FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

Department of Energy (DOE)
Office of Fossil Energy and Carbon Management (FECM)

Carbon Negative Shot Pilots

Funding Opportunity Announcement (FOA) Number: DE-FOA-0003082
FOA Type: Modification 000002
Assistance Listing Number: 81.089

FOA Issue Date:	02/12/2024
Modification 000001 Date:	02/29/2024
Modification 000002 Date:	03/28/2024
Submission Deadline for Full Applications:	04/16/2024 / 11:59PM ET
Expected Date for Selection Notifications:	August 2024
Expected Date for Award:	January 2025

Modifications

All modifications to the Funding Opportunity Announcement (FOA) are highlighted in the body of the FOA.

Mod. No.	Date	Description of Modification
000001	02/29/2024	Modification 000001 is to: • Revise language in Section I.C.ii; and • Add language in Section I.D. All changes are highlighted in yellow. Deleted text is denoted in strikethrough and additional text is denoted in red font.
000002	03/25/2024	Modification 000002 is to: • Revise language in Section I.D; • Add language to Section IV.A; and • Add "Letters of Commitment" to Section IV.B.ii. All changes are highlighted in turquoise. Deleted text is denoted in strikethrough and additional text is denoted in red font.

Registration Requirements

There are several one-time actions that must be completed before submitting an application in response to this Funding Opportunity Announcement (FOA) (e.g., register with the System for Award Management (SAM), obtain a Unique Entity Identifier (UEI) number, register with Grants.gov, and register with FedConnect.net to submit questions). It is vital that applicants address these items as soon as possible. Some may take several weeks, and failure to complete them could interfere with an applicant's ability to apply to this FOA.

- **SAM** Applicants must register with SAM at https://www.sam.gov/ prior to submitting an application in response to this FOA (unless the applicant is exempt from those requirements under 2 CFR 25.110). Designating an Electronic Business Point of Contact (EBiz POC) and obtaining a special password called an MPIN are important steps in SAM registration. Failure to register with SAM will prevent your organization from applying through Grants.gov.

The applicant must maintain an active SAM registration with current information at all times during which it has an active Federal award or application under consideration. More information about SAM registration for applicants is found at:
https://www.fsd.gov/gsafsd_sp?id=gsafsd_kb_articles&sys_id=650d493e1bab7c105465eaccac4bcbcb.

NOTE: If clicking the SAM links do not work, please copy and paste the link into your browser.

Due to the high demand of SAM registrations and UEI requests, entity legal business name and address validations are taking longer than expected to process. Entities should start the SAM and UEI registration process as soon as possible.
If entities have technical difficulties with the SAM registration or UEI validation process they should utilize the HELP feature on SAM.gov. SAM.gov will work entity service tickets in the order in which they are received and asks that entities not create multiple service tickets for the same request or technical issue. Additional entity validation resources can be found here: GSAFSD Tier 0 Knowledge Base - Validating your Entity.

- **UEI** Applicants must obtain an UEI from the SAM to uniquely identify the entity. The UEI is available in the SAM entity registration record.

  NOTE: Subawardees/subrecipients at all tiers must also obtain an UEI from the SAM and provide the UEI to the Prime Recipient before the subaward can be issued.

- **Grants.gov** - Applicants must register with Grants.gov and set up your WorkSpace. You cannot submit an application through Grants.gov unless you are registered. Please read the registration requirements carefully and start the process immediately.

  1) The Authorized Organizational Representative (AOR) must register at: https://apply07.grants.gov/apply/OrcRegister
  2) An email is sent to the E-Business (E-Biz) POC listed in SAM. The E-Biz POC must approve the AOR registration using their MPIN from their SAM registration.

     More information about the registration steps for Grants.gov is provided at:
     https://www.grants.gov/web/grants/applicants/registration.html

     In addition:
     - Add a Profile to a Grants.gov Account: A profile in Grants.gov corresponds to a single applicant organization the user represents (i.e., an applicant) or an individual applicant. If you work for or consult with multiple organizations and have a profile for each, you may log in to one Grants.gov account to access all of your grant applications. To add an organizational profile to your Grants.gov account, enter the UEI for the organization in the UEI field while adding a profile.

For more detailed instructions about creating a profile on Grants.gov, refer to: https://www.grants.gov/web/grants/applicants/registration/add-profile.html

- *EBiz POC Authorized Profile Roles*: After you register with Grants.gov and create an Organization Applicant Profile, the organization applicant's request for Grants.gov roles and access is sent to the EBiz POC. The EBiz POC will then log in to Grants.gov and authorize the appropriate roles, which may include the AOR role, thereby giving you permission to complete and submit applications on behalf of the organization. You will be able to submit your application online any time after you have been assigned the AOR role.

  NOTE: When applications are submitted through Grants.gov, the name of the organization applicant with the AOR role that submitted the application is inserted into the signature line of the application, serving as the electronic signature.

  The EBiz POC **must** authorize people who are able to make legally binding commitments on behalf of the organization as a user with the AOR role; **this step is often missed and it is crucial for valid and timely submissions.**

  For more detailed instructions about creating a profile on Grants.gov, refer to: https://www.grants.gov/web/grants/applicants/registration/authorize-roles.html

  To track your role request, refer to: https://www.grants.gov/web/grants/applicants/registration/track-role-status.html

Questions relating to the **registration process**, **system requirements, or how an application form works** must be directed to Grants.gov at 1-800-518-4726 or **support@grants.gov**.

- **FedConnect.net -** Applicants must register with FedConnect to submit questions. FedConnect website: www.fedconnect.net.

  See Section IV for Application and Submission Information (including how to create a WorkSpace).

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I. Funding Opportunity Description

A. Authorizing Statutes

The programmatic authorizing statutes are:

DOE Organization Act, 42 U.S.C. § 7101., et seq. (Public Law 95-91), as amended and; 42 U.S.C. § 16292.

Awards made under this announcement will fall under the purview of 2 Code of Federal Regulations (CFR) Part 200 as amended by 2 CFR Part 910.

B. Background/Description

The Department of Energy (DOE) Office of Fossil Energy and Carbon Management (FECM) with the National Energy Technology Laboratory (NETL), in partnership with other parts of the Department, including the Office of Clean Energy Demonstrations (OCED), Hydrogen and Fuel Cell Technologies Office (HFTO), Bioenergy Technologies Office (BETO), Water Power Technologies Office (WPTO), Geothermal Technologies Office (GTO), Office of Science, and the Office of Technology Transitions (OTT) intend to issue multiple funding opportunities over the next several years to support the development and commercialization of carbon dioxide removal (CDR) technologies and collectively enable the Department's Carbon Negative Shot (CNS) target of gigaton-scale deployment for less than $100 per net metric ton (tonne) of CO_2-equivalent (CO_2e) within a decade.

DOE plans to design and release a series of multi-topic, multi-year funding opportunities soliciting applied research, development, and demonstration (RD&D) for CDR technologies that will be coordinated across DOE offices in order to achieve CNS objectives across CDR pathways. These funding opportunities are expected to focus on several topics responsive to both Departmental annual CDR programmatic priorities and several CDR Bipartisan Infrastructure Law (BIL) related activities. In alignment with the Department's commitment to equity, justice, and community consultation, these topic areas incorporate Community Benefit Plan requirements to ensure projects do not have adverse impacts and do support workforce development and environmental protection. These funding opportunities include this FOA, DE-FOA-0003082 "Carbon Negative Shot Pilots", which is focused on integrated pilot-scale testing of advanced CDR technologies in relevant environments.

The "CNS," as part of the DOE's larger Energy Earthshots Initiative, is the United States (U.S.) government's first major effort in CDR and is a Department-wide call for crosscutting innovation and commercialization of a wide range of CDR pathways.

The challenge sets the goal of less than $100 per net tonne of CO_2-equivalent removed across CDR pathways with gigaton scale potential inclusive of monitoring, reporting, and verification (MRV) and durable storage by 2032. Achieving this ambitious goal is essential for the U.S. to achieve net-zero emissions by 2050, and to enable the clean-up of legacy emissions thereafter.

The BIL, Inflation Reduction Act (IRA), and annual Energy and Water Development Appropriations Acts have provided DOE with unprecedented funding to advance the CNS. However, the gap between the ambition of the CNS and the current commercial readiness of some CDR technologies is vast. DOE recognizes that additional funding will be needed to achieve the CNS goals, especially in areas outside of Direct Air Capture (DAC) (which has received the bulk of Congressional support to date). This FOA initializes a strategy to coordinate funding opportunities across CDR pathways, technology readiness levels, and DOE offices and programs for existing available funds as well as any additional funding from Congress in the future.

CDR is a crosscutting RD&D area for DOE requiring a coordinated approach to achieve CNS objectives through multiple CDR approaches enabled at scale to achieve the net-zero emissions in the U.S. by 2050. DOE emphasizes robust analysis of life cycle impacts of various CDR approaches and a deep commitment to environmental justice. This will include rigorously evaluating CDR practices and technologies, defining conditions for success, and leveraging FECM's extensive leadership and expertise.

i. Background and Purpose

In 2019, the National Academies of Sciences, Engineering and Medicine (NASEM) released a report titled, "Negative Emissions Technologies and Reliable Sequestration: A Research Agenda."[1] This report, co-funded by the Office of FECM's Carbon Capture Program, focuses on negative emissions technologies (NETs) that aim to capture carbon from the atmosphere, with the resultant carbon stored or utilized for carbon removal. The report assessed five types of NETs, including DAC and biomass carbon removal and storage (BiCRS), and provides perspective on the current state of these technologies. The report identified challenges in the application of CDR, including the dilute concentration of CO_2 in the atmosphere, large water and land use requirements, carbon lifecycle effectiveness, and impacts of DAC process pressure drop on overall energy use and system cost. In response to this report, DOE-FECM co-hosted a workshop in 2019 ("Workshop on Direct Air Capture Technology Needs"), and recently announced the selection of

[1] https://www.nationalacademies.org/our-work/developing-a-research-agenda-for-carbon-dioxide-removal-and-reliable-sequestration

projects that will focus on the development of transformational materials[2] and bench scale testing of components[3] for use in DAC, as well as initial engineering design for carbon capture, utilization and storage systems from air.[2] DOE-FECM also issued a Request for Information (RFI) (DE-FOA-000228) on February 11, 2020 to understand the impact of biomass processing on carbon capture systems.

Early in 2021, ICEF (Innovation for Cool Earth Forum) released a report titled "Biomass Carbon Removal and Storage (BiCRS) Roadmap". As some processes that use biomass to remove CO_2 from the atmosphere do not involve bioenergy, the report expands the definition of biomass utilization for carbon dioxide removal beyond bioenergy with carbon capture and storage (BECCS), and defines BiCRS as a process that "(i) uses biomass to remove CO_2 from the atmosphere, (ii) stores that CO_2 underground or in long-lived products, and (iii) does no damage to—and ideally promotes—food security, rural livelihoods, biodiversity conservation and other important values." The report also assumes that, "when bioenergy is combined with carbon capture and storage (CCS), the removal of carbon from the atmosphere—not the production of energy—will often be the most valuable part of the process."[4]

Oceans cover roughly 70% of the earth's surface and serve as a natural reservoir for excess CO_2 concentrations in the atmosphere. There are several physical, geochemical, and biological processes that influence the exchange between air and oceans, which have resulted in an excess of CO_2 in the oceans currently, causing negative impacts on ecosystems. In any type of research performed that can affect the makeup of the oceans, it is of critical importance that ecosystems are preserved or improved and that oceanic activities adhere to domestic and international agreements.

The NASEM released the report "A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration" in 2022, describing the key research impacts and challenges of ocean-based CDR as well as several approaches to be considered.[5] There are several different approaches to ocean-based CDR outlined in the NASEM report. Both biotic and abiotic ocean-based approaches, including direct ocean capture of CO_2, ocean

[2] https://www.energy.gov/articles/department-energy-invests-72-million-carbon-capture-technologies
[3] https://www.energy.gov/fe/articles/us-department-energy-announces-15-million-funding-opportunities-direct-air-capture-0
[4] https://www.icef.go.jp/pdf/summary/roadmap/icef2020_roadmap.pdf
[5] National Academies of Sciences, Engineering, and Medicine 2021. A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington, DC: The National Academies Press. https://doi.org/10.17226/26278.

alkalinity enhancement (mineral and electrochemical), and micro- and macroalgae-based pathways, are of interest under this FOA.

Carbon mineralization is the process in which CO_2 precipitates into carbonate minerals when exposed to silicate minerals enriched with calcium or magnesium, non-silicate mineral reactants, or enzyme catalysis with appropriate cations (e.g., CO_2 laden with brines). Enhanced mineralization processes remove CO_2 from the air and store it in the form of carbonate minerals such as calcite or magnesite. Alkaline materials, such as naturally occurring rocks (e.g., basalts and peridotite), industrial waste material, or mine tailings, react readily with CO_2 to form carbonates that permanently store CO_2 as a solid. For the processes of interest to DOE under this FOA, captured carbon may be permanently stored in natural systems or materials via mineralization processes either within the Earth's surface or subsurface. Captured carbon may undergo surficial carbon mineralization at the land surface with industrial wastes (e.g., in mine waste piles or ponds) or in ex-situ industrial settings (e.g., reactor vessels). The CO_2 removed must be obtained directly from the atmosphere.

Given the importance of scale to CO_2 removal, DOE will explore multiple RD&D opportunities which aim to transcend the classical reliance on economies of scale, such as process intensification, modularization and advanced manufacturing. An essential component of the RD&D effort in the drive for cost reduction is the act of "learning by doing" – i.e., construction and operation of pilot- and demonstration-scale facilities. Cost reductions in technologies novel for their time are common and well-documented in the evolution of environmental control processes and systems. Taylor et al. (2005) analyzed cost reductions in flue gas desulfurization (FGD) installations over time (Taylor, Rubin, & Hounshell, 2005).[6] Their findings showed that the maturation of FGD technology over a 20-year period led to a 50 percent decrease in capital costs arising from improvements in reliability. Increased reliability allowed designers to eliminate costly redundancies such as spare absorber modules. Additional capital cost savings resulted from technological trends that provided economies of scale, lowered unit costs and reduced reagent preparation costs. In addition, the analysis showed that operating costs were reduced, on average, to 83 percent of their original values for each doubling of cumulative power generation. This value of 83 percent is known as the "progress ratio" and is comparable to progress ratios found in many other industries through the "learning by doing" model of tacit knowledge acquisition. Current experience strongly suggests that similar cost

[6] Taylor, M. R., Rubin, E. S., & Hounshell, D. A. (2005). Control of SO2 emissions from power plants: A case of induced technological innovation in the U.S. Technological Forecasting & Social Change, 697-718.

reductions can be achieved as more experience is gained deploying and operating carbon capture technology.

Two important tools in the effort to drive down costs for CDR and evaluate how a CDR activity will impact natural systems, biodiversity, water consumption, land use, food security, and diverse ecosystems are pilot-scale testing and front-end engineering design (FEED) studies. Pilot-scale testing provides data not always available at laboratory/bench scale that can be used to drive FEED studies. This FOA is focused on integrated pilot-scale testing of advanced CDR technologies to inform efficient and responsible process maturation and accelerate technology deployment.

This FOA aims to expand the current DOE's portfolio of CDR technologies (e.g., biomass carbon removal and storage, enhanced mineralization, ocean-based CDR, DAC, etc.) to advance technologies that will ultimately achieve the Carbon Negative Shot target of under $100/net tonne CO_2e removed (i.e., both capture and storage), by 2032.

ii. Research and Development Community Benefits Plan (April 2023)

DOE is committed to investing in research and development (R&D) innovations that deliver benefits to the American public and leads to commercialization of technologies and products that foster sustainable, resilient, and equitable access to clean energy. Further, DOE is committed to supporting the development of more diverse, equitable, inclusive, and accessible workplaces to help maintain the nation's leadership in science and technology.

To support the goal of building a clean and equitable energy economy, projects funded under this Funding Opportunity Announcement are expected to (1) advance diversity, equity, inclusion, and accessibility (DEIA); (2) contribute to energy equality; and (3) invest in America's workforce. To ensure these objectives are met, applications must include a R&D Community Benefits Plan (R&D Community Benefits Plan) that addresses the three objectives stated above. See Section IV, "Application and Submission Information, R&D Community Benefits Plan", and the "R&D Community Benefits Plan" **Appendix A** for more information on the R&D Community Benefits Plan content requirements.

C. Objectives/Areas of Interest (AOI)

The current FOA aims to support achievement of CNS objectives across CDR pathways through support for integrated pilot-scale testing of advanced CDR technologies in relevant environments.

Under the current FOA opening, applications are solicited in the following subtopics:

AOI-1. Small Biomass Carbon Removal and Storage (BiCRS) Pilots

AOI-2. Small Mineralization Pilots

AOI-3. Multi-Pathways CDR Testbed Facilities

AOI-4 is anticipated to be issued under future amendments to the FOA.

i. AOI-1: Small Biomass Carbon Removal and Storage (BiCRS) Pilots

The objective of **AOI-1** is to support integrated pilot-scale testing of BiCRS or conversion with appropriate MRV. BiCRS pilots will investigate and validate various pathways, including but not limited to: pyrolysis, gasification, combustion, conversion, burial, sinking, bioliquid injection, and alternative conversion or storage methods, such as engineered wood products and biofiber entombment. These pathways may include coproducts, such as hydrogen, liquid transportation fuels, and electricity.

BiCRS feedstocks for **AOI-1** must be sustainably produced and not interfere with food crops, other land uses, or water resources and minimize ecological impact.[7] For **AOI-1**, sustainably-sourced biomass feedstock options include, but are not limited to: forestry products (e.g., forestry residues, processing residues (bark, sawdust, offcuts, wood pellets)), agriculture products (e.g., harvesting residues (straws, and corn stalks), processing residues (rice husks, peanut shells, fruit residues, cereal straws), animal waste), municipal waste, black liquor from paper production, microalgae (e.g., grown on land, in ponds, or in oceans), and energy crops (e.g., wood (willow, poplar), grasses). Applicants must demonstrate supply chain availability relevant to their project through a resource assessment.

For **AOI-1**, DOE is seeking applications that design, build, and test advanced biomass carbon removal systems. Pilot-scale testing for **AOI-1** is defined as pilot facilities with the design capacity to capture and remove at least 1,000 tonne CO_2e/yr.

[7] https://www.energy.gov/eere/bioenergy/2016-billion-ton-report

The successful applicants will test their integrated biomass carbon removal technology, at pilot-scale, for at least 500 hours of continuous operation. Systems should validate integrated operations in a relevant environment and should be capable of performing all the functions that will be required of the operational system, including layered MRV protocols, except compression and secure geologic storage of CO_2, if applicable. Applications proposing BiCRS pathways that produce CO_2 must deliver a concentrated stream with 95% or greater CO_2 purity and meet NETL's CO_2 impurity quality guidelines.[8] All projects must utilize a test site in the U.S.

To be considered ready for pilot-scale testing, technologies proposed for **AOI-1** must have already successfully completed an integrated, bench-scale validation (i.e., total system or multi-component system) with the same sustainably-sourced biomass feedstock in the proposed application. **AOI-1** applicants are highly encouraged to propose teams that include both the BiCRS technology developer, sustainably-sourced biomass supplier, and the landowner of the proposed test site.

If an applicant is proposing team member(s), letter(s) of commitment from the member(s) are required as evidence of the participation. The letter(s) of commitment must be signed by the person authorized to commit resources on behalf of the organization. Letter(s) should demonstrate the partner's level of commitment to the project, such as host site access, sustainably-source biomass supply availability, data access, and/or advisory services, etc.

Of particular interest for **AOI-1** are pilot-scale validations of integrated BiCRS processes that feature one or more of the following capabilities:

- Understanding of the diverse combinations of factors that influence BiCRS processes, including the selection and preparation of sustainably-sourced biomass (e.g., composition, harvesting, pre-treatment steps) and the influence of the environment (e.g., temperature, humidity, etc.). Ability to evince the advancement and potential impact of the proposed BiCRS technology.
- Ability to maximize BiCRS durability and permanence of carbon removal;
- Ability to characterize and quantify co-benefits, such as waste material utilization, stimulated biogenic CO_2 uptake, reduced emissions, and job creation.
- Ability to characterize and assess risks, such as cultivating, transporting, processing, and feeding biomass at large scale; potential water and land use competition; and impacts to local communities and ecosystems.
- Ability to maximize CO_2 removal volumetric productivity to reduce size, land requirements, and environmental footprint;

[8] Microsoft Word - QGESS CO2 Impurity Design Parameters - Update.docx (doe.gov)

- Ability to demonstrate effective project economics, including the production of marketable coproducts such as hydrogen, liquid transportation fuels, and electricity;
- Ability to consolidate two or more unit processes/unit operations to potentially achieve the desired reductions in carbon removal cost and improvements in carbon removal efficiency;
- Ability to reduce auxiliary power by utilizing novel equipment, component designs, and/or process schemes that allow heat integration; and
- Ability to develop and implement BiCRS carbon accounting and MRV approaches and technologies. Ability to deploy advanced detection tools to collect the needed data, define baselines, and develop automated analysis capabilities to monitor real-time CO_2 uptake rates and quantities achieved through BiCRS implementation.

