developing heterogeneous catalysts for use in producing SAF, renewable diesel, or marine fuels or intermediates to produce these

fuels. Briefly describe the feedstocks or the intermediates used, the overall process technology and the overall state of the technology.

17. What alternative technology pathways (such as syngas to olefins to fuel, ethanol to fuel, or catalytic upgrading of biochemical intermediates such 2,3 butanediol (2,3 BDO) to fuel) could provide value towards decarbonization goals? What aspects of the technology need additional work or research to move to the next stage of development?
18. In addition to the pathways listed above, do you see additional pathways for the conversion of biomass to SAF, renewable diesel, or marine fuels using heterogeneous catalysis? If yes, please list.
19. How should the balance between producing fuels and co-products be determined? What level of effort should go towards each to make the biomass to fuel conversion viable?
20. Is upgrading 2,3 BDO resulting from fermentation of sugars to fuels a viable approach or has a potential market value without further processing? Please explain why or why not.

Category 3: State of Technology (SOT) Analyses in the BETO Research Portfolio

BETO funds R&D on technologies necessary for the deployment and production of cost-competitive bioenergy, primarily biofuels. Results of experimental efforts are periodically compiled and compared with benchmark technology designs to assess overall progress.

As of 2020, BETO publishes annual updates on seven (7) pathways from biofuel feedstocks to finished fuel. These pathways are listed below. Each pathway is compared to a projected outyear design case. Design cases provide the benchmark against which the current SOT is assessed to understand the technology breakthroughs needed to reach ultimate design-case-based technical targets. Interim projections between the latest SOT results and goal-year projections anchor interim R&D technical targets. More detail can be found in the most recent SOT Research and Development Status Report.

- Dry Feedstocks Converted via Catalytic Fast Pyrolysis
- Dry Feedstocks Converted via Indirect Liquefaction and Upgrading
- Hydrocarbon Fuels and Coproducts from Dry Feedstocks via 2,3-BDO Intermediate
- Hydrocarbon Fuels and Coproducts from Dry Feedstocks via Mixed Acids Intermediate
- Algal Biomass Fractionation to Lipid-and Carbohydrate-Derived Fuel Products
- Algal Biomass to Hydrocarbons through Whole Algae Hydrothermal Liquefaction and Upgrading
- Hydrothermal Liquefaction Processing of Wet Waste to Fuels

SOT reports and design cases are designed to allow BETO to benchmark progress across multiple feedstocks and technologies and to be a reference to external stakeholders to help them guide R&D and investments. BETO is seeking input on how external stakeholders utilize current SOT reports and design cases and what additional data it would be useful for external stakeholders to have a record of in outyears.

To achieve BETO goals, future SOT pathways of interest will be required to produce sustainable aviation fuel (SAF) as the primary fuel product, and should be able to achieve a greater than 70% reduction in greenhouse gases (GHGs) when compared to incumbent petroleum technologies.

Responses to this Category may address one or more of the following questions:

1. How does your organization utilize current BETO SOT reports, or how might it plan to use them in the future?

  a. Is it more useful to publish a broad examination of a large number of pathways or to have additional detail on a smaller number of pathways? Why?
  b. Are focused analyses on unit operations for biofuels production of interest in addition to or in place of reports on full pathways from feedstock harvest to finished fuel? Why?
  c. Is focusing on early TRL pathways of greater or lesser benefit than benchmarking pathways near commercialization? Why?

2. What should be included in BETO SOT reports?
  a. Are there key metrics currently not included in the SOT reports that would be useful to include going forward? If so, what metrics would you like to see included?
  b. BETO pathways project nth plant project costs. Is this reasonable and are the assumptions on nth plant costs reasonable (e.g. internal rate of return, etc.)? If this is not reasonable, what are alternatives that you would recommend to provide consistent assumptions?
  c. Several of BETO's current pathways include the production of co-products along with a finished hydrocarbon fuel. Should the assumptions currently used by BETO to quantify the cost and life cycle sustainability effects of co-products be revised? If so, how would you recommend accounting for these co-product credits?

3. Is BETO including the right set of pathways in its SOT Reports?
  a. BETO currently only publishes SOT data on promising pre-commercial pathways. Is there an interest in BETO publishing updated standard data on commercial pathways such as HEFA and Fischer-Tropsch?
    i. If BETO were to pursue publishing standard data on common commercial pathways what data would be of interest?
  b. Are there specific pathways of interest that are currently not covered by BETO's SOT reports? If so, please list additional pathways that should be included. Note: additional pathways would need to utilize feedstocks allowed under Section 932 of the 2005 Energy Policy Act, produce SAF as the primary fuel product, and be able to achieve a 70% reduction in GHGs when compared to petroleum incumbents.

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to FY22ConversionRFI@ee.doe.gov no later than 5:00pm (ET) on March 11, 2022. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) attachment to the email, and no more than 6 pages in length, 12 point font, 1 inch margins. Only electronic responses will be accepted.

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

EERE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.

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