Projects selected under AOI-1 will perform activities including, but not limited to, those listed below:

a. Sourcing required quantities of sustainable biomass and other carbon capture materials to support the pilot-scale experimentation. If applicable, synthesis of required quantities of carbon capture materials (e.g., structured sorbents, solvents, membrane materials), structured materials systems (e.g., monoliths, laminar structures, electrodes, membrane modules), and other separation materials that cannot be sourced from existing commercial manufacturers to support the pilot-scale experimentation.

b. Design, fabrication, and commissioning of the integrated pilot-scale system. Development of an efficient pilot-scale test plan and a detailed MRV protocol with redundancies.

c. Pilot-scale testing and concomitant data collection and reporting of the integrated biomass carbon removal process in a relevant environment with natural variations in ambient conditions. Pilot-scale testing for at least 500 hours of continuous operation. If applicable, dynamic operations, such as trip-conditions, quick start-up and shutdown, varying input gas flowrates and varying gas contaminants beyond design parameters, should also be conducted.

d. Collection and reporting of mass and energy balance, CO_2 working capacity (if applicable), and state-point operating data (e.g., flowrates, compositions, pressures, temperatures) for all significant test unit streams.

e. Qualification of potential scale-up manufacturers and biomass suppliers.

f. Collection and reporting of technology related emissions (e.g., material losses, degradation products, wastes, byproducts, etc.) during the pilot-scale testing to assess the impacts and potential co-benefit emissions reduction of installing BiCRS technologies. If applicable, collection and reporting of the inlet and outlet criteria pollutants (e.g., NOx, SOx, PMs).

g. Reporting of overall carbon removal efficiency, and, as applicable, carbon capture efficiency, steam duty, and absorber/desorber secondary emissions in parametric testing as a function of conditions tested (e.g., space velocity, temperature, feed composition).

h. Disposition of biomass and other carbon capture material waste and decommissioning of equipment.

i. Development and utilization of rigorous, first-principles, multi-scale, validated process models with uncertainty quantification (UQ)[9,10,11,12,13,14] to guide pilot scale test conditions through statistical design of experiments and

[9] Morgan JC, Bhattacharyya D, Tong C, Miller DC, 2015. Uncertainty quantification of property models: methodology and its application to CO_2-loaded aqueous MEA solutions. AIChE J. 61 (6): 1822-1839. https://doi.org/10.1002/aic.14762

[10] Morgan JC, Chinen AS, Omell B, Bhattacharyya D, Tong C, Miller DC, 2017. Thermodynamic modeling and uncertainty quantification of CO_2-loaded aqueous MEA solutions. Chem. Eng. Sci. 168: 309-324. https://doi.org/10.1016/j.ces.2017.04.049

[11] Akola, P., J. Eslick, D. Bhattacharyya and D. C. Miller (2021). Model Development, Validation, and Optimization of an MEA-Based Post-Combustion CO_2 Capture Process under Part-Load and Variable Capture Operations. Industrial & Engineering Chemistry Research 60(14): 5176-5193, https://doi.org/10.1021/acs.iecr.0c05035

[12] Chinen AS, Morgan JC, Omell B, Bhattacharyya D, Tong C, Miller DC, 2018. Development of a rigorous modeling framework for solvent-based CO_2 capture. Part 1: hydraulic and mass transfer models and their uncertainty quantification. Ind. Eng. Chem. Res. 57: 10448-10463. https://doi.org/10.1021/acs.iecr.8b01471

[13] Morgan JC, Chinen AS, Omell B, Bhattacharyya D, Tong C, Miller DC, Buschle B, Lucquiaud M, 2018. Development of a rigorous modeling framework for solvent-based CO_2 capture. Part 2: steady-state validation and uncertainty quantification with pilot plant data. Ind. Eng. Chem. Res. 57: 10464-10481. https://doi.org/10.1021/acs.iecr.8b01472

[14] Akula, P., A. Lee, J. Eslick, D. Bhattacharyya and D. C. Miller (2023). "A modified electrolyte non-random two-liquid model with analytical expression for excess enthalpy: Application to the MEA-H_2O-CO_2 system." AIChE Journal 69(1): e17935, https://doi.org/10.1002/aic.17935.

robust optimization methodologies[15,16,17] and maximize learning from this project such that technical risk will be reduced for further scaleup and deployment. The recipient is encouraged to leverage existing open-source modeling tools such as those developed as part of the DOE/NETL-funded Carbon Capture Simulation Initiative (CCSI/CCSI^2/IDAES).[18,19,20,21] Development and delivery of process models will be subject to detailed review by CCSI^2 personnel via the substantial involvement clause to be included in the cooperative agreement. Based upon the review results, recipients will be required to update/improve models to achieve the objectives noted above.

j. **State-Point Data Table(s).** Recipients must revise their State Point Data Table(s) at the conclusion of the project based on the integrated pilot-scale experimental data acquired. Recipients must update the State Point Data Table(s) in the format provided in **Appendix B**, for submission 90 days prior to project completion based on the experimental data acquired.

k. **Technology Gap Analysis.** Recipients must prepare a Technology Gap Analysis (TGA), in the format provided in **Appendix C**, for submission 90 days prior to project completion.

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[15] Morgan, J. C., A. S. Chinen, C. Anderson-Cook, C. Tong, J. Carroll, C. Saha, B. Omell, D. Bhattacharyya, M. Matuszewski, K. S. Bhat and D. C. Miller (2020). "Development of a framework for sequential Bayesian design of experiments: Application to a pilot-scale solvent-based CO_2 capture process." Applied Energy 262: 114533, https://doi.org/10.1016/j.apenergy.2020.114533

[16] Morgan, J.C., Omell, B., Matuszewski, M., Miller, D.C., Shah, M.I., Benquet, C., Knarvik, A.B.N., de Cazenove, T., Anderson-Cook, C.M., Ahmed, T., Tong, C., Ng, B., and Bhattacharyya, D., "Application of Sequential Design of Experiments (SDoE) to Large Pilot-Scaled Solvent-Based CO2 Capture Process at Technology Centre Mongstad (TCM) (March 24, 2021). Proceedings of the 15th Greenhouse Gas Control Technologies Conference 15-18 March 2021. https://dx.doi.org/10.2139/ssrn.3811695

[17] N.M. Isenberg, P. Akula, J.C. Eslick, D. Bhattacharyya, D.C. Miller and C.E. Gounaris (2021). A Generalized Cutting-Set Approach for Nonlinear Robust Optimization in Process Systems Engineering Applications. AIChE Journal, 67(5):e17175. https://doi.org/10.1002/aic.17175

[18] Lee, A., J. H. Ghouse, J. C. Eslick, C. D. Laird, J. D. Siirola, M. A. Zamarripa, D. Gunter, J. H. Shinn, A. W. Dowling, D. Bhattacharyya, L. T. Biegler, A. P. Burgard and D. C. Miller (2021). "The IDAES process modeling framework and model library—Flexibility for process simulation and optimization." Journal of Advanced Manufacturing and Processing 3(3): e10095, https://doi.org/10.1002/amp2.10095.

[19] Miller, D. C., X. Sun, C. B. Storlie and D. Bhattacharyya (2015). "Using Advanced Modeling to Accelerate the Scale-Up of Carbon Capture Technologies." Power Engineering 119(6): 30-34

[20] Miller, D. C., M. Syamlal, D. S. Mebane, C. B. Storlie, D. Bhattacharyya, N. Sahinidis, D. A. Agarwal, C. Tong, S. E. Zitney, A. Sarkar, X. Sun, S. Sundaresan, E. M. Ryan, D. Engel and C. Dale (2014). "Carbon Capture Simulation Initiative: A Case Study in Multiscale Modeling and New Challenges." Chemical and Biomolecular Engineering 5: 301-323, 10.1146/annurev-chembioeng-060713-040321

[21] https://www.acceleratecarboncapture.org/

l. **Techno-economic Analysis.** Recipients must prepare a Techno-economic Analysis (TEA) in the format provided in **Appendix D**. The initial TEA is due 60 days prior to the Budget Period 1 end date, and should be updated with the experimental data acquired throughout the project period of performance. A final TEA should be submitted 90 days prior to project completion.

m. **Life Cycle Analysis.** Recipients must prepare a Life Cycle Analysis (LCA) (in the format provided in **Appendix E**) to demonstrate robust accounting of full lifecycle emissions. The initial LCA is due 60 days prior to the Budget Period 1 end date and should be updated with the experimental data acquired throughout the project period of performance. A final LCA should be submitted 90 days prior to project completion of the project.

n. **Market Analysis (as applicable).** Recipients must submit a market analysis for the carbon or CO_2 conversion product(s), if applicable. Recipients should include a refined assessment of the product market potential, including current and projected market volume and value, as well as the estimated quantity of CO_2e converted to durable products that have a lower greenhouse gas (GHG) life cycle compared to incumbent products. At a minimum, the Recipient should provide an initial estimate of the required selling price (RSP) of their primary product relative to existing markets (co-products should be valued at no more than their current market value). The current value and RSP should be reported on a U.S. Dollar (USD)/unit product basis. The Recipient should use assumptions for the required rate of return on investment, capital and operating costs, other co-feeds (if applicable), etc., consistent with the products and markets that they are targeting. The assumed purchase price of CO_2 and possibly other waste streams processed should be clearly stated, along with any potential tipping fees assumed. A thorough description of how the RSP estimate was derived should be clearly and completely described, with all key assumptions stated.

o. **Environmental Health & Safety Analysis.** Recipients must prepare an Environmental Health & Safety (EHS)Analysis that will be submitted 90 days prior to project completion in the format provided in **Appendix F**.

p. **Technology Maturation Plan.** Recipients must prepare a Technology Maturation Plan (TMP) that describes the current technology readiness level (TRL) of the proposed technology/technologies, relates the proposed project work to maturation of the proposed technology, describes the expected TRL at the end of the project, and describes any known post-project research and development necessary to further mature the technology. The initial TMP is due 90 days after award in the format provided in **Appendix G** and should be updated as needed throughout the project period of performance. A final TMP should be submitted 90 days prior to project completion of the project.

q. **R&D Community Benefits Plan:** Recipients must submit a package that includes all of the elements described in **Appendix A**.

Technical Elements that Must be Included in Applications

For **AOI-1**, applicants are expected to include the following in their applications:

a. **Technology Competitive Assessment**. A thorough competitive assessment on how the proposed technology would lead to performance advancements relative to the currently available BiCRS processes is required. Anticipated benefits, as well as challenges for the technology should also be discussed in detail. Discussion of the specific R&D challenges to be addressed by the proposed project.

b. **BiCRS Technology Description.** Applicants must provide a thorough description and data supporting the efficiency of the proposed BiCRS technology. Applicants must provide the current TRL and discuss plans for scale-up. Applicants must describe key parameters of the proposed BiCRS technology. Applicants must describe the proposed BiCRS pilot plant and the testing and MRV capabilities. The description of the technology and pilot plant should include, but is not limited to, the following: (1) overall process flow diagrams; (2) mass and energy balances; (3) resource requirements (i.e., biomass, energy, land, water, etc.); (4) discussion of the chemistry and operating cycle for the system; (5) management of electricity, heat, water, and waste in the proposed pilot-scale project; and (6) layered MRV protocol. A corresponding narrative is required to provide application reviewers a clear understanding of the proposed BiCRS process and project from technical, cost effectiveness, and integrated systems perspectives.

c. **BiCRS Technology Readiness Level Evaluation**. It is expected that Applicants have already validated their BiCRS technology **at TRL 5** in an integrated, bench-scale validation (i.e., total system or multi-component system) with the same sustainably-sourced biomass feedstock in the proposed application. The performance of the proposed biomass carbon removal technology should be substantiated by providing experimental evidence measured under relevant conditions. Applicants should discuss the specific expected short- and long-term effect on the overall BiCRS system performance under actual conditions during the proposed pilot-scale testing. Applicants must discuss their proposed testing scale and corresponding scaling methodology and selection rationale.

d. **Sustainably-Sourced Biomass Supply Chain Options.** Applicants must describe the biomass feedstock source, including sustainable harvesting and land maintenance practices, as well as potential environmental, economic,

and social effects. Applicants must demonstrate supply chain availability relevant to their project through a resource assessment. However, the proposed pilot-scale testing project should not include work to design the collection of the biomass feedstock. Additionally, research on plant breeding and genetic modification to enhance carbon uptake is not of interest.

e. **State Point Data Table(s)**. Applicants must complete a State Point Data Table(s) for their technology. Applicants must prepare the data tables based on the experimental data obtained at the largest scale the technology has been validated. Applicants must prepare the State Point Data Table(s) with the same sustainably-sourced biomass feedstock in the proposed application and under relevant BiCRS conditions, in the format provided in **Appendix B**. See Section IV. for submission information.

f. **Testing Site Selection**. Applicants must identify the location for conducting the pilot-scale testing. The specific test site must be located **exclusively in the U.S**. Applicants must submit a letter of commitment from the landowner for conducting the pilot-scale testing. The letter is required and must be signed by the person authorized to commit resources on behalf of the landowner organization. The letter must demonstrate that this organization has agreed to participate in the project. A finalized host site agreement will be a required deliverable 6 months after the project start date.

g. **Integrated Pilot-Scale BiCRS Test Plans.** As applicable, Applicants must describe the existing power or industrial facility and the integration with the BiCRS system including, but not limited to, process diagrams; emissions profiles of any CO_2-containing streams (e.g., location, concentration, temperature, pressure, and contaminants); on-site biomass feedstock processing (e.g., drying, grinding, pelletizing); the function and availability of required mechanical components; the function, operating conditions, and duration of all process steps; integration strategies; and planned testing duration. As applicable, Applicants must describe how the existing plant will be retrofitted to process the biomass feedstock. The description should also include details regarding how the BiCRS system will be integrated into the plant, including, but not limited to, any proposed criteria pollutants (e.g., NO_X, SO_X, particulate matter) abatement systems to be installed. As applicable, the description shall also include the following:

    1. *Anticipated test conditions* (e.g., pressure, temperature, flow rate, compositions, and contaminant levels)
    2. *Energy, water and waste management*. Applicants should describe how electricity, heat, water, and waste will be acquired and managed in the proposed pilot-scale project.

3. *Contaminants Controls*. Applicants should describe how wastes, byproducts, and the criteria pollutants (e.g., NOx, SOx, PM_s) are managed in the existing host facility and their potential effect on the BiCRS system.
4. *CO_2 product disposition*. If applicable, Applicants must demonstrate that the proposed biomass carbon removal technology will produce a CO_2 stream of required temperature and quality suitable for cost-effective compression and transport/disposition of the stream, without adversely affecting existing operations, compressors, pipelines or geologic storage formations.
5. *Description of the biomass carbon removal equipment design concept*.
6. *Description of testing plan.* Activities to be performed, data to be collected, and MRV protocol to validate the performance of the technology using the proposed integrated pilot-scale test unit.

h. **Summary of a Preliminary Techno-economic Analysis and Process Models, and a Preliminary Life Cycle Analysis).** Applicants must submit summary results of: (i) a preliminary TEA covering the entire biomass carbon removal system (including balance-of-plant), (ii) process models, and (iii) a preliminary LCA. Preliminary TEA and LCA should be prepared for a reference plant that removes 500,000 net tonne CO_2e/year based on cradle-to-gate LCA, regardless of the size of the proposed pilot-scale test system. If applicable, CO_2 pressure and CO_2 quality and quantity at the carbon capture plant "gate" should meet the requirements of the intended transport and storage or carbon conversion solution.

The summary TEA results should provide: (i) mass and energy balances, (ii) estimates of heating and cooling duties and electric power requirements covering the BiCRS system and balance-of-plant, (iii) the estimated cost of the proposed BiCRS system, (iv) levelized cost of electricity or product (if applicable), (v) the estimated land and water usage, as well as (vi) the cost of CO_2 capture on a $/net tonne CO_2e and $/gross tonne CO_2e basis. The preliminary TEA should be based upon prior engineering design and costing work, and does not need to conform to the requirements in **Appendix D**. Preliminary LCA should be prepared in the format provided in **Appendix E**.

Applicants are also expected to provide a summary of the process models developed to-date for the proposed biomass carbon removal technology that are used in the TEA, including but not limited to: (i) model assumptions, (ii) kinetics, mass-transfer, and heat-transfer correlations and their validation, (iii) model predictions for temperature/concentration profiles for major unit operations (e.g., absorber, desorber) and their validation with the experimental data.

i. **Market Analysis (as applicable).** Applicants must submit a market analysis for the carbon or CO_2 conversion product(s), if applicable. Applicants should include an initial assessment of the product market potential, including current and projected market volume and value, as well as the estimated quantity of CO_2e converted to durable products that have a lower GHG life cycle compared to incumbent products. At a minimum, the Applicant should provide an initial estimate of the required selling price (RSP) of their primary product relative to existing markets (co-products should be valued at no more than their current market value). The current value and RSP should be reported on a USD/unit product basis. The Applicant should use assumptions for the required rate of return on investment, capital and operating costs, other co-feeds (if applicable), etc., consistent with the products and markets that they are targeting. The assumed purchase price of CO_2 and possibly other waste streams processed should be clearly stated, along with any potential tipping fees assumed. A thorough description of how the RSP estimate was derived should be clearly and completely described, with all key assumptions stated.

j. **R&D Community Benefits Plan:** Applicants must submit a description of the proposed process for developing a community benefits plan that includes all of the elements discussed in **Appendix A**. See Section IV. for submission information.

k. **Data Management Plan:** Applicants must submit a Data Management Plan as part of their Full Application. The Data Management Plan is a document that outlines the proposed plan for data sharing or preservation. Submission of this plan is required with the full application, and failure to submit the plan may result in rejection of the application without further consideration. Applicants shall prepare the DMP in the format provided in **Appendix H**. See Section IV. for submission information.

Research Scope and Attributes that are Not of Interest

The pilot-scale effort should not involve laboratory- and bench-scale development or screening of any specific material composition, materials system, or individual component design. Applications that propose such laboratory and/or bench development or screening will be considered non-responsive.

See section I.D. for Applications Specifically Not of Interest

Anticipated Technology Readiness Level

Beginning of project: TRL 5

Technologies proposed for **AOI-1** must have already successfully completed work at TRL 5: laboratory scale, similar system validation in simulated environment (i.e. total system or multi-component system tested using simulated gases and conditions).

End of project: TRL 6
By the completion of the proposed effort, technologies must be tested at a minimum of a TRL 6 whereby engineering/pilot-scale, similar (prototypical) system validation in relevant environment will be completed.

Success Metric(s)

Success will be measured by completing at least 500 hours of integrated, pilot-scale testing of an advanced biomass carbon removal technology that shows progress towards the following:

(i) Improved carbon removal efficiency and capacity,
(ii) Decreased cost of net CO_2e removal,
(iii) Reduced land, energy, and water requirements,
(iv) Lower cost, scalable process, and
(v) Maximized durability and permanence of carbon removal with effective MRV protocols.

In addition, development of rigorous, first-principles, multi-scale, validated process models is required. These models are to include uncertainty quantification (UQ) that can be used to guide pilot scale test conditions through statistical design of experiments and robust optimization methodologies.

Quantitative success metric targets will be established during negotiations with successful applicants. The final techno-economic analysis should demonstrate: (1) the economic viability of the proposed technology that can justify its scale-up in a subsequent program, and (2) significant progress towards meeting the DOE's Carbon Negative Shot target of less than $100/net tonne CO_2e removed (i.e., both capture and storage).

ii. AOI-2: Small Mineralization Pilots

The objective of **AOI-2** is to support integrated pilot-scale testing of enhanced mineralization technologies with appropriate MRV from enacted authorities and appropriations. Enhanced mineralization pilots will demonstrate the potential to leverage alkaline materials and accelerated weathering techniques to hasten the rate of CO_2 storage in ex-situ or surficial contexts:

- Ex-situ: Minerals rich in calcium and magnesium are extracted from the subsurface, transported, crushed, and reacted with fluid or gas rich in CO_2. The process can be accelerated by heat and elevated pressures, which require energy.
- Surficial: Ambient or concentrated CO_2 is reacted with crushed alkaline rock (e.g., mined rocks, tailings), alkaline industrial wastes, or sedimentary formations rich in reactive rock fragments at the surface. Ultramafic mine tailings and alkaline industrial wastes spontaneously react with CO_2 in the air to form carbonate minerals during surficial weathering.

For **AOI-2**, DOE is seeking applications that design, build, and test enhanced mineralization systems. Pilot-scale testing for **AOI-2** is defined as pilot facilities with the design capacity to remove at least 1,000 tonne CO_2e/yr. The successful applicants will test their integrated enhanced mineralization technology, at pilot-scale, for at least 1,000 hours of continuous operation. Systems should validate integrated operations in a relevant environment and should be capable of performing all the functions that will be required of the operational system, including layered MRV protocols. All projects must utilize a test site in the U.S.

To be considered ready for pilot-scale testing, technologies proposed for **AOI-2** must have already successfully completed an integrated, bench-scale validation (i.e., total system or multi-component system) with the same mineral feedstock in the proposed application. **AOI-2** applicants are highly encouraged to propose teams that include both the enhanced mineralization technology developer, mineral supplier, and the landowner of the proposed test site.

If an applicant is proposing team member(s), letter(s) of commitment from the member(s) are required as evidence of the participation. The letter(s) of commitment must be signed by the person authorized to commit resources on behalf of the organization. Letter(s) should demonstrate the partner's level of commitment to the project, such as host site access, mineral supply availability, data access, and/or advisory services, etc.

Of particular interest for **AOI-2** are pilot-scale validations of integrated enhanced mineralization processes that feature one or more of the following capabilities:

- Understanding of the diverse combinations of factors that influence mineralization processes, including the selection and preparation of rocks and minerals (e.g., mineralogy, particle size, reactive surface area, mineral pre-treatment steps) and the influence of the environment (e.g., temperature, humidity, etc.). Ability to evince the advancement and potential impact of the proposed enhanced mineralization technology.

- Ability to avoid new mining efforts and energy-intensive heating and pressurizing steps, i.e., enabling readily available alkaline materials to passively react with atmospheric CO_2 via ambient weathering at the surface;
- Ability to maximize mineralization durability and permanence of carbon removal using existing alkaline materials, mine tailings, and suitable industrial waste byproducts (e.g., cement kiln dust, fly ash, steel slag) with the potential to disperse the crushed minerals along coastal beaches and across agricultural land;
- Ability to measure baseline and enhanced mineralization rates and kinetics across different mineral types, reaction fronts, and environmental conditions;
- Ability to characterize and quantify co-benefits, such as waste site remediation, soil pH amendment, improved crop yield and/or quality, stimulated biogenic CO_2 uptake, reduced fertilizer usage, reduced emissions (e.g., nitrous oxide, ammonia, etc.), and job creation.
- Ability to characterize and assess risks, such as mineral extraction, processing, transport, and application; particulate matter introduction; migration and fate of trace metals (e.g., chromium, nickel, etc.); and impact local communities and ecosystems.
- Ability to maximize CO_2 removal volumetric productivity to reduce size, land requirements, and environmental footprint;
- Ability to consolidate two or more unit processes/unit operations to potentially achieve the desired reductions in carbon removal cost and improvements in carbon removal efficiency;
- Ability to co-optimize enhanced carbon mineralization and the extraction of critical minerals;
- Ability to reduce auxiliary power by utilizing novel equipment, component designs, and/or process schemes that allow heat integration; and
- Ability to develop and implement enhanced mineralization carbon accounting and measurement, reporting, and verification (MRV) approaches and technologies. Ability to convey an understanding of the ideal sensor types (e.g., gas flux, solid carbonate precipitates, aqueous bicarbonates and carbonates in soil pore waters) to measure mineralization at specific sites. Ability to deploy advanced detection tools to collect the needed data, define baselines, and develop automated analysis capabilities to monitor real-time CO_2 uptake rates and quantities achieved through mineralization enhancement.

Projects selected under **AOI-2** will perform activities including, but not limited to, those listed below:

a. Sourcing required quantities of minerals and other carbon capture materials to support the pilot-scale experimentation.

b. Design, fabrication, and commissioning of the integrated pilot-scale system. Development of an efficient pilot-scale test plan and a detailed MRV protocol with redundancies.

c. Pilot-scale testing and concomitant data collection and reporting of the integrated enhanced mineralization process in a relevant environment with natural variations in ambient conditions. Pilot-scale testing for at least 1,000 hours of continuous operation. Pilot-scale testing should investigate the impacts of temperature, rainfall, humidity, plant-mineral interactions, and soil properties (e.g., pH, clay content, organic matter, carbonate content) on mineralization rates.

d. Collection and reporting of overall carbon removal efficiency, mass and energy balance, CO_2 working capacity (if applicable), and state-point operating data (e.g., flowrates, compositions, pressures, temperatures) for all significant test unit operations and streams.

e. Qualification of potential scale-up manufacturers and mineral suppliers.

f. Collection and reporting of technology related emissions (e.g., material losses, degradation products, wastes, byproducts, release and accumulation of metals, etc.) during the pilot-scale testing to assess the impacts and potential co-benefit emissions reduction of implementing enhanced mineralization. If applicable, collection and reporting of the inlet and outlet criteria pollutants (e.g., NOx, SOx, PMs).

g. Disposition of mineral and other carbon capture material waste and decommissioning of equipment.

h. Development and utilization of rigorous, first-principles, multi-scale, validated process models with uncertainty quantification (UQ) [9,10,11,12,13,14] to guide pilot scale test conditions through statistical design of experiments and robust optimization methodologies [15,16,17] and maximize learning from this project such that technical risk will be reduced for further scaleup and deployment. The recipient is encouraged to leverage existing open-source modeling tools such as those developed as part of the DOE/NETL-funded Carbon Capture Simulation Initiative (CCSI/CCSI^2/IDAES). [18,19,20,21] Development and delivery of process models will be subject to detailed review by CCSI^2 personnel via the substantial involvement clause to be included in the cooperative agreement. Based upon the review results, recipients will be required to update/improve models to achieve the

objectives noted above.

i. **State-Point Data Table(s).** Recipients must revise their State Point Data Table(s) at the conclusion of the project based on the integrated pilot-scale experimental data acquired. Recipients must update the State Point Data Table(s) in the format provided in **Appendix B**, for submission 90 days prior to project completion based on the experimental data acquired.

j. **Technology Gap Analysis (TGA).** Recipients must prepare a TGA, in the format provided in **Appendix C**, for submission 90 days prior to project completion.

k. **Techno-economic Analysis (TEA).** Recipients must prepare a TEA in the format provided in **Appendix D**. The initial TEA is due 60 days prior to the Budget Period 1 end date, and should be updated with the experimental data acquired throughout the project period of performance. A final TEA should be submitted 90 days prior to project completion.

l. **Life Cycle Analysis (LCA).** Recipients must prepare an LCA (in the format provided in **Appendix E**) to demonstrate robust accounting of full lifecycle emissions. The initial LCA is due 60 days prior to the Budget Period 1 end date and should be updated with the experimental data acquired throughout the project period of performance. A final LCA should be submitted 90 days prior to project completion.

m. **Market Analysis (as applicable).** Recipients must submit a market analysis for the carbon or CO_2 conversion product(s), if applicable. Recipients should include a refined assessment of the product market potential, including current and projected market volume and value, as well as the estimated quantity of CO_2e converted to durable products that have a lower greenhouse gas (GHG) life cycle compared to incumbent products. At a minimum, the Recipient should provide an initial estimate of the required selling price (RSP) of their primary product relative to existing markets (co-products should be valued at no more than their current market value). The current value and RSP should be reported on a USD/unit product basis. The Recipient should use assumptions for the required rate of return on investment, capital and operating costs, other co-feeds (if applicable), etc., consistent with the products and markets that they are targeting. The assumed purchase price of CO_2 and possibly other waste streams processed should be clearly stated, along with any potential tipping fees assumed. A thorough description of how the RSP estimate was derived should be clearly and completely described, with all key assumptions stated.

n. **Environmental Health & Safety (EHS) Analysis.** Recipients must prepare an EHS analysis that will be submitted 90 days prior to project completion in the format provided in **Appendix F**.

o. **Technology Maturation Plan (TMP).** Recipients must prepare a TMP that describes the current technology readiness level (TRL) of the proposed technology/technologies, relates the proposed project work to maturation of the proposed technology, describes the expected TRL at the end of the project, and describes any known post-project research and development necessary to further mature the technology. The initial TMP is due 90 days after award in the format provided in **Appendix G** and should be updated as needed throughout the project period of performance. A final TMP should be submitted 90 days prior to project completion.

p. **R&D Community Benefits Plan:** Recipients must submit a package that includes all of the elements described in **Appendix A**.

Technical Elements that Must be Included in Applications

For **AOI-2**, applicants are expected to include the following in their applications:

a. **Technology Competitive Assessment**. A thorough competitive assessment on how the proposed technology would lead to performance advancements relative to the currently available mineralization processes is required. Anticipated benefits, as well as challenges for the technology should also be discussed in detail. Discussion of the specific R&D challenges to be addressed by the proposed project should be included.

b. **Enhanced Mineralization Technology Description.** Applicants must provide a thorough description and data supporting the efficiency of the proposed enhanced mineralization technology. Applicants must provide the current TRL and discuss plans for scale-up. Applicants must describe key parameters of the proposed enhanced mineralization technology. Applicants must describe the proposed enhanced mineralization pilot plant and the testing and MRV capabilities. The description of the technology and pilot plant should include, but is not limited to, the following: (1) overall process flow diagrams; (2) mass and energy balances; (3) resource requirements (i.e., minerals, energy, land, water, etc.); (4) discussion of the capture chemistry and operating cycle for the system; (5) management of electricity, heat, water, and waste in the proposed pilot-scale project; and (6) layered MRV protocol. A corresponding narrative is required to provide application reviewers a clear understanding of the proposed mineralization process and project from technical, cost effectiveness, and integrated systems perspectives.

c. **Enhanced Mineralization Technology Readiness Level Evaluation**. It is expected that Applicants have already validated their enhanced mineralization technology **at TRL 5** in an integrated, bench-scale validation (i.e., total system or multi-component system) with the same mineralogy in the proposed application. The performance of the proposed mineralization technology should be substantiated by providing experimental evidence measured under relevant environmental conditions. Applicants should discuss the specific expected short- and long-term effect on the overall ~~biomass~~ carbon removal system performance under actual conditions during the proposed pilot-scale testing. Applicants must discuss their proposed testing scale and corresponding scaling methodology and selection rationale.

d. **State Point Data Table(s)**. Applicants must complete a State Point Data Table(s) for their technology. Applicants must prepare the data tables based on the experimental data obtained at the largest scale the technology has been validated. Applicants must prepare the State Point Data Table(s) with the same mineralogy in the proposed application and under relevant environmental conditions, in the format provided in **Appendix B**. See Section IV for submission information.

e. **Testing Site Selection**. Applicants must identify the location for conducting the pilot-scale testing and submit a baseline assessment of natural mineralization processes prior to the proposed enhancement. The specific test site must be located **exclusively in the U.S**. Applicants must submit a letter of commitment from the landowner for conducting the pilot-scale testing. The letter is required and must be signed by the person authorized to commit resources on behalf of the landowner organization. The letter must demonstrate that this organization has agreed to participate in the project. A finalized host site agreement will be a required deliverable 6 months after the project start date.

f. **Integrated Pilot-Scale Enhanced Mineralization Test Plans.** Applicants must describe the proposed integrated pilot-scale mineralization test system with process diagrams and plans to evaluate the technology across a range of relevant environmental conditions. Applicants must discuss mineral extraction, processing, transport, and application; the function and availability of required mechanical components; the function, operating conditions, and duration of all process steps; integration strategies; and planned testing duration. As applicable, the description shall also include the following:

    1. *Anticipated test conditions* (e.g., pressure, temperature, relative humidity, and contaminant levels)

2. *Energy, water, critical mineral, and waste management*. Applicants should describe how electricity, heat, water, and waste will be managed in the proposed pilot-scale project.
3. *Contaminants Controls*. Applicants should describe how wastes, byproducts, and the criteria pollutants (e.g., NOx, SOx, PM_s) are managed and their potential effect on the enhanced mineralization system.
4. *CO_2 product disposition*. If applicable, Applicants must demonstrate that the proposed ~~biomass~~ carbon removal technology will produce a CO_2 stream of required temperature and quality suitable for cost-effective compression and transport/disposition of the stream, without adversely affecting existing operations, compressors, pipelines or geologic storage formations.
5. *Description of the mineralization equipment design concept.*
6. *Description of testing plan.* Activities to be performed, data to be collected, and MRV protocol to validate the performance of the technology using the proposed integrated pilot-scale test unit.

l. **Summary of a Preliminary Techno-economic Analysis (TEA) and Process Models, and a Preliminary Life Cycle Analysis (LCA).** Applicants must submit summary results of: (i) a preliminary TEA covering the entire mineralization system (including balance-of-plant), (ii) process models, and (iii) a preliminary LCA. Preliminary TEA and LCA should be prepared for a reference mineralization facility that captures 100,000 net tonne CO_2e/year based on cradle-to-gate LCA, regardless of the size of the proposed pilot-scale test system. If applicable, CO_2 pressure and CO_2 quality and quantity at the carbon capture plant "gate" should meet the requirements of the intended transport and storage or carbon conversion solution.

The summary TEA results should provide: (i) mass and energy balances, (ii) estimates of heating and cooling duties and electric power requirements covering the mineralization system and balance-of-plant, (iii) the estimated cost of the proposed mineralization system, (iv) levelized cost of electricity or product (if applicable), (v) the estimated land and water usage, as well as (vi) the cost of CO_2 capture on a $/net tonne CO_2e and $/gross tonne CO_2e basis. The preliminary TEA should be prepared based upon prior engineering design and costing work, and does not need to conform to the requirements in **Appendix D**. Preliminary LCA should be prepared in the format provided in **Appendix E**.

Applicants are also expected to provide a summary of the process models developed to-date for the proposed mineralization technology that are used in the TEA, including but not limited to: (i) model assumptions, (ii) kinetics, mass-transfer, and heat-transfer correlations and their validation, (iii) model

predictions for temperature/concentration profiles for major unit operations (e.g., absorber, desorber) and their validation with the experimental data.

g. **Market Analysis (as applicable).** Applicants must submit a market analysis for the carbon or CO_2 conversion product(s), if applicable. Applicants should include an initial assessment of the product market potential, including current and projected market volume and value, as well as the estimated quantity of CO_2e converted to durable products that have a lower GHG life cycle compared to incumbent products. At a minimum, the Applicant should provide an initial estimate of the required selling price (RSP) of their primary product relative to existing markets (co-products should be valued at no more than their current market value). The current value and RSP should be reported on a USD/unit product basis. The Applicant should use assumptions for the required rate of return on investment, capital and operating costs, other co-feeds (if applicable), etc., consistent with the products and markets that they are targeting. The assumed purchase price of CO_2 and possibly other waste streams processed should be clearly stated, along with any potential tipping fees assumed. A thorough description of how the RSP estimate was derived should be clearly and completely described, with all key assumptions stated.

h. **R&D Community Benefits Plan:** Applicants must submit a description of the proposed process for developing a community benefits plan that includes all of the elements discussed in **Appendix A**. See Section IV. for submission information.

i. **Data Management Plan:** Applicants must submit a Data Management Plan as part of their Full Application. The Data Management Plan is a document that outlines the proposed plan for data sharing or preservation. Submission of this plan is required with the full application, and failure to submit the plan may result in rejection of the application without further consideration. Applicants shall prepare the DMP in the format provided in **Appendix H**. See Section IV. for submission information.

Research Scope and Attributes that are Not of Interest

The pilot-scale effort should not involve laboratory- and bench-scale development or screening of any specific material composition, materials system, or individual component design. Applications that propose such laboratory and/or bench development or screening will be considered non-responsive.

See section I.D for Applications Specifically Not of Interest

Anticipated Technology Readiness Level

Beginning of project: TRL 5
Technologies proposed for **AOI-2** must have already successfully completed work at TRL 5: laboratory scale, similar system validation in simulated environment (i.e. total system or multi-component system tested using simulated gases and conditions).

End of project: TRL 6
By the completion of the proposed effort, technologies must be tested at a minimum of a TRL 6 whereby engineering/pilot-scale, similar (prototypical) system validation in relevant environment will be completed.

Success Metric(s)

Success will be measured by completing at least 1,000 hours of integrated, pilot-scale testing of an enhanced mineralization technology that shows progress towards the following:

(i) Improved carbon removal efficiency and capacity,
(ii) Decreased cost of net CO_2e removal,
(iii) Reduced land, energy, and water requirements,
(iv) Lower cost, scalable process, and
(v) Maximized durability and permanence of carbon removal with effective MRV protocols.

In addition, development of rigorous, first-principles, multi-scale, validated process models is required. These models are to include uncertainty quantification (UQ) that can be used to guide pilot scale test conditions through statistical design of experiments and robust optimization methodologies.

Quantitative success metric targets will be established during negotiations with successful applicants. The final TEA should demonstrate: (1) the economic viability of the proposed technology that can justify its scale-up in a subsequent program, and (2) significant progress towards meeting the DOE's Carbon Negative Shot target of less than $100/net tonne CO_2e removed (i.e., both capture and storage).

iii. AOI-3 Multi-Pathways CDR Testbed Facilities

The objective of **AOI-3** is to support CDR testbed facilities suitable for evaluating, developing, and integrating multiple CDR pathways across different ecosystems, climates, and communities. Testbeds should demonstrate capacity to accommodate and enhance the testing of several CDR pathways with common infrastructure, interdisciplinary assessment, and commercialization support.

To bridge the TRL risks associated with advancing CDR technologies and optimize CDR deployments, multi-pathway CDR testbed facilities capable of providing multiple and simultaneous testing platforms for design capacities ranging from 1 – 1,000 tonne CO_2e/yr are required. These test facilities will cost-effectively research and evaluate, in an integrated process, the technical efficacy of integrated systems and components across multiple scales under relevant and variable environmental conditions. These multi-pathway CDR test facilities will also promote and conduct the evaluation of advanced technologies to identify and resolve environmental, health and safety, social, economic, operational, component, system, and multi-system development issues in collaboration with DOE and project partners.

For **AOI-3**, DOE is seeking applications from entities with existing CDR testbed facilities seeking to expand current capabilities to simultaneously test and integrate multiple CDR technology pathways (i.e., DAC, BiCRS, Enhanced Mineralization and Weathering and/or mCDR) at scales ranging from 1 – 1,000 tonne CO_2e/yr under relevant and variable environmental conditions. The successful applicants will test their multi-pathway CDR testbed facilities for at least 1,000 hours of continuous operation. DOE is seeking applications involving strategic collaborations with industrial, academic, and governmental partners to provide flexible, multi-pathway CDR test facilities suited for evaluating advanced domestic and international CDR technologies under development at bench-scale and pilot-scale.

DOE emphasizes team-oriented approaches. ***It is considered critical that analyses related to environmental performance, safety and health, permitting, technical and economic assessments be conducted by individuals or organizations with professional capabilities in these areas.*** It is anticipated that the Applicant, with its team members, will be capable of performing all aspects associated with this announcement, such as testing of advanced materials and processes from third parties, development and execution of analytical and MRV protocols, environmental health and safety evaluations, test plan development for technology assessments, and permitting required. The Applicant will demonstrate that they have controlling interest in the existing R&D testing facilities.

The R&D testing facilities will advance the scientific understanding of the advanced technologies being tested so that existing or future industrial partners can support them at the next scale. The Applicant will offer the following, as a minimum:

- The Applicant will provide actual feedstock(s) to test multiple third-party advanced CDR technologies, components, materials and instruments in parallel with common infrastructure at various scales (1 – 1,000 tonne CO_2e/yr) across different ecosystems and climates.
- Integrated project team experience in operating and maintaining CDR test units and required balance-of-plant (BOP) equipment. Inter-disciplinary team dedicated to testing and analyzing various CDR technologies, including, but not

limited to: experience providing design, installation/modification, permitting, and operation of equipment required for simultaneously testing third-party developer technologies, various test unit apparatus conditions (e.g., field fabrication vs. skid-mounted, on-site vs. remote operation, or pre-treatment systems included or not, etc.), and layered, CDR technology-specific MRV protocols.

- Methodology to generate and maintain a global data repository of CDR technologies under development.
- Procedure to identify and resolve environmental, health and safety, social, economic, operational, component, system, and multi-system development issues in collaboration with DOE and project partners.
- Provide reports on the technical and operational lessons learned of each technology tested and based on the aggregate knowledge-base of each technology type tested (i.e., DAC, BiCRS, Enhanced Mineralization and Weathering and/or mCDR) at the R&D testing facilities without compromising third-party agreements. Updates to the reports will be performed as new information is available or warranted.
- Rational and structured process detailing a logical progression of work for maximum facility utilization and impact.

Projects selected under AOI-3 will perform activities including, but not limited to, those listed below:

a. Design, fabrication, and commissioning of new CDR pathway(s) testing, analysis, and MRV infrastructure. Development of an efficient multi-CDR test plan and a detailed MRV protocol with redundancies.

b. Sourcing required quantities of feedstock(s) (e.g., air, sustainable biomass, minerals, ocean water, etc.) and other carbon capture materials to support the proposed multi-CDR test campaign(s). If applicable, synthesis of required quantities of carbon capture materials (e.g., structured sorbents, solvents, membrane materials), structured materials systems (e.g., monoliths, laminar structures, electrodes, membrane modules), and other separation materials that cannot be sourced from existing commercial manufacturers to support the proposed multi-CDR test campaign(s).

c. Multi-CDR testing and concomitant data collection and reporting in relevant environment(s) with natural variations in ambient conditions. Testing for at least 1,000 hours of continuous operation. If applicable, dynamic operations, such as trip-conditions, quick start-up and shutdown, varying input gas flowrates and varying gas contaminants beyond design parameters, should also be conducted.

d. Collection and reporting of mass and energy balance, CO_2 working capacity (if applicable), and state-point operating data (e.g., flowrates, compositions, pressures, temperatures) for all significant test unit streams.

e. Qualification of potential scale-up manufacturers and suppliers.

f. Collection and reporting of technology related emissions (e.g., material losses, degradation products, wastes, byproducts, etc.) during testing to assess the impacts and potential co-benefit emissions reduction of installing CDR technologies. If applicable, collection and reporting of the inlet and outlet criteria pollutants (e.g., NOx, SOx, PMs).

g. Reporting of overall carbon removal efficiency, and, as applicable, carbon capture efficiency, steam duty, and absorber/desorber secondary emissions in parametric testing as a function of conditions tested (e.g., space, velocity, temperature, feed composition).

h. Discussion and reporting of multi-CDR integration efficiencies, advancements, opportunities, and challenges.

i. Disposition of CDR material waste and byproducts in accordance with test facility procedures.

j. Development and utilization of rigorous, first-principles, multi-scale, validated process models with uncertainty quantification (UQ) [9,10,11,12,13,14] to guide pilot scale test conditions through statistical design of experiments and robust optimization methodologies [15,16,17] and maximize learning from this project such that technical risk will be reduced for further scaleup and deployment. The recipient is encouraged to leverage existing open-source modeling tools such as those developed as part of the DOE/NETL-funded Carbon Capture Simulation Initiative (CCSI/CCSI^2/I). [18,19,20,21] Development and delivery of process models will be subject to detailed review by CCSI^2 personnel via the substantial involvement clause to be included in the cooperative agreement. Based upon the review results, recipients will be required to update/improve models to achieve the objectives noted above.

k. **State-Point Data Table(s).** Recipients must revise their State Point Data Table(s) at the conclusion of the project based on the multi-CDR experimental data acquired. Recipients must update the State Point Data Table(s) in the format provided in **Appendix B**, for submission 90 days prior to project completion based on the experimental data acquired.

l. **Technology Gap Analysis (TGA).** Recipients must prepare a TGA in the format provided in **Appendix C**, for submission 90 days prior to project completion.

m. **Techno-economic Analysis (TEA).** Recipients must prepare a TEA in the format provided in **Appendix D**. The initial TEA is due 60 days prior to the Budget Period 1 end date, and should be updated with the experimental data acquired throughout the project period of performance. A final TEA should be submitted 90 days prior to project completion.

n. **Life Cycle Analysis (LCA).** Recipients must prepare an LCA (in the format provided in **Appendix E**) to demonstrate robust accounting of full lifecycle emissions. The initial LCA is due 60 days prior to the Budget Period 1 end date and should be updated with the experimental data acquired throughout the project period of performance. A final LCA should be submitted 90 days prior to project completion of the project.

o. **Environmental Health & Safety (EHS) Analysis.** Recipients must prepare an EHS analysis that will be submitted 90 days prior to project completion in the format provided in **Appendix F**.

p. **R&D Community Benefits Plan:** Recipients must submit a package that includes all of the elements described in **Appendix A**.

Technical Elements that Must be Included in Applications

For **AOI-3**, applicants are expected to include the following in their applications:

a. **Current CDR Tested Facility Description.** Applicants must provide a thorough description and data supporting the efficiency of the existing CDR testbed and technology testing capabilities. Applicants must discuss existing facility capabilities, including type of CDR technology(ies) that have been testing, quantity and scale of CDR testbeds, available footprint and infrastructure, proximity of the existing CDR testbed facility to required balance-of-plant (BOP) infrastructure, analytical and MRV capabilities, and historical online availability of existing CDR testbeds. The description of the CDR testbed should include, but is not limited to, the following: (1) overall process flow diagrams; (2) mass and energy balances; (3) resource requirements (i.e., feedstock(s), energy, land, water, etc.) for the existing and proposed facility; and (4) existing EH&S procedures and any new procedures that would be implemented during the project performance period. Provide an inventory of the proposed facilities, their major components and systems. The discussion will be sufficiently detailed to assess the operational life and availability of the facilities for the project performance period. A corresponding narrative is required to provide application reviewers a clear understanding of the proposed multi-CDR testbed facility from technical, cost effectiveness, and integrated systems perspectives. The following shall be included as a minimum for existing facilities:

1. *Available feed conditions* (e.g., pressure, temperature, relative humidity, flow rate, gas composition, and contaminant levels).
2. *Electrical, water, and waste management.* Applicants should describe how electricity, heat, water, and waste will be managed in the proposed project.
3. *Contaminants Controls.* Applicants should describe how the criteria pollutants (e.g., NO_x, SO_x, PM_s) will be managed and their potential effect on the CDR systems.
4. *CO_2 product disposition.* Although compression, transportation, and storage are not requested, Applicants must discuss CO_2 product analytical capabilities and disposal practices.
5. *Description of the multi-CDR equipment design concept* (e.g., membrane module architecture, absorber/desorber design, etc.).
6. *Physical systems*, such as, architectural, civil, mechanical, electrical, other engineering systems, underground facilities, and physical infrastructure associated with the R&D testing facilities;
7. *Certifications of safety and health hazards* for the past two years;
8. *12-month maintenance history* and preventative maintenance records of all critical and major components and systems for the R&D testing facilities, including its respective cost estimates;
9. *Process for mitigating operational risks t*o third-party technologies and the CDR testbed facility (e.g., indicate the availability of independent auxiliary support systems from the facility to third-party technology developers, such as a cooling, heating, or purge systems).
10. *Process diagrams, stream tables, and plans* to support the condition assessment discussion and robustness of the facility to meet the objectives of this FOA.
11. *Analytical, data acquisition, MRV, and control room capabilities* of the facilities for testing multiple CDR technologies simultaneously and
12. *Description of testing plan.* Activities to be performed, data to be collected, and MRV protocol to validate the performance of the technology using the proposed multi-CDR test facility.

b. **Plans for Multi-Pathway CDR Testbed Facility.** Applicants must provide a thorough description of the proposed plan to expand current CDR testbed capabilities to simultaneously test and integrate multiple CDR technology pathways (i.e., DAC, BiCRS, Enhanced Mineralization and Weathering and/or mCDR) at scales ranging from 1 – 1,000 tonne CO_2e/yr under relevant and variable environmental conditions. Applicants must discuss their process for assessing and priority ranking CDR pathways and technologies proposed for testing, proposed testing scale and corresponding scaling methodology, and selection rationale. Applicant must discuss integration of the new CDR testbed capabilities into the existing facility, operational approach to provide actual feedstock(s) and relevant and variable environmental conditions to multiple

third-party technology developers to be tested in parallel, predicted multi-CDR integration efficiencies, advancements, opportunities, and challenges, MRV strategy, and specific R&D challenges to be addressed by the proposed project.

c. **Inter-disciplinary Team Capabilities.** Applicant must thoroughly describe the integrated project team's experience in operating and maintaining CDR test units and required BOP equipment. Applicant must evince a deep commitment to testing and analyzing various CDR technologies, including, but not limited to: experience providing design, installation/modification, permitting, and operation of equipment required for simultaneously testing third-party developer technologies, various test unit apparatus conditions (e.g., field fabrication vs. skid-mounted, on-site vs. remote operation, or pre-treatment systems included or not, etc.), and layered, CDR technology-specific MRV protocols.

d. **Host Site Agreement.** Applicants must submit a host site agreement for an existing CDR testbed facility located exclusively in the United States. The agreement and corresponding letter of commitment are required and must be signed by the person authorized to commit resources on behalf of organization. The letter must demonstrate that this organization has agreed to participate in the project.

e. **State Point Data Table(s)**. Applicants must complete a State Point Data Table(s) for their technology(ies). Applicants must prepare the data tables based on the experimental data obtained at the largest scale the technology has been validated. Applicants must prepare the State Point Data Table(s) with the same process in the proposed application and under relevant environmental conditions, in the format provided in **Appendix B**. See Section IV for submission information.

f. **Summary of a Preliminary Techno-economic Analysis (TEA) and Process Models, and a Preliminary Life Cycle Analysis (LCA).** Applicants must submit summary results of: (i) a preliminary TEA covering the proposed CDR technologies (including balance-of-plant), (ii) process models, and (iii) a preliminary LCA. Preliminary TEA and LCA should be prepared for a reference CDR installation that captures 100,000 net tonne CO_2e/year based on cradle-to-gate LCA, regardless of the size of the proposed testbed systems. If applicable, CO_2 pressure and CO_2 quality and quantity at the CDR plant "gate" should meet the requirements of the intended transport and storage or carbon conversion solution.

The summary TEA results should provide: (i) mass and energy balances, (ii) estimates of heating and cooling duties and electric power requirements covering the CDR systems and balance-of-plant, (iii) the estimated cost of the proposed CDR systems, (iv) levelized cost of electricity or product (if applicable),

(v) the estimated land and water usage, as well as (vi) the cost of CO_2 capture on a $/net tonne CO_2e and $/gross tonne CO_2e basis. The preliminary TEA should be prepared based upon prior engineering design and costing work, and does not need to conform to the requirements in **Appendix D**. Preliminary LCA should be prepared in the format provided in **Appendix E**.

Applicants are also expected to provide a summary of the process models developed to-date for the proposed CDR technologies that are used in the TEA, including but not limited to: (i) model assumptions, (ii) kinetics, mass-transfer, and heat-transfer correlations and their validation, (iii) model predictions for temperature/concentration profiles for major unit operations (e.g., absorber, desorber) and their validation with the experimental data.

g. **R&D Community Benefits Plan:** Applicants must submit a description of the proposed process for developing a community benefits plan that includes all of the elements discussed in **Appendix A**. See Section IV. for submission information.

h. **Data Management Plan:** Applicants must submit a Data Management Plan as part of their Full Application. The Data Management Plan is a document that outlines the proposed plan for data sharing or preservation. Submission of this plan is required with the full application, and failure to submit the plan may result in rejection of the application without further consideration. Applicants shall prepare the DMP in the format provided in **Appendix H**. See Section IV. for submission information.

Research Scope and Attributes that are Not of Interest

See section I.D. for Applications Specifically Not of Interest

Anticipated Technology Readiness Level

Beginning of project: TRL 3
Technologies proposed for **AOI-3** must have already successfully completed work at TRL 3: analytical and experimental critical function and/or characteristic proof of concept.

End of project: TRL 6
By the completion of the proposed effort, technologies must be tested at a minimum of a TRL 6 whereby engineering/pilot-scale, similar (prototypical) system validation in relevant environment will be completed.

Success Metric(s)

Success will be measured by successfully upgrading the existing CDR test bed facility to simultaneously test multiple CDR pathways in parallel and completing at least 1,000 hours of continuous, multi-CDR testing of advanced CDR technologies that shows progress towards the following:

(i) Improved carbon removal efficiency and capacity,
(ii) Decreased cost of net CO_2e removal,
(iii) Reduced land, energy, and water requirements,
(iv) Lower cost, scalable process, and
(v) Maximized durability and permanence of carbon removal with effective MRV protocols.

In addition, development of rigorous, first-principles, multi-scale, validated process models is required. These models are to include uncertainty quantification (UQ) that can be used to guide pilot scale test conditions through statistical design of experiments and robust optimization methodologies.

Quantitative success metric targets will be established during negotiations with successful applicants. The final techno-economic analysis should demonstrate: (1) the economic viability of the proposed technologies that can justify its scale-up in a subsequent program, and (2) significant progress towards meeting the DOE's Carbon Negative Shot target of less than $100/net tonne CO_2e removed (i.e., both capture and storage).

iv. AOI-4. Small Marine CDR Pilots (Unfunded)

The objective of **AOI-4** is to support integrated marine CDR (mCDR) pilot projects, in lab, closed-system, and representative field pilot environments, to demonstrate the feasibility, cost, and scalability of both biotic and abiotic ocean-based approaches, including direct ocean capture of CO_2, ocean alkalinity enhancement (mineral and electrochemical), and micro- and macroalgae-based pathways.

Applications are not being sought under AOI-4 at this time but are anticipated to be solicited under future amendments to the FOA.

D. Applications Specifically Not of Interest

The following types of applications will be deemed nonresponsive and will not be reviewed or considered (See Section III, Eligibility Information; Responsiveness Criteria):

- Submissions that fall outside the technical parameters specified in Section I, "Funding Opportunity Description; Objectives/Areas of Interest" of the FOA,
- Submissions for proposed technologies that are not based on sound scientific principles (e.g., violates the laws of thermodynamics),
- R&D on CO_2 compression technologies,
- R&D on CO_2 storage technologies,
- Submissions that propose a test site that is not located in the United States, ~~and~~
- R&D on nitrogen and/or oxygen selective capture/separation materials,
- Submissions that propose biomass and/or mineral feedstocks sourced outside of the United States, and
- Submissions that propose pilot-scale testing using simulated gas.

AOI-1 Only

- Feedstocks that are not 100% sustainably-sourced biomass,
- R&D on post-combustion CO_2 capture technologies at the laboratory/bench-scale,
- R&D on pre-combustion CO_2 capture technologies at the laboratory/bench-scale,
- R&D on CO_2 conversion technologies at the laboratory/bench-scale,
- R&D on oxy-combustion and chemical looping configurations at the laboratory/bench-scale,
- R&D on direct air capture of CO_2, enhanced mineralization and weathering, marine CDR, or afforestation/reforestation,
- R&D on sustainably-sourced biomass production, including plant breeding and genetic modification to enhance carbon uptake,
- R&D on biological CO_2 capture technologies (e.g., algae-based processes) at the laboratory/bench-scale, and
- Laboratory- and bench-scale testing and development of materials and processes for biomass carbon removal and storage.

AOI-2 Only

- R&D on post-combustion CO_2 capture technologies at the laboratory/bench-scale, ~~engineering, or pilot scale,~~
- R&D on pre-combustion CO_2 capture technologies at the laboratory/bench-scale, ~~engineering, or pilot scale,~~
- R&D on CO_2 conversion technologies at the laboratory/bench-scale,
- R&D on oxy-combustion and chemical looping configurations at the laboratory/bench-scale, engineering, or pilot scale,
- R&D on direct air capture of CO_2, biomass carbon removal and storage, marine CDR, or afforestation/reforestation,
- R&D on mineral extraction and processing,
- R&D on biological CO_2 capture technologies (e.g., algae-based processes),

and

- Laboratory- and bench-scale testing and development of materials and processes for enhanced mineralization and weathering.

AOI-3 Only

- Submissions that propose a testbed facility that does not have existing CDR technology testing capabilities, and
- Submissions that propose a greenfield CDR testbed facility.

AOI-4 Only

- Applications are not being sought under AOI-4 at this time but should AOI-4 be solicited/incorporated under a future amendment to this FOA, this bullet will be revised to reflect any specific types of applications that would be deemed nonresponsive and would not be reviewed or considered.

II. Award Information

A. Type of Application

DOE will accept only new applications under this announcement.

B. Type of Award Instrument

Cooperative Agreements
DOE anticipates awarding cooperative agreements under this funding opportunity announcement (See Section VI, "Award Administration Information; Statement of Substantial Involvement").

C. Award Overview

i. Estimated Funding, Number of Awards, Anticipated Award Size, and Maximum DOE Share

Newly defined areas of interest could be funded with future multi-year, multi-program appropriations, if available, in which case the FOA document will be amended as appropriate.

DOE expects to make Federal funding available for new awards under this FOA as follows:

Area of Interest	Estimated Federal Funding $K	Anticipated No. of Awards	Anticipated Individual Award Size			Maximum DOE Share of Award $K
			DOE Share $K/80%	Cost Share $K/20%	Total $K	
1	$35,000	0 - 5	$7,000	$1,750	$8,750	$7,000
2	$40,000	0 – 10	$4,000	$1,000	$5,000	$4,000
3	$25,000	0 – 5	$5,000	$1,250	$6,250	$5,000
Total	**$100,000**	**0 - 20**				

DOE may issue awards in one, multiple or none of the areas of interests.

APPLICATIONS WHICH EXCEED THE "MAXIMUM DOE SHARE OF AWARD" SPECIFIED ABOVE WILL BE CONSIDERED NONCOMPLIANT (SEE SECTION III, "ELIGIBILITY INFORMATION; COMPLIANCE CRITERIA"). DOE WILL NOT REVIEW OR CONSIDER NONCOMPLIANT APPLICATIONS.

DOE may establish more than one budget period for each award and fund only the initial budget period(s). Funding for all budget periods, including the initial budget period, is not guaranteed. Funding for all awards and future

budget periods are contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority.

Project continuation will be contingent upon satisfactory performance and go/no-go decision review. At the go/no-go decision points, DOE will evaluate project performance, project schedule adherence, meeting milestone objectives, compliance with reporting requirements, and overall contribution to the program goals and objectives. As a result of this evaluation, DOE will make a determination to continue the project, re-direct the project, or discontinue funding the project.

ii. Estimated Project Period of Performance per Area of Interest

Estimated Project Period of Performance per Area of Interest
The anticipated project period of performance for projects under each Area of Interest in this announcement is:

Area of Interest	Project Period of Performance	Budget Periods
1	Up to 36 months	Up to 12 months
2	Up to 36 months	Up to 12 months
3	Up to 36 months	Up to 12 months

Typically, budget periods are established on an annual basis. In some cases, shorter or longer budget periods may be established for compelling programmatic or administrative reasons, such as to allow for project phases not evenly divisible with 12-month increments or to provide program personnel with logical decision points to evaluate whether the project should proceed.

III. Eligibility Information

A. General

To be considered for substantive evaluation, an applicant's submission must meet the criteria set forth below. If the application does not meet these initial requirements, it will be considered non-responsive, removed from further evaluation, and ineligible for any award.

B. Eligible Applicants

i. Individuals

U.S. citizens and lawful permanent residents are eligible to apply for funding as a Prime Recipient or Subrecipient.

ii. Domestic Entities

For-profit entities, educational institutions, and nonprofits that are organized, chartered or incorporated (or otherwise formed) under the laws of a particular State or territory of the United States and have a physical location for business operations in the United States are eligible to apply for funding as a Prime Recipient or Subrecipient.

Nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995, **are not eligible to apply for funding**.

iii. Domestic Public Entities (excluding Federal entities)

State, local, and tribal government entities are eligible to apply for funding as a Prime Recipient or Subrecipient.

Entities banned from doing business with the United States government such as entities debarred, suspended, or otherwise excluded from or ineligible for participating in Federal programs are not eligible.

Federal entity eligibility is discussed below.

iv. Federally Funded Research and Development Centers and National Laboratories

DOE/National Nuclear Security Administration (NNSA) Federally Funded Research and Development Centers (FFRDCs) and National Laboratories (NL) are eligible to apply for funding as a Subrecipient (only) but are not eligible to apply as a Prime Recipient. Non-DOE/NNSA FFRDCs and National Laboratories are eligible to apply for funding as a Subrecipient but are not eligible to apply as a Prime Recipient.

NETL is not eligible for award under this announcement and may not be proposed as a subrecipient on another entity's application. An application that includes NETL as a prime recipient or subrecipient will be considered non-responsive.

Authorization. The cognizant contracting officer for the DOE/NNSA FFRDC/NL or the non-DOE/NNSA Federal agency sponsoring the FFRDC/NL contractor must authorize in writing the use of the FFRDC/NL on the proposed project and this authorization must be submitted with the application. The use of a FFRDC/NL must be consistent with its authority under its award and will not place the laboratory in direct competition with the domestic private sector.

The following wording is acceptable for this authorization:

> "Authorization is granted for the [Name] Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complimentary to the missions of the laboratory, will not adversely impact execution of the [DOE/NNSA/or FEDERAL AGENCY] assigned programs at the laboratory, and will not place the laboratory in direct competition with the domestic private sector."

DOE will NOT fund DOE/NNSA FFRDCs participating as a subrecipient through the DOE field work authorization process. DOE will NOT fund non-DOE/NNSA FFRDCs through an interagency agreement with the sponsoring agency. Therefore, the prime recipient and FFRDC are responsible for entering into an appropriate subaward that will govern, among other things, the funding of the FFRDC portion of the work from the prime recipient under its DOE award. Such an agreement must be entered into before any project work begins.

The applicant should prepare the budgets using rates appropriate for funding the FFRDCs through subawards. The applicant's cost share requirement will be based on the total cost of the project, including the applicant's, the subrecipient's, and the FFRDC's portions of the project.

Responsibility. The applicant, if successful, will be the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues, including but not limited to, disputes and claims arising out of any agreement between the applicant and the FFRDC/NL.

v. Federal Entities

Federal agencies and instrumentalities (other than DOE) are eligible to apply for funding as a Subrecipient but are not eligible to apply as a Prime Recipient.

vi. Foreign Entities

Foreign entities, whether for-profit or otherwise, are eligible to apply for funding as a Prime Recipient or Subrecipient under this FOA. Other than as provided in the "Individuals" or "Domestic Entities" sections above, all Prime Recipients receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a State or territory of the United States and have a physical location for business operations in the United States. If a foreign entity applies for funding as a Prime Recipient, it must designate in the Full Application a subsidiary or affiliate incorporated (or otherwise formed) under the laws of a State or territory of the United States and have a physical location for business operations in the United States to be the Prime Recipient. The Full Application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate.

Foreign entities may request a waiver of the requirement to designate a subsidiary in the United States as the Prime Recipient in the Full Application (i.e., a foreign entity may request that it remains the Prime Recipient on an award). To do so, the Applicant must submit an explicit written waiver request in the Full Application. The "Waiver Requests: Foreign Entity Participation as the Prime Recipient and Performance of Work in the United States" Appendix lists the necessary information that must be included in a request to waive this requirement. The applicant does not have the right to appeal DOE's decision concerning a waiver request.

In the waiver request, the applicant must demonstrate to the satisfaction of DOE that it would further the purposes of this FOA and is otherwise in the

economic interests of the United States to have a foreign entity serve as the Prime Recipient. DOE may require additional information before considering the waiver request.

C. Cost Sharing

i. Cost Share Requirements

The cost share must be at least 20% of the total allowable costs for research and development projects (i.e., the sum of the Government share, including FFRDC/NL costs if applicable, and the recipient share of allowable costs equals the total allowable cost of the project) and must come from non-Federal sources unless otherwise allowed by law. See 2 CFR part 200.306 as amended by 2 CFR part 910.130 for the applicable cost sharing requirements.

DOE understands that projects selected under this FOA may require the use of existing data. For purposes of this FOA, DOE will consider data that is commercially available at an established market price to be an allowable cost under the project (either as DOE share or non-federal cost share) but DOE will not consider in-kind data (e.g., data, owned by an entity, that is not routinely sold commercially but is instead donated to the project and assigned a value) to be an allowable cost under the project, including as Recipient cost share. Estimation methods used by the Recipient to assign a value to in-kind data cannot be objectively verified by DOE and therefore will not be accepted by DOE as an allowable cost under any project selected from this FOA. Consequently, DOE will not recognize in-kind data costs in any resulting approved DOE budget.

To assist applicants in calculating proper cost share amounts, DOE has included a cost share information sheet and sample cost share calculation in the **"Cost Share Information" Appendix J** of this FOA.

ii. Legal Responsibility

Applicants will be bound by the cost share proposed in their applications and incorporated into their award.

The cost share requirement applies to the project as a whole, including work performed by members of the project team other than the Prime Recipient. The Prime Recipient is legally responsible for paying the entire cost share. The Prime Recipient's cost share obligation is expressed in the Assistance Agreement as a static amount in U.S. dollars (cost share amount) and as a percentage of the Total Project Cost (cost share percentage). If the funding

agreement is terminated prior to the end of the project period, the Prime Recipient is required to contribute at least the cost share percentage of total expenditures incurred through the date of termination.

The Prime Recipient is solely responsible for managing cost share contributions by the Project Team and enforcing cost share obligation assumed by Project Team members in subawards or related agreements.

iii. Cost Share Allocation

Each Project Team is free to determine how best to allocate the cost share requirement among the team members. The amount contributed by individual Project Team members may vary, as long as the cost share requirement for the project as a whole is met.

iv. Cost Share Types and Allowability

Every cost share contribution must be allowable under the applicable Federal cost principles, as described in Section IV, "Application and Submission Information; Funding Restrictions". In addition, cost share must be verifiable upon submission of the Full Application. Cost share may be provided in the form of cash or cash equivalents, or in-kind contributions. Cost share must come from non-federal sources (unless otherwise allowed by law), such as project participants, state or local governments, or other third-party financing. DOE Loan Guarantee, cannot be leveraged by applicants to provide the required cost share or otherwise support the same scope that is proposed under a project.

Cost share may be provided by the prime recipient, subrecipients, or third parties (entities that do not have a role in performing the scope of work). Vendors/contractors may not provide cost share. Any partial donation of goods or services is considered a discount and is not allowable.

Cash contributions include, but are not limited to: personnel costs, fringe costs, supply and equipment costs, indirect costs and other direct costs.

In-kind contributions are those where a value of the contribution can be readily determined, verified and justified but where no actual cash is transacted in securing the good or service comprising the contribution. Allowable in-kind contributions include but are not limited to: the donation of volunteer time or the donation of space or use of equipment.

Project teams may use funding or property received from state or local governments to meet the cost share requirement, so long as Federal Government did not provide the funding to the state or local government. The Recipient may not use the following sources to meet its cost share obligations including, but not limited to:

- Revenues or royalties from the prospective operation of an activity beyond the project period;
- Proceeds from the prospective sale of an asset of an activity;
- Federal funding or property (e.g., Federal grants, equipment owned by the Federal Government); or
- Expenditures that were reimbursed under a separate Federal Program.

Project Teams may not use the same cash or in-kind contributions to meet cost share requirements for more than one project or program.

Cost share contributions must be specified in the project budget, verifiable from the Prime Recipient's records, and necessary and reasonable for proper and efficient accomplishment of the project. As all sources of cost share are considered part of total project cost, the cost share dollars will be scrutinized under the same Federal regulations as Federal dollars to the project. Every cost share contribution must be reviewed and approved in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

Applicants are encouraged to refer to 2 CFR 200.306 as amended by 2 CFR 910.130 for additional cost sharing requirements.

Please refer to the **"Cost Share Information" Appendix J** of the FOA.

v. Cost Share Verification

Applicants are required to provide written assurance of their proposed cost share contributions in their Full Applications.

Upon selection for award negotiations, applicants are required to provide additional information and documentation regarding their cost share contributions. Please refer to the **"Cost Share Information" Appendix J** of the FOA.

vi. Cost Share Contributions by FFRDCs

Because FFRDCs and NLs are funded by the Federal Government, costs incurred by FFRDCs and NLs generally may not be used to meet the cost share requirement. FFRDCs and NLs may contribute cost share only if the contributions are paid directly from the contractor's Management Fee or another non-Federal source. In such instance, the FFRDC and NLs must certify in writing that the cost share comes from non-Federal sources.

D. Compliance Criteria

A review of all submitted documents and information is performed to determine if the submissions are in compliance with the FOA requirements. **<u>All</u> submitted information and documents must meet all Compliance Criteria listed below to be eligible for review or the submission will be considered noncompliant. DOE will NOT review or consider noncompliant submissions**.

Full Applications are deemed compliant if:

- The Full Application complies with the maximum DOE share of the individual award size in Section II, "Award Information; Award Overview" of the FOA;
- The Full Application complies with the content and form requirements in Section IV, "Application and Submission Information; Form and Content Requirements," and Section IV, "Application and Submission Information; Full Applications" of the FOA; and
- The applicant successfully uploaded all required documents and clicked the "Submit" button in Grants.gov by the deadline stated in the FOA. DOE will not extend the submission deadline for applicants that fail to submit required information by the applicable deadline due to server/connection congestion.

E. Responsiveness Criteria

A review of all submitted documents and information is performed to determine if the submissions are responsive to the FOA requirements. **<u>All</u> submitted information and documents must meet all of the Responsiveness Criteria listed below to be eligible for review or the submission will be considered non-responsive. DOE will NOT review or consider non-responsive submissions.**

Full Applications are deemed responsive if:

- The application meets the technical requirements as described in the "Objectives/Areas of Interest" contained in Section I, "Funding Opportunity Description" of the FOA; and

- The Applicant/application meets the Eligibility Criteria in Section III, "Eligibility Information" of the FOA.

Only compliant/responsive applications will be eligible for a comprehensive merit review.

F. Number of Submissions Eligible for Review

Applicants may submit multiple applications under each area of interest of this FOA; **HOWEVER**, applicants may not submit duplicate applications under multiple areas of interest. Put simply, each submitted application should be distinct and tailored to the specific area of interest.

G. Questions Regarding Eligibility

DOE will not make eligibility determinations for potential applicants prior to the date on which applications to this FOA must be submitted. The decision whether to submit an application in response to this FOA lies solely with the applicant.

IV. Application and Submission Information

A. Form and Content Requirements

All submissions must conform to the following form and content requirements, including maximum page limits (described below) and must be submitted as specifically stated. **Applications which do not meet ALL of the form and content requirements listed below will be considered noncompliant (See Section III, "Eligibility Information; Compliance Criteria"). DOE will NOT review or consider noncompliant applications.** DOE will not review or consider submissions submitted through means other than specifically stated in the FOA, submissions submitted after the applicable deadline, and incomplete submissions. DOE will not extend deadlines for applicants who fail to submit required information and documents by the applicable deadline due to server/connection congestion.

Full Applications must conform to ALL of the following requirements in order to be considered compliant:

- Each must be submitted in Adobe PDF format unless stated otherwise.
- Each must be written in English.
- All pages must be formatted to fit on 8.5 x 11 inch paper with margins not less than one inch on every side. Use Times New Roman typeface, a black font color, and a font size of 11 point or larger (except in figures or tables, which may be 10 point font and single spaced). A symbol font may be used to insert Greek letters or special characters, but the font size requirement still applies. References must be included as footnotes or endnotes in a font size of 10 or larger. Footnotes and endnotes are counted toward the maximum page requirement.
- Each submission must not exceed the specified maximum page limit (described below) when printed using the formatting requirements set forth above and **double spaced**. The maximum page limitation includes the cover page, references, charts, graphs, data, maps, photographs, other pictorial presentations, and other reference material the applicant may include its submission.

Full Applications which do not conform to ALL of the requirements listed above will be considered noncompliant (See Section III, "Eligibility Information; Compliance Criteria"). DOE will not review or consider noncompliant submissions.

Applicants are responsible for meeting the submission deadline. Applicants are strongly encouraged to submit their Full Applications at least 48 hours in advance of the submission deadline. Under normal conditions (i.e., at least 48 hours in advance

of the submission deadline), applicants should allow at least 1 hour to submit a Full Application. Once the Full Application is submitted, applicants may revise or update that submission until the expiration of the applicable deadline. If changes are made, the applicant must resubmit the Full Application, before the applicable deadline.

DOE urges applicants to carefully review their Full Applications and to allow sufficient time for the submission of required information and documents. All Full Applications that pass the initial eligibility review will undergo comprehensive technical merit review according to the criteria identified in Section V, "Application Review Information; Review Criteria" of the FOA.

B. Full Applications

Applicants must submit a Full Application by the specified due date and time to be considered for funding under this FOA. Applicants must complete the mandatory forms and any applicable optional forms (e.g., SF-LLL- Disclosure of Lobbying Activities) in accordance with the instructions on the forms and the additional instructions below. Files that are attached to the forms must be in Adobe Portable Document Format (PDF) unless otherwise specified in this announcement.

i. Application Package

Application forms and instructions are available at https://www.grants.gov/.

ii. Content and Form of Full Application

DOE will not review or consider ineligible Full Applications (see Section III, "Eligibility Information; Compliance Criteria" of the FOA).

Each Full Application must be limited to a **single** area of interest. Concepts or technologies unrelated to the specific area of interest should not be consolidated into a single Full Application.

Full Applications must conform to the following requirements:

Submission	Components	Format	File Name
Full Application (PDF, unless stated otherwise)	SF-424	Form	N/A
	Project/Performance Site Location(s)	Form	N/A
	Project Narrative (**30** page limitation, see chart below for further instruction)	PDF	Project.pdf
	Summary for Public Release (1 page limit)	PDF	Summary.pdf

	Project Management Plan (**10** page limitation, see chart below for further instruction)	PDF	PMP.pdf
	Resume	PDF	Resume.pdf
	SF424a Budget Information – Non-Construction Programs File	Microsoft Excel	SF424A.xls or .xlsx
	Budget Justification – SEE DETAILED INSTRUCTIONS BELOW	Microsoft Excel	RecipientBudget Justification.xls or .xlsx
	Subaward Budget Justification, if applicable – SEE DETAILED INSTRUCTIONS BELOW	Microsoft Excel	Subawardee_name BudgetJustification.xls or xlsx
	Budget for DOE/NNSA FFRDC/NL or non-DOE/NNSA FFRDC/NL, if applicable	PDF	Use up to 10 letters of the FFRDC/NL name plus "Budget" as the file name (e.g., FFRDC/NL_nameBudget.xls or xlsx), and click on "Add Optional Other Attachment" to attach.
	Authorization from cognizant Contracting Officer for DOE/NNSA FFRDC/NL or non-DOE FFRDC/NL, if applicable	PDF	Use up to 10 letters of the FFRDC/NL name plus FFRDC as the file name (e.g. anlFFRDC or lincolnFFRDC.pdf)
	Environmental Questionnaire	PDF	Env.pdf
	Cost Share Commitment Letters, if applicable	PDF	CSCL.pdf
	SF-LLL Disclosure of Lobbying Activities, if applicable	Form	N/A
	Foreign Entity Participation Waiver Requests if applicable	PDF	FN_Waiver.pdf
	Performance of Work in the United States waiver request, if applicable	PDF	PerformanceofWork_Waiver.pdf
	Data Management Plan	PDF	DMP.pdf
	R&D Community Benefits Plan (5 page limitation)	PDF	CBP.pdf
	Current and Pending Support	PDF	CPS.pdf
	Transparency of Foreign Connections	PDF	BusinessSensitive.pdf
	Potentially Duplicative Funding	PDF	PDFN.pdf
	State Point Data Table(s)	PDF	SPDT.pdf
	Letters of Commitment	PDF	LOC.pdf

Note: The maximum file size that can be uploaded to the Grants.gov website is 10MB. Files in excess of 10MB cannot be uploaded, and hence cannot be submitted for review. If a file exceeds 10MB but is still within the maximum page limit specified in the FOA, it must be broken into parts and denoted to that effect. For example:

Project Part 1
Project Part 2, etc.

DOE will not accept late submissions that resulted from technical difficulties due to uploading files that exceed 10MB.

Detailed guidance on the content and form of each component is listed below.

iii. SF-424: Application for Federal Assistance

Complete the SF 424 form first to populate data in other forms. Complete all required fields in accordance with the instructions on the form. The list of certifications and assurances in Field 21 can be found at https://www.energy.gov/management/financial-assistance-forms-and-information-applicants-and-recipients, under Certifications and Assurances.

iv. Project/Performance Site Location(s)

Indicate the primary site where the work will be performed by the prime recipient or subrecipient(s). If a portion of the project will be performed at any other site(s), identify the site location(s) in the blocks provided.

Note that the Project/Performance Site Congressional District is entered in the format of the 2-digit state code followed by a dash and a 3 digit Congressional district code, for example VA-001. Hover over this field for additional instructions.

Use the Next Site button to expand the form to add additional Project/Performance Site Locations.

v. Other Attachments Form

Submit the following files with your application and attach them to the Other Attachments Form. Click on "Add Mandatory Other Attachment" to attach the Project Narrative. Click on "Add Optional Other Attachment," to attach the other files.

vi. Project Narrative File – Mandatory Other Attachment

The Project Narrative File must be submitted in Adobe PDF format. The project narrative must not exceed **30** pages, including cover page, table of contents, footnotes/endnotes, charts, graphs, maps, photographs, and other pictorial presentations, when printed using standard 8.5" by 11" paper with 1 inch margins (top, bottom, left, and right) **doubled spaced.** The font must not be smaller than 11 point. The **Identification of Potential Conflicts of**

Interest or Bias in Selection of Reviewers, and Bibliography sections are <u>NOT</u> included in the project narrative page limitation. Do not include any Internet addresses (URLs) that provide information necessary to review the application. See Section VIII, "Other Information; Treatment of Application Information" for instructions on how to mark proprietary application information.

EVALUATORS WILL REVIEW ONLY THE NUMBER OF PAGES INDICATED ABOVE.

Save the information in a single file named "Project.pdf," and click on "Add Mandatory Other Attachment" to attach.

The project narrative (30 page limitation) must include:

SECTION	MAXIMUM PAGE LIMIT* (if applicable)	DESCRIPTION
Cover Page	Included in the page limitation (1-page maximum)	The cover page should include the project title, the specific FOA area of interest being addressed, the Applicant's name, and the names of all team member organizations. In addition, provide the Applicant's technical and business points of contact along with e-mail addresses and telephone numbers, names of project manager, Senior/Key personnel and their organizations. The cover page should also include the federal and non-federal share of costs associated with each team member's proposed effort. Applicants should ensure the cost information is consistent with the submitted budget justification(s).
Table of Contents	Included in the page limitation	Applicant to capture, at a minimum, all of the required sections identified in this table.
Project Objectives	Included in the page limitation	This section should provide a clear, concise statement of the specific objectives/aims of the proposed project. Buy America Requirements for Infrastructure Projects: Within the first two (2) pages of the Narrative, include a short statement on whether the project will involve the construction, alteration, and/or repair of infrastructure in the United States. See the "Required Use of American Iron, Steel, Manufactured Products, and Construction Materials – Buy America Requirements for Infrastructure Projects" **Appendix K** for applicable definitions and other information to inform this statement.
Merit Review Criterion Discussion	Included in the page limitation	The section should be formatted to address each of the merit review criterion and sub-criterion listed in Section V, "Application Review Information; Review Criteria". Provide sufficient information so that reviewers will be able to evaluate the application in accordance with these merit review criteria.

		DOE/NNSA WILL EVALUATE AND CONSIDER ONLY THOSE APPLICATIONS THAT ADDRESS SEPARATELY EACH OF THE MERIT REVIEW CRITERION AND SUB-CRITERION.
Statement of Project Objectives	Included in the page limitation	The project narrative must contain a single, detailed Statement of Project Objectives that addresses how the project objectives will be met. The Statement of Project Objectives must contain a clear, concise description of all activities to be completed during project performance. It is therefore required that it shall not contain proprietary or confidential business information. The Statement of Project Objectives is generally **less than 10 pages** in total for the proposed work. Applicants shall prepare the Statement of Project Objectives in the format provided in the "Statement of Project objectives Template" **Appendix L** of the FOA.
Relevance and Outcomes/Impacts	Included in the page limitation	This section should explain the relevance of the effort to the objectives in the program announcement and the expected outcomes and/or impacts. The justification for the proposed project should include a clear statement of the importance of the project in terms of the utility of the outcomes and the target community of beneficiaries.
Roles of Participants	Included in the page limitation	For multi-organizational or multi-investigator projects, describe the roles and the work to be performed by each participant/investigator, business agreements between the applicant and participants, and how the various efforts will be integrated and managed.
Multiple Principal Investigators	Included in the page limitation	The applicant, whether a single organization or team/partnership/consortium, must indicate if the project will include multiple PIs. This decision is solely the responsibility of the applicant. If multiple PIs will be designated, the application must identify the Contact PI/Project Coordinator and provide a "Coordination and Management Plan" that describes the organization structure of the project as it pertains to the designation of multiple PIs. This plan should, at a minimum, include: - process for making decisions on scientific/technical direction; - publications; - intellectual property issues; - communication plans; - procedures for resolving conflicts; and - PIs' roles and administrative, technical, and scientific responsibilities for the project.
Facilities and Other Resources	Included in the page limitation	Identify the facilities (e.g., office, laboratory, computer, etc.) to be used at each performance site listed and, if appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Describe only those resources that are directly applicable to the proposed work. Provide any information describing the other resources available to the project such as machine and electronics shops.

Equipment	Included in the page limitation	List important items of equipment already available for this project and, if appropriate, note the location and pertinent capabilities of each. If you are proposing to acquire equipment, describe comparable equipment, if any, already at your organization and explain why it cannot be used.
Project Narrative Specific Requirements that are included in the page limitations	**Included in the page limitation**	See Section I.C. and the respective Appendices of the FOA for a full list of specific requirements that applicants will need to include in the narrative section of the application, respective to the area of interest.
Identification of Potential Conflicts of Interest or Bias in Selection of Reviewers	**Not included in the page limitation**	Provide the following information in this section: ▪ Collaborators and Co-editors: List in alphabetical order all persons, including their current organizational affiliation, who are, or who have been, collaborators or co-authors with you on a research project, book or book article, report, abstract, or paper during the 48 months preceding the submission of this application. Also, list any individuals who are currently, or have been, co-editors with you on a special issue of a journal, compendium, or conference proceedings during the 24 months preceding the submission of this application. If there are no collaborators or co-editors to report, state "None." ▪ Graduate and Postdoctoral Advisors and Advisees: List the names and current organizational affiliations of your graduate advisor(s) and principal postdoctoral sponsor(s) during the last 5 years. Also, list the names and current organizational affiliations of your graduate students and postdoctoral associates.
Bibliography	Not included in the page limitation	If applicable: Provide a bibliography for any references cited in the Project Narrative section. This section must include only bibliographic citations.

*As indicated above, a maximum page limit has been established for the project narrative so when the project narrative sections identified in the table above as included in the page limitation are totaled together (including the cover page, table of contents, footnotes/endnotes, charts, graphs, maps, photographs, and other pictorial presentations) it should **not exceed 30 pages**. **EVALUATORS WILL REVIEW ONLY THE NUMBER OF PAGES INDICATED ABOVE.** Full Applications which do not conform to ALL of the requirements listed above will be considered noncompliant (See Section III, "Eligibility Information; Compliance Criteria"). DOE will not review or consider noncompliant submissions.

vii. Summary for Public Release File (April 2023)

The project summary/abstract must contain a one-page summary of the proposed activity suitable for dissemination to the public. It should be a self-contained document that identifies the name of the applicant, the project

director/principal investigator(s), the project title, the objectives of the project, a description of the project, including methods to be employed, the potential impact of the project (i.e., benefits, outcomes), major participants (for collaborative projects), and the project's commitments and goals described in the Community Benefits Plan. This document must not include any proprietary or sensitive business information as the Department may make it available to the public after selections. The project summary must not exceed one (1) page when printed using standard 8.5" by 11" paper with 1" margins (top, bottom, left and right) **double spaced** with font no smaller than 11 point.

Save this information in a file named "Summary.pdf," and click on "Add Optional Other Attachment" to attach.

viii. Project Management Plan

The Project Management Plan (PMP) must not exceed 10 pages including cover page, table of contents, footnotes/endnotes, charts, graphs, maps, photographs, and other pictorial presentations, when printed using standard 8.5" by 11" paper with 1" margins (top, bottom, left and right) **double spaced** with font no smaller than 11 point. Applicants shall prepare the PMP in the format provided in the "Project Management Plan Template" **Appendix M** of the FOA.

Save this information in a file named "PMP.pdf," and click on "Add Optional Other Attachment" to attach.

ix. Resume File (April 2023)

Provide a resume for each key person proposed, including subawardees and consultants if they meet the definition of key person. A key person is any individual who contributes in a substantive, measurable way to the execution of the project. The biographical information for each resume must not exceed 3 pages when printed on 8.5" by 11" paper with 1 inch margins (top, bottom, left, and right **double spaced** with font no smaller than 11 point and should include the following information, if applicable:

- Contact Information;
- Education and Training. Undergraduate, graduate and postdoctoral training, provide institution, major/area, degree and year.
- Research and Professional Experience. Beginning with the current position list, in chronological order, professional/academic positions with a brief description. List all current academic, professional, or

institutional appointments, foreign or domestic, at the applicant institution or elsewhere, whether or not remuneration is received, and, whether full-time, part-time, or voluntary;

- Awards and honors;
- Publications. Provide a list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically. An abbreviated style such as the Physical Review Letters (PRL) convention for citations (list only the first author) may be used for publications with more than 10 authors;
- Patents, copyrights, and software systems developed may be provided in addition to or substituted for publications.
- Synergistic Activities. List no more than 5 professional and scholarly activities related to the effort proposed.
- There should be no lapses in time over the past ten years or since age 18, which ever time period is shorter.

As an alternative to a resume, it is acceptable to use the biographical sketch format approved by the National Science Foundation (NSF). The biographical sketch format may be generated by the Science Experts Network Curriculum Vita (SciENcv), a cooperative venture maintained at https://www.ncbi.nlm.nih.gov/sciencv/, and is also available at: https://new.nsf.gov/funding/senior-personnel-documents#biographical-sketch-0bd. The use of a format required by another agency is intended to reduce the administrative burden to researchers by promoting the use of common formats.

Save all resumes in a single file named "Resume.pdf" and click on "Add Optional Other Attachment" to attach.

x. SF 424A Budget Information – Non-Construction Programs (SF424) File

You must provide a separate budget for each year of support requested and a cumulative budget for the total project period of performance. Use the SF 424 A Excel, "Budget Information - Non Construction Programs" form on the DOE Financial Assistance Forms Page at https://www.energy.gov/management/financial-assistance-forms-and-information-applicants-and-recipients under DOE budget forms.

You may request funds under any of the Object Class Categories as long as the item and amount are necessary to perform the proposed work, meet all the criteria for allowability under the applicable Federal cost principles, and are not prohibited by the funding restrictions in this announcement (See Section IV, “Application and Submission Information; Funding Restrictions”).

Save the information in a single file named "SF424A.xls or xlsx," and click on "Add Optional Other Attachment" to attach.

xi. Budget Justification File

Applicants are required to provide a detailed budget justification for the project as a whole, including all work to be performed by the Applicant and its Subrecipients and Contractors, and provide all requested documentation (e.g., a Federally-approved rate agreement, contractor quotes). Applicants should include costs associated with the Buy America Requirements for Infrastructure projects and Community Benefits Plan, required annual audits and incurred cost proposals in their proposed budget documents. Such costs may be reimbursed as direct or indirect costs.

A Budget Justification workbook is included as an attachment to this announcement for use and to describe the level of detail required in the budget justification. Although the data requested is mandatory, the use of the budget justification workbook is not.

The “Instructions and Summary” included with the Budget Justification workbook will auto-populate as the applicant enters information into the workbook. Applicants must carefully read the “Instructions and Summary” tab provided within the Budget Justification workbook. In addition, Applicants must carefully read and note each “Instructions” Summary contained within each individual tab of the Budget Justification workbook. **As stipulated within the Budget Justification workbook, all direct costs must be identified by specific task. All cost should include the basis of cost and justification of need, as applicable. Of specific note is the necessity to identify personnel costs for each individual proposed for all tasks to which they are assigned.** Note EXAMPLES provided within each tab for further clarification.

DOE understands that projects selected under this FOA may require the use of existing data. For purposes of this FOA, DOE will consider data that is commercially available at an established price to be an allowable cost under the project (either as DOE share or non-federal cost share) but DOE will not consider in-kind data (e.g., data, owned by an entity, that is not routinely sold commercially but is instead donated to the project and assigned a value)

to be an allowable cost under the project, including as Recipient cost share. Estimation methods used by the Recipient to assign a value to in-kind data cannot be objectively verified by DOE and therefore will not be accepted by DOE as an allowable cost under any project selected from this FOA. Consequently, DOE will not recognize in-kind data costs in any resulting approved DOE budget.

Save the Budget Justification workbook in a single file named "RecipientBudgetJustification.xls or xlsx" and click on "Add Optional Other Attachment" to attach.

xii. Subaward Budget Justification (if applicable)

Applicants must provide a separate detailed budget justification for each subrecipient that is expected to perform work estimated to be more than $250,000 or 25 percent of the total work effort (whichever is less). A Budget Justification workbook is included as an attachment to this announcement. Although the data requested is mandatory, the use of the budget justification workbook is not. The level of detail to be included in the subaward budget justification (if applicable) must be commensurate with that provided by the Prime Recipient.

Save the information in a single file named "Subawardee_name BudgetJustification.xls or xlsx" and click on "Add Optional Other Attachment" to attach.

xiii. Budget for DOE/NNSA FFRDC/NLs or non-DOE/NNSA FFRDC/NLs, (if applicable)

If proposed, FFRDC/NLs will be treated as subawards for applicants. Therefore, prepare the budgets utilizing rates appropriate for such an arrangement. You must provide a separate detailed budget justification for each FFRDC/NL proposed that is expected to perform work estimated to be more than $250,000 or 25 percent of the total work effort (whichever is less). A Budget Justification workbook is included as an attachment to this announcement. Although the data requested is mandatory, the use of the budget justification workbook is not. The level of detail to be included in the FFRDC/NL budget justification (if applicable) must be commensurate with that provided by the Prime Recipient.

Use up to 10 letters of the FFRDC/NL name plus "Budget" as the file name (e.g., FFRDC/NL_nameBudget.xls or xlsx), and click on "Add Optional Other Attachment" to attach.

If a DOE/NNSA FFRDC/NL is to perform a portion of the work, you shall use the Department's Strategic Partnership Projects program in accordance with the requirements of DOE Order 481.1 Strategic Partnership Projects (SPP) [formerly known as "Work for Others" (WFO)]. This order and the applicable terms and conditions are available at: https://www.directives.doe.gov/directives-documents/400-series/0481.1-BOrder-e-chg1-ltdchg. Subawards to other FFRDCs will utilize the terms and conditions of the sponsoring agency.

xiv. Authorization for DOE/NNSA FFRDC/NLs or non-DOE/NNSA FFRDCs/NLs (if applicable)

The cognizant contracting officer for the DOE/NNSA FFRDC/NL or the non-DOE/NNSA Federal agency sponsoring the FFRDC must authorize in writing the use of the FFRDC on the proposed project, and this authorization, as specified in Section III, "Eligibility Information" of the FOA, must be submitted with the application. The use of a FFRDC must be consistent with the contractor's authority under its award.

Use up to 10 letters of the FFRDC name plus FFRDC as the file name (e.g., lanlFFRDC.pdf or lincolnFFRDC.pdf), and click on "Add Optional Other Attachment" to attach.

xv. Environmental Questionnaire

The Applicant must submit an environmental questionnaire providing for the work of the entire project. The Applicant is also responsible for submitting a separate environmental questionnaire for each proposed subrecipient performing at a different location. The environmental questionnaire is available at https://netl.doe.gov/sites/default/files/2018-02/451_1-1-3.pdf.

Save the questionnaire in a single file named "Env.pdf" (or "Env-FILL IN TEAM MEMBER.pdf" if more than questionnaire is submitted) and click on "Add Optional Other Attachment" to attach.

NOTE: If selected for award and if a subrecipient's location is not known at the time of application, a subsequent environmental questionnaire will be needed prior to them beginning work at an alternate location.

xvi. Cost Share Commitment Letters (if applicable)

Cost share commitment letters are required from any party (other than the organization submitting the application) proposing to provide all or part of the required cost share (including subrecipients). The letter should state the party is committed to providing a specific minimum dollar amount of cost share, identify the type of proposed cost share (e.g., cash, services, and/or property) to be contributed, and be signed by the person authorized to commit the expenditure of funds by the entity. The applicant should submit the letter(s) in PDF format.

Save this information in a single file named “CSCL.pdf" and click on "Add Optional Other Attachment” to attach.

xvii. SF-LLL: Disclosure of Lobbying Activities (if applicable)

Recipients and Subrecipients may not use any Federal funds to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters.

If applicable, complete SF-LLL. Applicability: If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the grant/cooperative agreement, you must complete and submit Standard Form - LLL, "Disclosure of Lobbying Activities."

xviii. Waiver Requests (if applicable) (April 2023)

i. Foreign Entity Participation

As set forth in Section III, “Eligibility Information, Eligible Applicants”, all recipients must qualify as domestic entities. To request a waiver of this requirement, the applicant must submit an explicit waiver request in the Full Application. The “Waiver Requests: Foreign Entity Participation and Performance of Work in the United States **Appendix I”** lists the information that must be included in a waiver request.

ii. Performance of Work in the United States (Foreign Work Waiver)

As set forth in Section IV, Application and Submission Information; “Performance of Work in the United States (Foreign Work Waiver),” all work for the projects selected under this FOA must be performed in the United

States. To request a waiver of this requirement, the applicant must submit an explicit waiver request in the Full Application.
The "Waiver Requests: Foreign Entity Participation and Performance of Work in the United States **Appendix I"** lists the information that must be included in a foreign work waiver request.

Save the Waivers in a single PDF file using the following naming convention for the title "FN_Waiver.pdf" and click on "Add Optional Other Attachment" to attach.

xix. Data Management Plan

Applicants are required to submit a Data Management Plan as part of their Full Application. The Data Management Plan is a document that outlines the proposed plan for data sharing or preservation. Submission of this plan is required with the full application, and failure to submit the plan may result in rejection of the application without further consideration. Applicants shall prepare the DMP in the format provided in the "Data Management Plan" **Appendix H** of this FOA.

Save this plan in a single file named "DMP.pdf" and click on "Add Optional Other Attachment" to attach.

xx. R&D Community Benefits Plan (April 2023)

The R&D Community Benefits Plan must set forth the applicant's approach to ensuring the Federal investments advance the following three (3) objectives: (1) advance diversity, equity, inclusion and accessibility (DEIA); (2) contribute to energy equity; and (3) invest in America's workforce. The below sections set forth the content requirements for the R&D Community Benefits Plan, which addresses each of the foregoing objectives. Applicants must address all three (3) sections.

The applicant's R&D Community Benefits Plan must include at least one Specific, Measurable, Attainable, Realistic, and Timely (SMART) milestone per budget period to measure progress on the proposed actions. The R&D Community Benefits Plan will be evaluated as part of the technical review process. If a project is selected and awarded, the R&D Community Benefits Plan will be incorporated into the award and the recipient must implement its R&D Community Benefits Plan as part of carrying out its project. During the life of the award, the DOE will evaluate the recipient's progress.

The plan should be specific to the proposed project and not a restatement of organizational policies. Applicants should describe the future implications or a milestone-based plan for identifying future implications of their research on energy equity, including, but not limited to, benefits for the U.S. workforce. These impacts may be uncertain, occur over a long period of time, and/or have many factors within and outside the specific proposed research. Applicants are encouraged to describe the influencing factors and the most likely workforce and energy equity implications of the proposed research if the research is successful. While some guidance and example activities are provided in the "R&D Community Benefits Plan Guidance" **Appendix A**, applicants are encouraged to leverage promising practices and develop a plan that is tailored for their project.

The Applicant's R&D Community Benefits Plan must address the following three (3) sections:

1) Diversity, Equity, Inclusion, and Accessibility (DEIA):
To building a clean and equitable energy economy, it is important that there are opportunities for people of all racial, ethnic, socioeconomic and geographic backgrounds, sexual orientation, gender identify, persons with disabilities, and those re-entering the workforce from incarceration. This section of the plan must demonstrate how DEIA is incorporated in the technical project objectives. The plan must identify the specific action the applicant would undertake that integrated into the research goals and project teams. Submitting an institutional DEIA plan without specific integration into the project will be deemed insufficient.

2) Energy Equity:
This section must articulate the applicant's consideration of long-term equity implications of the research. It must identify how the specific project integrates equity considerations into the project design to support equitable outcomes should the innovation be successful. Like cost reductions and commercialization plans, the R&D Community Benefits Plan requires description of the equity implications of the innovation.

3) Workforce Implications:
This section must articulate the applicant's consideration of long-term workforce impacts and opportunities for the research. It must identify how the project is designed and executed to include an understanding of the future workforce needs should the resulting innovations be successful.

See the "R&D Community Benefits Plan Guidance" **Appendix A** for additional guidance.

The R&D Community Benefits Plan must **not exceed 5 pages**. Save this plan in a single file named 'CBP.pdf' and click on "Add Optional Other Attachment" to attach.

xxi. Current and Pending Support (April 2023)

Current and pending support is intended to allow the identification of potential duplication, overcommitment, potential conflicts of interest or commitment, and all other sources of support. As part of the application, the principal investigator and all senior/key personnel at the applicant and subrecipient level must provide a list of all sponsored activities, awards, and appointments, whether paid or unpaid; provided as a gift with terms or conditions or provided as a gift without terms or conditions; full-time, part-time, or voluntary; faculty, visiting, adjunct, or honorary; cash or in-kind; foreign or domestic; governmental or private-sector; directly supporting the individual's research or indirectly supporting the individual by supporting students, research staff, space, equipment, or other research expenses. All connections with foreign government-sponsored talent recruitment programs must be identified in current and pending support.

For every activity, list the following items:

- The sponsor of the activity or the source of funding;
- The award or other identifying number;
- The title of the award or activity. If the title of the award or activity is not descriptive, add a brief description of the research being performed that would identify any overlaps or synergies with the proposed research;
- The total cost or value of the award or activity, including direct and indirect costs and cost share. For pending proposals, provide the total amount of requested funding;
- The award period (start date through end date); and
- The person-months of effort per year being dedicated to the award or activity.

To identify overlap, duplication of effort, or synergistic efforts, append a description of the other award or activity to the current and pending support.

Details of any obligations, contractual or otherwise, to any program, entity, or organization sponsored by a foreign government must be provided on request to either the applicant institution or DOE. Supporting documents of any identified source of support must be provided to DOE on request, including certified translations of any document.

PIs and senior/key personnel must provide a separate disclosure statement listing the required information above regarding current and pending support. Each individual must sign and date their respective disclosure statement and include the following certification statement:

> *I, [Full Name and Title], certify to the best of my knowledge and belief that the information contained in this Current and Pending Support Disclosure Statement is true, complete and accurate. I understand that any false, fictitious, or fraudulent information, misrepresentations, half-truths, or omissions of any material fact, may subject me to criminal, civil or administrative penalties for fraud, false statements, false claims or otherwise. (18 U.S.C. §§ 1001 and 287, and 31 U.S.C. §§ 3729-3733 and 3801-3812). I further understand and agree that (1) the statements and representations made herein are material to DOE's funding decision, and (2) I have a responsibility to update the disclosures during the project period of performance of the award should circumstances change which impact the responses provided above.*

The information may be provided in theformat approved by the National Science Foundation (NSF), which may be generated by the Science Experts Network Curriculum Vita (SciENcv), a cooperative venture maintained at https://www.ncbi.nlm.nih.gov/sciencv/, and is also available at: https://www.nsf.gov/bfa/dias/policy/researchprotection/commonform_cps.pdf.

The use of a format required by another agency is intended to reduce the administrative burden to researchers by promoting the use of common formats. If the NSF format is used, the individual must still include a signature, date, and a certification statement using the language included in the paragraph above.

Save this plan in a single file named "CPS.pdf" and click on "Add Optional Other Attachment" to attach.

Definitions:

Current and pending support – (a) All resources made available, or expected to be made available, to an individual in support of the individual's RD&D efforts, regardless of (i) whether the source is foreign or domestic; (ii) whether the resource is made available through the entity applying for an award or directly to the individual; or (iii) whether the resource has monetary value; and (b) includes in-kind contributions requiring a commitment of time and directly supporting the individual's RD&D efforts, such as the provision of office or laboratory space, equipment, supplies,

employees, or students. This term has the same meaning as the term Other Support as applied to researchers in NSPM-33: For researchers, Other Support includes all resources made available to a researcher in support of and/or related to all of their professional RD&D efforts, including resources provided directly to the individual or through the organization, and regardless of whether or not they have monetary value (e.g., even if the support received is only in-kind, such as office/laboratory space, equipment, supplies, or employees). This includes resource and/or financial support from all foreign and domestic entities, including but not limited to, gifts provided with terms or conditions, financial support for laboratory personnel, and participation of student and visiting researchers supported by other sources of funding.

Foreign Government-Sponsored Talent Recruitment Program – An effort directly or indirectly organized, managed, or funded by a foreign government, or a foreign government instrumentality or entity, to recruit science and technology professionals or students (regardless of citizenship or national origin, or whether having a full-time or part-time position). Some foreign government-sponsored talent recruitment programs operate with the intent to import or otherwise acquire from abroad, sometimes through illicit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government. Many, but not all, programs aim to incentivize the targeted individual to relocate physically to the foreign state for the above purpose. Some programs allow for or encourage continued employment at United States research facilities or receipt of federal research funds while concurrently working at and/or receiving compensation from a foreign institution, and some direct participants not to disclose their participation to United States entities. Compensation could take many forms including cash, research funding, complimentary foreign travel, honorific titles, career advancement opportunities, promised future compensation, or other types of remuneration or consideration, including in-kind compensation.

Senior/Key Personnel – An individual who contributes in a substantive, meaningful way to the scientific development or execution of a research, development and demonstration (RD&D) project proposed to be carried out with DOE award.[22]

[22] Typically, these individuals have doctoral or other professional degrees, although individuals at the masters or baccalaureate level may be considered senior/key personnel if their involvement meets this definition. Consultants, graduate students, and those with a postdoctoral role also may be considered senior/key personnel if they meet this definition.

xxii. U.S. Competitiveness

A primary objective of DOE's multibillion-dollar research, development and demonstration investments is to cultivate new research and development ecosystems, manufacturing capabilities, and supply chains for and by U.S. industry and labor. Therefore, in exchange for receiving taxpayer dollars to support an applicant's project, the applicant must agree to the following U.S. Competitiveness Provision as part of an award under this FOA.

U.S. Competitiveness

The Recipient agrees that any products embodying any subject invention or produced through the use of any subject invention will be manufactured substantially in the United States unless the Recipient can show to the satisfaction of DOE that it is not commercially feasible. In the event DOE agrees to foreign manufacture, there will be a requirement that the Government's support of the technology be recognized in some appropriate manner, e.g., alternative binding commitments to provide an overall net benefit to the U.S. economy. The Recipient agrees that it will not license, assign or otherwise transfer any subject invention to any entity, at any tier, unless that entity agrees to these same requirements. Should the Recipient or other such entity receiving rights in the invention(s): (1) undergo a change in ownership amounting to a controlling interest, or (2) sell, assign, or otherwise transfer title or exclusive rights in the invention(s), then the assignment, license, or other transfer of rights in the subject invention(s) is/are suspended until approved in writing by DOE. The Recipient and any successor assignee will convey to DOE, upon written request from DOE, title to any subject invention, upon a breach of this paragraph. The Recipient will include this paragraph in all subawards/contracts, regardless of tier, for experimental, developmental or research work.

Please note that a subject invention is any invention conceived or first actually reduced to practice in performance of work under an award. An invention is any invention or discovery which is or may be patentable. The recipient shall ensure that these requirements also apply to subrecipients.

As noted in the U.S. Competitiveness Provision, if any entity cannot meet the requirements of the U.S. Competitiveness Provision, the entity may request a modification or waiver of the U.S. Competitiveness Provision. For example, the entity may propose modifying the language of the U.S. Competitiveness Provision in order to change the scope of the requirements or to provide more specifics on the application of the requirements for a particular

technology. As another example, the entity may request that the U.S. Competitiveness Provision be waived in lieu of a net benefits statement or U.S. manufacturing plan. The statement or plan would contain specific and enforceable commitments that would be beneficial to the U.S. economy and competitiveness. Examples of such commitments could include manufacturing specific products in the U.S., making a specific investment in a new or existing U.S. manufacturing facility, keeping certain activities based in the U.S. or supporting a certain number of jobs in the U.S. related to the technology. DOE may, in its sole discretion, determine that the proposed modification or waiver promotes commercialization and provides sufficient U.S. economic benefits, and grant the request. If granted, DOE will modify the award terms and conditions for the requesting entity accordingly. If not granted, the requesting entity must continue to perform according to the existing terms and conditions. More information and guidance on the waiver and modification request process can be found in the DOE Financial Assistance Letter on this topic.

The U.S. Competitiveness Provision is implemented by DOE pursuant to a Determination of Exceptional Circumstances (DEC) under the Bayh-Dole Act and DOE Patent Waivers. See Section VIII, "Other Information; Intellectual Property Developed Under This Program" of this FOA for more information on the DEC and DOE Patent Waiver.

xxiii. Transparency of Foreign Connections

Applicants must provide the following as it relates to the proposed recipient and subrecipients. Include a separate disclosure for the applicant and each proposed subrecipient. U.S. National Laboratories, domestic government entities, and institutions of higher education are only required to respond to items 1, 2 and 9, and if applying as to serve as the prime recipient, must provide complete responses for project team members that are not U.S. National Laboratories, domestic government entities, or institutions of higher education.

1. Entity name, website address, and physical address;
2. The identity of all owners, principal investigators, project managers, and senior/key personnel who are a party to any *Foreign Government-Sponsored Talent Recruitment Program* of a foreign country of risk (i.e., China, Iran, North Korea, and Russia);
3. The existence of any joint venture or subsidiary that is based in, funded by, or has a foreign affiliation with any foreign country of risk;
4. Any current or pending contractual or financial obligation or other agreement specific to a business arrangement, or joint venture-like

arrangement with an enterprise owned by a foreign state or any foreign entity;

5. Percentage, if any, that the proposed recipient or subrecipient has foreign ownership or control;
6. Percentage, if any, that the proposed recipient or subrecipient is wholly or partially owned by an entity in a foreign country of risk;
7. Percentage, if any, of venture capital or institutional investment by an entity that has a general partner or individual holding a leadership role in such entity who has a foreign affiliation with any foreign country of risk;
8. Any technology licensing or intellectual property sales to a foreign country of risk, during the 5-year period preceding submission of the proposal;
9. Any foreign business entity, offshore entity, or entity outside the United States related to the proposed recipient or subrecipient;
10. Complete list of all directors (and board observers), including their full name, citizenship and shareholder affiliation, date of appointment, duration of term, as well as a description of observer rights as applicable;
11. Complete capitalization table for your entity, including all equity interests (including LLC and partnership interests, as well as derivative securities). Include both the number of shares issued to each equity holder, as well as the percentage of that series and all equity on a fully diluted basis. Identify the principal place of incorporation (or organization) for each equity holder. If the equity holder is a natural person, identify the citizenship(s). If the recipient or subrecipient is a publicly traded company, provide the above information for shareholders with an interest greater than 5%;
12. A summary table identifying all rounds of financing, the purchase dates, the investors for each round, and all the associated governance and information rights obtained by investors during each round of financing; and
13. An organization chart to illustrate the relationship between your entity and the immediate parent, ultimate parent, and any intermediate parent, as well as any subsidiary or affiliates. Identify where each entity is incorporated.

DOE reserves the right to request additional or clarifying information based on the information submitted.

Save this plan in a single file named “BusinessSensitive.pdf” and click on “Add Optional Other Attachment” to attach.

xxiv. Potentially Duplicative Funding Notice

If the applicant or project team member has other active awards of federal funds, the applicant must determine whether the activities of those awards potentially overlap with the activities set forth in its application to this FOA. If there is a potential overlap, the applicant must notify DOE in writing of the potential overlap and state how it will ensure any project funds (i.e., recipient cost share and federal funds) will not be used for identical cost items under multiple awards. Likewise, for projects that receive funding under this FOA, if a recipient or project team member receives any other award of federal funds for activities that potentially overlap with the activities funded under the DOE award, the recipient must promptly notify DOE in writing of the potential overlap and state whether project funds from any of those other federal awards have been, are being, or are to be used (in whole or in part) for one or more of the identical cost items under the DOE award. If there are identical cost items, the recipient must promptly notify the DOE Contracting Officer in writing of the potential duplication and eliminate any inappropriate duplication of funding.

Save this plan in a single file named "PDFN.pdf" and click on "Add Optional Other Attachment" to attach.

xxv. State Point Data Table(s)

Applicants must complete a State Point Data Table(s) for their technology. See Section I.C. and **Appendix B** for more guidance.

Save the SPDT in a single file named "SPDT.pdf" and click on "Add Optional Other Attachment" to attach.

xxvi. Letters of Commitment

As described under Section I.C. of this FOA, all applications submitted in response to the FOA must provide one or more letters of commitment from:

- ***Proposed team member(s) as evidence of their participation.*** Letter(s) should demonstrate the partner's level of commitment to the project, such as host site access, sustainably-source biomass supply availability, data access, and/or advisory services, etc. The letter(s) of commitment must be signed by the person authorized to commit resources on behalf of the organization.

- ***Testing Site Selection.***

  - **For AOI 1 & 2:** Applicants must identify the location for conducting the pilot-scale testing.
    The specific test site must be located exclusively in the U.S. Applicants must submit a letter of commitment from the landowner for conducting the pilot-scale testing. The letter is required and must be signed by the person authorized to commit resources on behalf of the landowner organization. The letter must demonstrate that this organization has agreed to participate in the project.

    Note: A finalized host site agreement will be a required deliverable 6 months after the project start date.

  - **For AOI 3:** Applicants must submit a host site agreement for an existing CDR testbed facility located exclusively in the U.S. The agreement and corresponding letter of commitment are required and must be signed by the person authorized to commit resources on behalf of organization. The letter must demonstrate that this organization has agreed to participate in the project.

Save this information in a single file named "LOC.pdf" and click on "Add Optional Other Attachment" to attach.

C. Post Selection Information Requests

If selected for award negotiations, DOE reserves the right to require that selected applicants provide additional or clarifying information regarding the application submissions, the project, the project team, the award requirements, and any other matters related to anticipated award. The following is a non-exhaustive list of examples of information that may be required:

- Personnel proposed to work on the project and collaborating organizations (See Section VI, "Award Administration Information; Participants and Collaborating Organizations");
- Current and Pending Support (See Section VI, "Award Administration Information; Current and Pending Support");
- Indirect cost information;
- Other budget information;
- Information related to any proposed Workforce and Community Agreement, as defined above in "Community Benefits Plan: Job Quality and Equity," that applicants may have made with the relevant community;

- Name and phone number of the Designated Responsible Employee for complying with national policies prohibiting discrimination (See 10 CFR 1040.5);
- Listing of Protected Data and Unlimited Rights Data, if applicable;
- Representation of Limited Rights Data and Restricted Software, if applicable;
- Updated Commitment Letters from Third Parties Contributing to Cost Share, if applicable;
- Updated Environmental Questionnaire, if applicable;
- Foreign National Participation;
- Information for the DOE Office of Civil Rights to process assurance reviews under 10 CFR 1040;

D. Submission Dates and Times

Full Applications must be received no later than the time/dates provided on the cover page of this FOA. **APPLICATIONS RECEIVED AFTER THE DEADLINE WILL NOT BE REVIEWED OR CONSIDERED FOR AWARD.**

E. Intergovernmental Review

This program is not subject to Executive Order 12372 - Intergovernmental Review of Federal Programs.

F. Other Submission and Registration Requirements

i. Registration Process

There are several one-time actions before submitting an application in response to this FOA, and it is vital that applicants address these items as soon as possible. Some may take several weeks, and failure to complete them could interfere with an applicant's ability to apply to this FOA, or to meet the negotiation deadlines and receive an award if the application is selected. These requirements are provided immediately following the FOA cover page or modification summary, if applicable.

ii. Where to Submit

You cannot submit an application through Grants.gov unless you are registered. Please read the registration requirements carefully and start the process immediately. **Applications submitted via e-mail will not be accepted.**

Grants.gov applicants can apply online using Workspace. Workspace is a shared, online environment where members of a grant team may simultaneously access and edit different webforms within an application. For each funding opportunity announcement (FOA), you can create individual instances of a workspace.

Below is an overview of submitting an application using Workspace on Grants.gov. For access to complete instructions on how to apply for opportunities using Workspace, refer to: https://www.grants.gov/web/grants/applicants/workspace-overview.html

1) *Create a Workspace*: Creating a workspace allows you to complete it online and route it through your organization for review before submitting.

2) *Complete a Workspace*: Add participants to the workspace to work on the application together, complete all the required forms online or by downloading PDF versions, and check for errors before submission. The Workspace progress bar will display the state of your application process as you apply. As you apply using Workspace, you may click the blue question mark icon near the upper-right corner of each page to access context-sensitive help.

    a. *Adobe Reader*: If you decide not to apply by filling out webforms you can download individual PDF forms in Workspace. The individual PDF forms can be downloaded and saved to your local device storage, network drive(s), or external drives, then accessed through Adobe Reader. NOTE: Visit the Adobe Software Compatibility page on Grants.gov to download the appropriate version of the software at: https://www.grants.gov/web/grants/applicants/adobe-software-compatibility.html
    b. *Mandatory Fields in Forms:* In the forms, you will note fields marked with an asterisk and a different background color. These fields are mandatory fields that must be completed to successfully submit your application.
    c. *Complete SF-424 Fields First:* The forms are designed to fill in common required fields across other forms, such as the applicant name, address, and UEI. Once it is completed, the information will transfer to the other forms.

3) *Submit a Workspace:* An application may be submitted through workspace by clicking the Sign and Submit button on the Manage Workspace page, under the Forms tab. Grants.gov recommends submitting your application package at least 24-48 hours prior to the close date to provide you with time to correct any potential technical issues that may disrupt the application submission.

4) *Track a Workspace Submission:* After successfully submitting a workspace application, a Grants.gov Tracking Number (GRANTXXXXXXXX) is automatically assigned to the application. The number will be listed on the Confirmation page that is generated after submission. Using the tracking number, access the Track My Application page under the Applicants tab or the Details tab in the submitted workspace.

For additional training resources, including video tutorials, refer to: https://www.grants.gov/web/grants/applicants/applicant-training.html
Applicant Support: Grants.gov provides applicants 24/7 support via the toll-free number 1-800-518-4726 and email at support@grants.gov. For questions related to the specific grant opportunity, contact the number listed in the application package of the grant you are applying for.
If you are experiencing difficulties with your submission, it is best to call the Grants.gov Support Center and get a ticket number. The Support Center ticket number will assist the DOE with tracking your issue and understanding background information on the issue.

iii. Full Application Proof of Timely Submissions

Proof of timely submission is automatically recorded by Grants.gov. An electronic date/time stamp is generated within the system when the application is successfully received by Grants.gov. The applicant with the AOR role who submitted the application will receive an acknowledgement of receipt and a tracking number (GRANTXXXXXXXX) from Grants.gov with the successful transmission of their application. The applicant with the AOR role will also receive the official date/time stamp and Grants.gov Tracking number in an email serving as proof of their timely submission. The Grants.gov Support Center reports that some applicants end the transmission because they think that nothing is occurring during the transmission process. Please be patient and give the system time to process the application.

When DOE successfully retrieves the application from Grants.gov, and acknowledges the download of submissions, Grants.gov will provide an electronic acknowledgment of receipt of the application to the email address

of the applicant with the AOR role who submitted the application. Again, proof of timely submission shall be the official date and time that Grants.gov receives your application. Applications received by Grants.gov after the established due date for the FOA will be considered non-compliant.

iv. Electronic Authorization of Applications and Award Documents

Submission of an application and supplemental information under this FOA through electronic systems used by the DOE, including Grants.gov and FedConnect.net, constitutes the authorized representative's approval and electronic signature.

G. Funding Restrictions (April 2023)

Funding for all awards and future budget periods are contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority.

Costs must be allowable, allocable and reasonable in accordance with the applicable federal cost principles referenced in 2 CFR part 200 as amended by 2 CFR part 910. Pursuant to 2 CFR 910.352, the cost principles in the Federal Acquisition Regulations (48 CFR 31.2) apply to for-profit entities. The cost principles contained in 2 CFR Part 200, Subpart E apply to all entities other than for-profits.

H. Pre-Award Costs

Recipients may charge to an award resulting from this announcement pre-award costs that were incurred within the ninety (90) calendar day period immediately preceding the effective date of the award, if the costs are allowable in accordance with the applicable Federal cost principles referenced in 2 CFR part 200 as amended by 2 CFR part 910 [DOE Financial Assistance Regulation]. Recipients must obtain the prior approval of the contracting officer for any pre-award costs that are for periods greater than this 90-day calendar period.

Pre-award costs are incurred at the applicant's risk. DOE is under no obligation to reimburse such costs if for any reason the applicant does not receive an award or if the award is made for a lesser amount than the applicant expected.

I. Pre-Award Costs Related to National Environmental Policy Act (NEPA) Requirements

DOE's decision whether and how to distribute Federal funds under this FOA is subject to NEPA. Applicants should carefully consider and should seek legal counsel or other expert advice before taking any action related to the proposed project that would have an adverse effect on the environment or limit the choice of reasonable alternatives prior to DOE completing the NEPA review process.

DOE does not guarantee or assume any obligation to reimburse pre-award costs incurred prior to receiving written authorization from the Contracting Officer. If the applicant elects to undertake activities that DOE determines may have an adverse effect on the environment or limit the choice of reasonable alternatives prior to receiving such written authorization from the Contracting Officer, the applicant is doing so at risk of not receiving Federal funding for the project and such costs may not be recognized as allowable cost share. Nothing contained in the pre-award cost reimbursement regulations or any pre-award costs approval letter from the Contracting Officer override these NEPA requirements to obtain the written authorization from the Contracting Officer prior to taking any action that may have an adverse effect on the environment or limit the choice of reasonable alternatives. Likewise, if a project is selected for negotiation of award, and the Prime Recipient elects to undertake activities that are not authorized for Federal funding by the Contracting Officer in advance of DOE completing a NEPA review, the Prime Recipient is doing so at risk of not receiving Federal Funding and such costs may not be recognized as allowable cost share.

J. Performance of Work in the United States (Foreign Work Waiver) (April 2023)

i. Requirement

All work performed under DOE awards issued under this FOA must be performed in the United States. The prime recipient must flow down this requirement to its subrecipients.

ii. Failure to Comply

If the prime recipient fails to comply with the Performance of Work in the United States requirement, DOE may deny reimbursement for the work conducted outside the United States and such costs may not be recognized as allowable recipient cost share. The prime recipient is responsible should any work under this award be performed outside the United States, absent a

waiver, regardless of whether the work is performed by the prime recipient, subrecipients, contractors or other project partners.

iii. Waiver

To seek a foreign work waiver, the applicant must submit a written waiver request to DOE. The "Waiver Requests: Foreign Entity Participation and Performance of Work in the United States" **Appendix I** lists the information that must be included in a request for a foreign work waiver.

It is noted that direct labor associated with foreign travel to attend or present at a scientific/technical conference or consortium that has been approved by DOE does not require a waiver.

K. Foreign Travel

If international travel is proposed for your project, please note that your organization must comply with the International Air Transportation Fair Competitive Practices Act of 1974 (49 USC 40118), commonly referred to as the "Fly America Act," and implementing regulations at 41 CFR 301-10.131 through 301-10.143. The law and regulations require air transport of people or property to, from, between, or within a country other than the United States, the cost of which is supported under this award, to be performed by or under a cost-sharing arrangement with a U.S. flag carrier, if service is available.

L. Equipment and Supplies

Property disposition may be required at the end of a project if the current fair market value of property exceeds $5,000. For-profit entity disposition requirements are set forth at 2 CFR 910.360. Property disposition requirements for other non-Federal entities are set forth in 2 CFR 200.310 – 200.316.

M. Buy America Requirements for Infrastructure Projects (April 2023)

Pursuant to the Build America Buy America Act, subtitle IX of the Infrastructure Investment and Jobs Act[23], more commonly known as the Bipartisan Infrastructure Law (BIL) (Buy America, or "BABA"), and in accordance with 2 CFR 184, Federally assisted projects that involve infrastructure work, undertaken by applicable recipient types, require that:

[23] Infrastructure Investment and Jobs Act, Public Law 117-58 (November 15, 2021). https://www.congress.gov/bill/117th-congress/house-bill/3684.

- all iron, steel, and manufactured products used in the infrastructure work are produced in the United States; and
- all construction materials used in the infrastructure work are manufactured in the United States.

Whether a given project must apply this requirement is project-specific and dependent on several factors, such as the recipient's entity type, whether the work involves "infrastructure," as that term is defined in Section 70914 of the Bipartisan Infrastructure Law, and whether the infrastructure in question is publicly owned or serves a public function.

Applicants are strongly encouraged to consult the "Required Use of American Iron, Steel, Manufactured Products, and Construction Materials-Buy America Requirement for Infrastructure Projects" **Appendix K** of this FOA to determine whether their project may have to apply this requirement, both to make an early determination as to the need of a waiver, as well as to determine what impact, if any, this requirement may have on the proposed project's budget.

Please note that, based on the implementation guidance from the Office of Management and Budget (OMB) issued on October 25, 2023, the Buy America requirements of the BIL do not apply to DOE projects in which the prime recipient is a for-profit entity; the requirements only apply to projects whose prime recipient is a "non-Federal entity," e.g., a State, local government, Indian tribe, Institution of Higher Education, or nonprofit organization. Subawards should conform to the terms of the prime award from which they flow; in other words, for-profit prime recipients are not required to flow down these Buy America requirements to subrecipients, even if those subrecipients are non-Federal entities as defined above. Conversely, prime recipients which are non-Federal entities must flow the Buy America requirements down to all subrecipients, even if those subrecipients are for-profit entities. Finally, for all applicants—both non-Federal entities and for-profit entities—DOE is including a Program Policy Factor that the Selection Official may consider in determining which Full Applications to select for award negotiations that considers whether the applicant has made a commitment to procure U.S. iron, steel, manufactured products, and construction materials in its project.

The DOE financial assistance agreement will require each recipient: (1) to fulfill the commitments made in its application regarding the procurement of U.S.-produced products and (2) to fulfill the commitments made in its application regarding the procurement of other key component metals and manufactured products domestically that are deemed available in sufficient and reasonably available quantities or of a satisfactory quality at the time of award negotiation. Applicants may seek waivers of these requirements in very limited circumstances and for good cause shown. Further details on requesting a waiver can be found

in The "Required Use of American Iron, Steel, Manufactured Products, and Construction Materials – Buy America Requirements for Infrastructure Projects" **Appendix K** and the terms and conditions of an award

Applicants are strongly encouraged to consult the "Required Use of American Iron, Steel, Manufactured Products, and Construction Materials – Buy America Requirements for Infrastructure Projects" **Appendix K** and 2 CFR 184 for more information. Application Review Information

A. Review Criteria

i. Compliance/Responsiveness Review

Prior to a comprehensive merit evaluation, DOE will (1) perform a compliance review to determine that submissions are timely and the information required by the FOA has been submitted (form and content requirements); and (2) perform a responsiveness review to determine that the Applicant is eligible for an award and the proposed project is responsive to the objectives of the FOA. Applications that fail the compliance and responsiveness review will not be forwarded for merit review and will be eliminated from further consideration.

ii. Full Application Merit Review Criteria

The following evaluation criteria will be utilized by the Technical Evaluation Committee and Federal Merit Review Panel members in conducting their evaluations of applications subjected to comprehensive merit review.

Merit Review Criterion 1: Scientific and Technological Merit (AOI-1 and AOI-2: 40%; AOI-3: 25%)

All AOIs

- Thoroughness of the description of the proposed technology and degree to which the proposed technology or methodology meets the stated objectives and success metrics of the FOA and AOI. Completeness of the description of the CDR system, including CO_2 removal mechanism, chemistry, kinetics and thermodynamics, process steps, and MRV protocols.
- Feasibility of the proposed concept, project, or resource; the degree to which the proposed work is based on sound scientific and engineering principles.

- Adequacy of the Technology Readiness Level evaluation as supported with experimental results diagrams, and graphs of the Applicant's previous and active research corresponding to the AOI addressed. Including evidence that the project is at the minimum TRL required and proposed at an appropriate scale based on current and planned technology development activities, technology scaling methodology, and scaling factor analysis. Footnotes and the bibliography are only to be utilized to validate the information requested in the narrative.
- Adequacy and completeness of information provided in the summary of the preliminary TEA, including mass and energy balances, estimates of heating and cooling duties and electric power requirements covering the CDR system and balance-of-plant, and cost of CO_2 removal. Degree to which the application specifically and convincingly demonstrates how the proposed project can ultimately facilitate meaningful progress toward achievement of DOE's Carbon Negative Shot goal.
- Adequacy of the preliminary LCA and degree to which a complete description of the LCA was provided, including ability to assess net-climate benefits of the project.
- Thoroughness and completeness of the State Point Data Table(s).

AOI 1 Only

- Degree to which the Applicant provided details regarding sustainable biomass harvesting and land maintenance practices; potential environmental, economic, and social effects; and the development of an adequate supply chain for sustainably-sourced biomass feedstock based on a resource assessment.

AOIs 1 and 2 Only

- Thoroughness of the Technology Competitive Assessment. Degree to which the Applicant comprehensively advances arguments and provides details that specifically and convincingly demonstrates the transformative and innovative nature of the technology and/or its applications and why it is needed now relative to prior work.
- If applicable, adequacy and thoroughness of the market analysis, including market size, required selling price of the product, and CO_2 removal potential.

AOI-3 Only

- Adequacy of the Applicant's discussion of their awareness of the CDR technologies that may be tested at their CDR testbed facility. Soundness of the Applicant's proposed process for assessing and priority ranking CDR pathways and technologies proposed for testing.

Merit Review Criterion 2: Technical Approach and Understanding (AOI-1 and AOI-2: 30%; AOI-3: 25%)

All AOIs

- Adequacy and feasibility of the Applicant's approach and scope to achieve the objectives of the FOA and the relevant AOI.
- Thoroughness of the pilot-scale test plans and project description (including process diagrams, hardware sketches, etc.) and plans necessary for the design, installation/modification, permitting, and operation of equipment for required scale of design. Adequacy of analytical capabilities and MRV protocols.
- Reasonableness of the discussion regarding the quality of the expected data, analysis, MRV, and reporting that the Applicant will provide.
- Feasibility, appropriateness, rationale, and completeness of the proposed Statement of Project Objectives, such that there is a logical progression of work.
- The adequacy and completeness of the Project Management Plan (PMP) in establishing baselines (technical scope, budget, schedule), performance metrics that will be assessed during the proposed R&D project and in managing project performance relative to those baselines; defining the actions that will be taken when these baselines must be revised; and identification of project risks and strategies for mitigation.

AOI-3 Only

- The adequacy of the technical, process, operational, and plant integration risks assessment protocol for testing new technologies at the CDR testbed facility. The extent of the Applicant's discussion regarding any limitations imposed by their testing facilities and the reasonableness of any proposed mitigation strategies.

Merit Review Criterion 3: Technical/Management Capabilities and Facilities (AOI-1 and AOI-2: 20%; AOI-3: 40%)

All AOIs

- Demonstrated experience of the Applicant and partnering organizations in the technology, methods, and resource areas addressed in the application and in managing projects of similar size, scope, and complexity. Adequacy and completeness of the Applicant's discussion of the proposed project team's multi-disciplinary capabilities to perform effective project management, pilot-scale process design and process modeling, efficient test plan development, pilot-scale procurement and fabrication, integrated process commissioning and operation, techno-economic,

environmental, and life cycle analyses, and required community benefits plan activities.

- Credentials, capabilities, and experience of all key personnel, including partnering organizations.
- Clarity and likely effectiveness of the project organization, including sub-recipients or partners, to successfully complete the project. Adequacy of proposed team structure that includes, at a minimum, the CDR technology developer and host site operator or landowner.
- Adequacy and availability of proposed personnel, facilities, and equipment to perform project tasks. Demonstrated adequacy and commitment of the proposed host site operator or landowner to support the pilot-scale testing. Strength of project team member commitments to the project as evidenced by letters of commitment or signed agreements among team members.

AOI-3 Only

- Thoroughness of the Applicant's discussion of the existing CDR testbed facility, including photographs, schematics, flow diagrams, and plan views with sufficient details regarding the type, size, and availability of equipment to be used. Thoroughness of the existing facility condition assessment. Adequacy of the maintenance and replacement schedule for components, systems, and supporting infrastructure for the CDR testbed facility.
- The degree to which the Applicant's CDR testbed facility is capable of simultaneously accommodating multiple CDR technology test systems.
- Demonstrated knowledge and experience of the processes necessary for the design, installation/modification, permitting, operation, and maintenance of equipment required for testing CDR technologies at various scales and test apparatus conditions (i.e., fully integrated test unit versus a component requiring a test stand).
- Adequacy of the team to address the process engineering, equipment operation and maintenance, development, and execution of analytical and MRV protocols, test plans, and facility environmental health and safety issues with regards to selected CDR technologies to be tested.
- Reasonableness of the Applicant's knowledge and experience on the permitting necessary to operate the facilities. Reasonableness of the Applicant's knowledge or involvement in the NEPA process for an R&D test facility.

Merit Review Criterion 4: R&D Community Benefits Plan (10%)

Diversity, Equity, Inclusion, and Accessibility (DEIA)

- Clear articulation of the project's goal related to diversity, equity, inclusion, and accessibility;
- Quality of the project's DEIA goals, as measured by the goals' depth, breadth, likelihood of success, inclusion of appropriate and relevant SMART milestones, and overall project integration;
- Degree of applicant's commitment and ability to track progress towards meeting each of the diversity, equity, inclusion, and accessibility goals; and
- Extent of engagement of organizations that represent underserved communities as a core element of their mission, including MSIs, Minority Business Entities, and non-profit or community-based organizations.

Energy Equity

- Clear workplan tasks, staffing, research, and timeline for engaging energy equity stakeholders and/or evaluating the possible near and long-term implications of the project for the benefit of the American public; including but not limited to the public health and public prosperity benefits;
- Approach, methodology, and expertise articulated in the plan for addressing energy equality and justice issues associated with the technology innovation; and
- Likelihood that the plan will result in improved understanding of distributional public benefits and costs related to the innovation if successful.

Workforce Implications

- Clear and comprehensive workplan tasks, staffing, research, and timeline for engaging workforce stakeholders and/or evaluating the possible near and long-term implications of the project for the United States workforce;
- Approach to document the knowledge, skills, and abilities of the workforce required for successful commercial deployment of innovations resulting from this research; and
- Likelihood that the plan will result in improved understanding of the workforce implications related to the innovation if successful.

B. Other Selection Factors

i. Program Policy Factors

In addition to the above criteria, the Selection Official may consider the following program policy factors in determining which Full Applications to select for award negotiations:

- It may be desirable to select for award a project, or group of projects, that represent a diversity of technical approaches, methods, and resources under this FOA or the overall program.
- It may be desirable to support complementary and/or similar projects which, when taken together, will best achieve the program's research goals and objectives.
- It may be desirable that different kinds and sizes of organizations be selected for award in order to provide a balanced programmatic effort and a variety of technical perspectives under this FOA or the overall program. For example, it may be desirable to select a project, or group of projects, that exhibit team member diversity, with participants including but not limited to those from MSIs (e.g., HBCUs/OMIs).[24]
- In order to best achieve the program's research goals and objectives, it may be desirable to select for award a project or group of projects with a broad or specific geographic distribution under this FOA or the overall program.
- It may be desirable to select a project, or group of projects, if such a selection will optimize use of available funds.
- It may be desirable to select a project, or group of projects, if such a selection presents lesser schedule risk, lesser budget risk, lesser technical risk, lesser societal considerations and impacts risk, and/or lesser environmental risks. Environmental risk includes, but is not limited to, an adverse impact to air, soil, water, or increase in overall cradle-to-grave greenhouse gas footprint (carbon dioxide equivalent, CO_2e).
- It may be desirable to select an entity located in an urban and economically distressed area including a Qualified Opportunity Zone (QOZ) or to select a project, or group of projects, if the proposed project(s) will occur in a QOZ or otherwise advance the goals of a

[24] Minority Serving Institutions (MSIs), including HBCUs/OMIs as educational entities recognized by the Office of Civil Rights (OCR), U.S. Department of Education, and identified on the OCR's Department of Education U.S. accredited postsecondary minorities' institution list. See https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html.

QOZ, including spurring economic development and job creation in distressed communities throughout the United States.
- The degree to which the proposed project will employ procurement of U.S. iron, steel, manufactured products, and construction materials.
- The degree to which the proposed project, when compared to the existing DOE project portfolio and other projects to be selected from the subject FOA, contributes to the total portfolio meeting the goals reflected in the Community Benefits Plan criteria.

C. Other Review Requirements

i. Risk Assessment (May 2023)

Pursuant to 2 CFR 200.206, DOE will conduct an additional review of the risk posed by applications submitted under this FOA. Such risk assessment will consider:

- Financial stability;
- Quality of management systems and ability to meet the management standards prescribed in 2 CFR 200 as amended by 2 CFR 910;
- History of performance;
- Audit reports and findings; and
- The applicant's ability to effectively implement statutory, regulatory, or other requirements imposed on non-Federal entities.

DOE may make use of other publicly available information and the history of an applicant's performance under DOE or other federal agency awards.

Depending on the severity of the findings and whether the findings were resolved, DOE may elect not to fund the applicant.

In addition to this review, DOE must comply with the guidelines on government-wide suspension and debarment in 2 CFR 180, and must require non-Federal entities to comply with these provisions. These provisions restrict Federal awards, subawards and contracts with certain parties that are debarred, suspended or otherwise excluded from or ineligible for participation in Federal programs or activities.

Further, as DOE invests in critical infrastructure and funds critical and emerging technology areas, DOE also considers possible vectors of undue foreign influence in evaluating risk. If high risks are identified and cannot be sufficiently mitigated, DOE may elect to not fund the applicant. As part of the

research, technology, and economic security risk review, DOE may contact the applicant and/or proposed project team members for additional information to inform the review.

ii. Recipient Responsibility and Qualifications (May 2023)

DOE, prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold, is required to review and consider any responsibility and qualification information about the applicant that is in entity information domain in SAM.gov (see 41 U.S.C. 2313).
The applicant, at its option, may review information in the entity information domain in SAM.gov and comment on any information about itself that a federal awarding agency previously entered and is currently in the entity information domain in SAM.gov.

DOE will consider any written comments by the applicant, in addition to the other information in the entity information domain in SAM.gov, in making a judgment about the applicant's integrity, business ethics, and record of performance under Federal awards when completing the review of risk posed by applicants as described in 2 CFR 200.206 - Federal awarding agency review of risk posed by applicants.

D. Review and Selection Process

i. Merit Review

Applications that pass the compliance/responsiveness review will be subjected to a merit review in accordance with the Merit Review Criteria listed in the FOA and the guidance provided in the "Merit Review Guide for Financial Assistance and Unsolicited Proposals." This guide is available at https://energy.gov/management/financial-assistance.

ii. Selection

The Selection Official may consider the merit review, program policy factors, risk reviews, and the amount of funds available in arriving at selections for this FOA.

iii. Discussions and Award

The Government may enter into discussions with a selected applicant for any reason deemed necessary, including but not limited to: (1) the budget is not appropriate or reasonable for the requirement; (2) only a portion of the

application is selected for award; (3) the Government needs additional information to determine that the recipient is capable of complying with the requirements in 2 CFR part 200 as amended by 2 CFR part 910 [DOE Financial Assistance Regulation]; and/or (4) special terms and conditions are required. Failure to resolve satisfactorily the issues identified by the Government will preclude award to the applicant.

V. Award Administration Information

A. Notices

i. Ineligible Submissions

Ineligible Full Applications will not be further reviewed or considered for award. The Contracting Officer will send a notification letter by email to the technical and administrative points of contact designated by the applicant in Grants.gov. The notification letter will state the basis upon which the Full Application is ineligible and not considered for further review.

ii. Full Application Notifications

DOE will notify applicants of its determination via a notification letter by email to the technical and administrative points of contact designated by the applicant in Grants.gov. The notification letter will inform the applicant whether or not its Full Application was selected for award negotiations. Alternatively, DOE may notify one or more applicants that a final selection determination on particular Full Applications will be made at a later date, subject to the availability of funds or other factors.

(a) Successful Applicants

Receipt of a notification letter selecting a Full Application for award negotiations does not authorize the applicant to commence performance of the project. If an application is selected for award negotiations, it is not a commitment by DOE to issue an award. Applicants do not receive an award until award negotiations are complete and the Contracting Officer executes the funding agreement, accessible by the Prime Recipient in FedConnect.

The award negotiation process may take up to 120 days. Applicants must designate a primary and a backup point-of-contact in Grants.gov with whom DOE will communicate to conduct award negotiations. The applicant must be responsive during award negotiations (i.e., provide requested documentation) and meet the negotiation deadlines. If the applicant fails to do so or if award negotiations are otherwise unsuccessful, DOE will cancel the award negotiations and rescind the Selection. DOE reserves the right to terminate award negotiations at any time for any reason.

Please refer to Section IV, "Application and Submission Information; Pre-Award Costs" of the FOA for guidance on pre-award costs.

(b) Unsuccessful Applicants

DOE shall promptly notify in writing each applicant whose application has not been selected for negotiation or award. This notice will explain why the application was not selected.

(c) Alternate Selection Determinations

In some instances, an applicant may receive a notification that its application was not selected for award and DOE designated the application to be an alternate. As an alternate, DOE may consider the Full Application for Federal funding in the future. A notification letter stating the Full Application is designated as an alternate does not authorize the applicant to commence performance of the project. DOE may ultimately determine to select or not select the Full Application for award negotiations.

(d) Notice of Award

An Assistance Agreement issued by the Contracting Officer is the authorizing award document. It normally includes either as an attachment or by reference: (1) Special Terms and Conditions; (2) Applicable program regulations, if any; (3) Application, which includes the project description and budget, as approved by DOE; (4) 2 CFR part 200 as amended by 2 CFR part 910; (5) National Policy Assurances To Be Incorporated As Award Terms; (6) Budget Summary; (7) Federal Assistance Reporting Checklist and Instructions, which identifies the reporting requirements; (8) Intellectual Property; (9) Federal-wide Research Terms and Conditions; (10) Agency Specific Requirements; and (11) any award specific terms and conditions.

B. Administrative and National Policy Requirements

i. Award Administrative Requirements

The administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR Part 200 as amended by 2 CFR Part 910.

DOE Special Terms and Conditions for Use in Most Grants and Cooperative Agreements.

The DOE Special Terms and Conditions for Use in Most Grants and Cooperative Agreements are located at: https://www.energy.gov/management/financial-assistance-forms-and-information-applicants-and-recipients under Award Terms.

National Policy Requirements. The National Policy Assurances that are incorporated as a term and condition of award are located at: https://www.energy.gov/management/financial-assistance-forms-and-information-applicants-and-recipients.

Intellectual Property Provisions. The standard DOE financial assistance intellectual property provisions applicable to the various types of recipients are located at: https://energy.gov/gc/standard-intellectual-property-ip-provisions-financial-assistance-awards.

ii. Unique Entity Identifier Requirements and System for Award Management (April 2023)

Each applicant (unless the applicant is an individual or federal awarding agency that is excepted from those requirements under 2 CFR 25.110(b) or (c), or has an exception approved by the federal awarding agency under 2 CFR 25.110(d)) is required to: (1) Be registered in the SAM at https://www.sam.gov before submitting its application; (2) provide a valid UEI number in its application; and (3) continue to maintain an active SAM registration with current information at all times during which it has an active federal award or an application or plan under consideration by a federal awarding agency. DOE may not make a federal award to an applicant until the applicant has complied with all applicable UEI and SAM requirements and, if an applicant has not fully complied with the requirements by the time DOE is ready to make a federal award, the DOE will determine that the applicant is not qualified to receive a federal award and use that determination as a basis for making a federal award to another applicant.

NOTE: Due to the high demand of UEI requests and SAM registrations, entity legal business name and address validations are taking longer than expected to process. Entities should start the UEI and SAM registration process as soon as possible. If entities have technical difficulties with the UEI validation or SAM registration process, they should utilize the **HELP** feature on **SAM.gov**. SAM.gov will work entity service tickets in the order in which they are received and asks that entities not create multiple service tickets for the same request or technical issue. Additional entity validation resources can be found here: GSAFSD Tier 0 Knowledge Base - Validating your Entity**.**

iii. Uniform Commercial Code (UCC) Financing Statements

Per 2 CFR 910.360 (Real Property and Equipment) when a piece of equipment is purchased by a for-profit recipient or subrecipient with Federal Funds (federal and/or non-federal), and when the Federal share of the financial assistance agreement is more than $1,000,000, the recipient or subrecipient must:

Properly record, and consent to the Department's ability to properly record if the recipient fails to do so, Uniform Commercial Code (UCC) financing statement(s) for all equipment in excess of $5,000 purchased with project funds. These financing statement(s) must be approved in writing by the contracting officer prior to the recording, and they shall provide notice that the Recipient's title to all equipment (not real property) purchased with Federal funds under the financial assistance agreement is conditional pursuant to the terms of this section, and that the Government retains an undivided reversionary interest in the equipment. The UCC financing statement(s) must be filed before the Contracting Officer may reimburse the recipient for the Federal share of the equipment unless otherwise provided for in the relevant financial assistance agreement. The recipient shall further make any amendments to the financing statements or additional recordings, including appropriate continuation statements, as necessary or as the contracting officer may direct.

Note: All costs associated with filing UCC financing statements, UCC financing statement amendments, and UCC financing statement terminations, are allowable and allocable costs to be charged to the Federal award.

iv. Foreign National Participation (April 2023)

All applicants selected for an award under this FOA and project participants (including subrecipients and contractors) who anticipate involving foreign nationals in the performance of an award, will be required to provide DOE with specific information about each foreign national to satisfy requirements for foreign national participation and access approvals. The volume and type of information collected may depend on various factors associated with the award. DOE concurrence may be required before a foreign national can participate in the performance of any work under an award.

Approval for foreign nationals in Principal Investigator/Co-Investigator roles, from countries of risk (i.e., China, Iran, North Korea and Russia), or from countries identified on the U.S. Department of State’s list of State Sponsors of Terrorism (https://www.state.gov/state-sponsors-of-terrorism/) may

require written authorization from DOE before they can participate in the performance of any work under an award.

A “foreign national” is defined as any person who is not a United States citizen by birth or naturalization. DOE may elect to deny foreign national’s participation in the award. Likewise, DOE may elect to deny a foreign national’s access to a DOE sites, information, technologies, equipment, programs, or personnel.

Applicants selected for award negotiations must include this requirement in subawards.

v. Export Control (April 2023)

The United States government regulates the transfer of information, commodities, technology, and software considered to be strategically important to the United States to protect national security, foreign policy, and economic interests without imposing undue regulatory burdens on legitimate international trade. There is a network of federal agencies and regulations that govern exports that are collectively referred to as “Export Controls”. All recipients and subrecipients are responsible for ensuring compliance with all applicable United States Export Control laws and regulations relating to any work performed under a resulting award.

The selected applicant must immediately report to DOE any export control violations related to the projected funded under the DOE award, at the prime or subrecipient level, and provide corrective action(s) to prevent future violations.

vi. Statement of Federal Stewardship

DOE will exercise normal Federal stewardship in overseeing the project activities performed under DOE Awards. Stewardship Activities include, but are not limited to, conducting site visits; reviewing performance and financial reports; providing assistance and/or temporary intervention in usual circumstances to correct deficiencies that develop during the project; assuring compliance with terms and conditions; and reviewing technical performance after project completion to ensure that the project objectives have been accomplished.

vii. Statement of Substantial Involvement

Cooperative agreements will be awarded under this announcement. There will be substantial involvement between the DOE and the Recipient during performance of this Cooperative Agreement.

Recipient's Responsibilities. The Recipient is responsible for:

- Performing the activities supported by this award in accordance with the Project Management Plan, including providing the required personnel, facilities, equipment, supplies and services;
- Managing and controlling project activities in accordance with established processes and procedures to ensure tasks and subtasks are completed within schedule and budget constraints defined by the current Project Management Plan;
- Implementing an approach to identify, analyze, and respond to project risks that is commensurate with the complexity of the project;
- Defining and revising approaches and plans, submitting the plans to DOE for review, and incorporating DOE comments;
- As applicable, coordinating related project activities with subrecipients and external suppliers, including contractors, to ensure effective integration of all work elements;
- Attending annual project review meetings and reporting project status;
- Participating in peer review evaluations of the project, or peer review evaluations of the program that their project supports;
- Submitting technical reports and publicly releasable documents that incorporate DOE comments; and
- Presenting the project results at appropriate technical conferences or meetings as directed by the DOE Project Officer.

DOE Responsibilities. DOE has the right to intervene in the conduct or performance of project activities for programmatic reasons. Intervention includes the interruption or modification of the conduct or performance of project activities. Suspension or termination of the cooperative agreement under 2 CFR part 200, as amended by 2 CFR part 910 (DOE Financial Assistance Regulations) does not constitute intervention in the conduct or performance of project activities.

DOE is responsible for:

- Reviewing in a timely manner project plans, including project management, testing and technology transfer plans, and

recommending alternate approaches, if the plans do not address critical programmatic issues;

- Participating in project management planning activities, including risk analysis, to ensure DOE's program requirements or limitations are considered in performance of the work elements;
- Conducting annual project review meetings to ensure adequate progress and that the work accomplishes the program and project objectives. Recommending alternate approaches or shifting work emphasis, if needed;
- Providing substantial involvement to ensure that project results address critical system and programmatic goals established by DOE Offices, such as the Office of Fossil Energy and Carbon Management and other offices (listed on page 9 of this FOA), in coordination with DOE's Carbon Dioxide Removal Program;
- Promoting and facilitating technology transfer activities, including disseminating program results through presentations and publications;
- Serving as scientific/technical liaison between awardees and other program or industry staff; and
- Reviewing and concurring with ongoing technical performance to ensure that adequate progress has been obtained within the current Budget Period authorized by DOE before work can commence on subsequent Budget Periods.

viii. Environmental Review in Accordance with National Environmental Policy Act (NEPA)

DOE's decision whether and how to distribute federal funds under this FOA is subject to the National Environmental Policy Act (42 USC 4321, *et seq.*). NEPA requires Federal agencies to integrate environmental values into their decision-making processes by considering the potential environmental impacts of their proposed actions. For additional background on NEPA, please see DOE's NEPA website, at http://nepa.energy.gov/.

While NEPA compliance is a Federal agency responsibility and the ultimate decisions remain with the Federal agency, all recipients selected for an award will be required to assist in the timely and effective completion of the NEPA process in the manner most pertinent to their proposed project. If DOE determines certain records must be prepared to complete the NEPA review process (e.g., biological evaluations or environmental assessments), the recipient may be required to prepare the records and the costs to prepare the necessary records may be included as part of the project costs.

ix. Conference Spending

The recipient shall not expend **any** funds on a conference not directly and programmatically related to the purpose for which the grant or cooperative agreement was awarded that would defray the cost to the United States Government of a conference held by any Executive branch department, agency, board, commission, or office for which the cost to the United States Government would otherwise exceed $20,000, thereby circumventing the required notification by the head of any such Executive Branch department, agency, board, commission, or office to the Inspector General (or senior ethics official for any entity without an Inspector General), of the date, location, and number of employees attending such conference.

x. Indemnity

Awards resulting from this FOA will contain the following provision reminding Recipients of DOE's rights of indemnification.

The Recipient shall indemnify the Government and its officers, agents, or employees for any and all liability, including litigation expenses and attorneys' fees, arising from suits, actions, or claims of any character for death, bodily injury, or loss of or damage to property or to the environment, resulting from the project, except to the extent that such liability results from the direct fault or negligence of Government officers, agents or employees, or to the extent such liability may be covered by applicable allowable costs provisions.

xi. Go/No-Go Review

Each project selected under this FOA will be subject to a periodic project evaluation referred to as a Go/No-Go Review. At the Go/No-Go decision points, DOE will evaluate project performance, project schedule adherence, meeting milestone objectives, compliance with reporting requirements, and overall contribution to the DOE program goals and objectives. Federal funding beyond the Go/No Go decision point (continuation funding), is contingent on (1) the availability of funds appropriated by Congress for the purpose of this program; (2) the availability of future-year budget authority; (3) recipient's technical progress compared to the Milestone Summary Table stated in Attachment 1 of the award; (4) recipient's submission of required reports; (5) recipient's compliance with the terms and conditions of the award; (6) DOE's Go/No-Go decision; (7) the recipient's submission of a continuation application; and (8) written approval of the continuation application by the Contracting Officer.

As a result of the Go/No Go Review, DOE may, at its discretion, authorize the following actions: (1) continue to fund the project, contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority; (2) recommend redirection of work under the project; (3) place a hold on federal funding for the project, pending further supporting data or funding; or (4) discontinue funding the project because of insufficient progress, change in strategic direction, or lack of funding.

The Go/No-Go decision is distinct from a non-compliance determination. In the event a recipient fails to comply with the requirements of an award, DOE may take appropriate action, including but not limited to, redirecting, suspending or terminating the award.

xii. Interim Conflict of Interest Policy for Financial Assistance

The DOE interim Conflict of Interest Policy for Financial Assistance (COI Policy)[25] is applicable to all non-Federal entities applying for, or that receive, DOE funding by means of a financial assistance award (e.g., a grant, cooperative agreement, or technology investment agreement) and, through the implementation of this policy by the entity, to each Investigator who is planning to participate in, or is participating in, the project funded wholly or in part under the DOE financial assistance award. The term "Investigator" means the PI and any other person, regardless of title or position, who is responsible for the purpose, design, conduct, or reporting of a project funded by DOE or proposed for funding by DOE. Recipients must flow down the requirements of the interim COI Policy to any subrecipient non-Federal entities. Further, for DOE funded projects, the recipient must include all financial conflicts of interest (FCOI) (i.e., managed and unmanaged/ unmanageable) in their initial and ongoing FCOI reports.

It is understood that non-Federal entities and individuals receiving DOE financial assistance awards will need sufficient time to come into full compliance with DOE's interim COI Policy. To provide some flexibility, DOE allows for a staggered implementation. **Specifically, prior to award, applicants selected for award negotiations must: ensure all Investigators complete their significant financial disclosures; review the disclosures; determine whether a FCOI exists; develop and implement a management plan for FCOIs; and provide DOE with an initial FCOI report that includes all FCOIs (i.e., managed and unmanaged/ unmanageable).**

[25] DOE's interim COI Policy can be found at: Department of Energy Interim Conflict of Interest Policy Requirements for Financial Assistance | Department of Energy.

Recipients will have 180 days from the date of the award to come into full compliance with the other requirements set forth in DOE's interim COI Policy. **Prior to award, the applicant must certify that it is, or will be within 180 days of the award, compliant with all requirements in the interim COI Policy.**

xiii. Participants and Collaborating Organizations

If selected for award negotiations, the selected applicant must submit a list of personnel who are proposed to work on the project, both at the recipient and subrecipient level and a list of proposed collaborating organizations within 30 days after the applicant is notified of the selection. Recipients will have an ongoing responsibility to notify DOE of changes to the personnel and collaborating organizations, and submit updated information during the life of the award.

xiv. Current and Pending Support

If selected for award negotiations, within 30 days of the selection notice, the selectee must submit 1) current and pending support disclosures and resumes for any new PIs or senior/key personnel and 2) updated disclosures if there have been any changes to the current and pending support submitted with the application. Throughout the life of the award, the Recipient has an ongoing responsibility to submit 1) current and pending support disclosure statements and resumes for any new PI and senior/key personnel and 2) updated disclosures if there are changes to the current and pending support previously submitted to DOE. Also See Section IV, "Application and Submission Information; Current and Pending Support".

xv. Fraud, Waste and Abuse (April 2023)

The mission of the DOE Office of Inspector General (OIG) is to strengthen the integrity, economy and efficiency of the Department's programs and operations including deterring and detecting fraud, waste, abuse and mismanagement. The OIG accomplishes this mission primarily through investigations, audits, and inspections of DOE activities to include grants, cooperative agreements, loans, and contracts.

The OIG maintains a Hotline for reporting allegations of fraud, waste, abuse, or mismanagement. To report such allegations, please visit https://www.energy.gov/ig/ig-hotline.

Additionally, recipients of DOE awards must be cognizant of the requirements of 2 CFR § 200.113 Mandatory disclosures:

> The non-Federal entity or applicant for a Federal award must disclose, in a timely manner, in writing to the Federal awarding agency or pass-through entity all violations of Federal criminal law involving fraud, bribery, or gratuity violations potentially affecting the Federal award. Non-Federal entities that have received a Federal award including the term and condition outlined in Appendix XII of 2 CFR Part 200 are required to report certain civil, criminal, or administrative proceedings to SAM. Failure to make required disclosures can result in any of the remedies described in § 200.339. (See also 2 CFR part 180, 31 U.S.C. 3321, and 41 U.S.C. 2313.) [85 FR 49539, Aug. 13, 2020]

Applicants and subrecipients (if applicable) are encouraged to allocate sufficient costs in the project budget to cover the costs associated for personnel and data infrastructure needs to support performance management and program evaluation needs including but not limited to independent program and project audits to mitigate risks for fraud, waste, and abuse.

xvi. Human Subjects Research (April 2023)

Research involving human subjects, biospecimens, or identifiable private information conducted with DOE funding is subject to the requirements of DOE Order 443.1C, Protection of Human Research Subjects, 45 CFR Part 46, Protection of Human Subjects (subpart A which is referred to as the "Common Rule"), and 10 CFR Part 745, Protection of Human Subjects. Additional information on the DOE Human Subjects Research Program can be found at: https://science.osti.gov/ber/human-subjects.

xvii. Real Property and Equipment

Real property and equipment purchased with project funds (federal share and recipient cost share) are subject to the requirements at 2 CFR 200.310, 200.311, 200.313, and 200.316 (non-Federal entities, except for-profit entities) and 2 CFR 910.360 (for-profit entities). For projects selected for award under this FOA, the recipient may (1) take disposition action on the real property and equipment; or (2) continue to use the real property and equipment after the conclusion of the award period of performance, with Contracting Officer approval.

The recipient's written Request for Continued Use must identify the property and include: a summary of how the property will be used (must align with the authorized project purposes); a proposed use period, (e.g., perpetuity, until fully depreciated, or a calendar date where the recipient expects to submit disposition instructions); acknowledgement that the recipient shall not sell or encumber the property or permit any encumbrance without prior written DOE approval; current fair market value of the property; and an Estimated Useful Life or depreciation schedule for equipment.

When the property is no longer needed for authorized project purposes, the recipient must request disposition instructions from DOE. For-profit entity disposition requirements are set forth at 2 CFR 910.360. Property disposition requirements for other non-federal entities are set forth in 2 CFR 310-200.316.

C. Reporting

i. Reporting Requirements

Reporting requirements are identified on the Federal Assistance Reporting Checklist and Instructions, DOE F 4600.2, attached to the award agreement. A sample checklist is available at: https://www.netl.doe.gov/sites/default/files/netl-file/4600.2-FE.pdf.

ii. Subaward and Executive Reporting

Prime Recipients awarded a new Federal financial assistance award greater than or equal to $30,000 as of October 1, 2010 are subject to Federal Funding and Transparency Act of 2006 (FFATA) sub-award reporting requirements as outlined in 2 CFR Chapter 1, Part 170 REPORTING SUB-AWARD AND EXECUTIVE COMPENSATION INFORMATION.

The FFATA Subaward Reporting System (FSRS) is the reporting tool Federal prime awardees (i.e. prime contractors and prime grants recipients) use to capture and report subaward and executive compensation data regarding their first-tier subawards to meet the FFATA reporting requirements. Prime awardees must register with the new FSRS database and report the required data on their first tier subawardees/subrecipient at https://www.fsrs.gov.

Prime awardees must report the executive compensation for their own executives as part of their registration profile in the System for Award Management (SAM). The sub-award information entered in FSRS will then

be displayed on https://www.usaspending.gov/ associated with the prime award furthering Federal spending transparency.

Applicants must ensure they have the necessary processes and systems in place to comply with the reporting requirements should they receive funding.

D. Applicant Representations and Certifications

i. Lobbying Restrictions

By accepting funds under this award, the Prime Recipient agrees that none of the funds obligated on the award shall be expended, directly or indirectly, to influence Congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. §1913. This restriction is in addition to those prescribed elsewhere in statute and regulation.

ii. Nondisclosure and Confidentiality Agreements Representations

In submitting an application in response to this FOA the applicant represents that:

It **does not and will not** require its employees or contractors to sign internal nondisclosure or confidentiality agreements or statements prohibiting or otherwise restricting its employees or contactors from lawfully reporting waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.

It **does not and will not** use any Federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:

1) ‘‘These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling

Executive orders and statutory provisions are incorporated into this agreement and are controlling.''

The limitation above shall not contravene requirements applicable to Standard Form 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

2) Notwithstanding the provision listed in paragraph (a), a nondisclosure or confidentiality policy form or agreement that is to be executed by a person connected with the conduct of an intelligence or intelligence-related activity, other than an employee or officer of the United States Government, may contain provisions appropriate to the particular activity for which such document is to be used. Such form or agreement shall, at a minimum, require that the person will not disclose any classified information received in the course of such activity unless specifically authorized to do so by the United States Government. Such nondisclosure or confidentiality forms shall also make it clear that they do not bar disclosures to Congress, or to an authorized official of an executive agency or the Department of Justice, that are essential to reporting a substantial violation of law.

iii. Corporate Felony Convictions and Tax Liabilities Representations (March 2014)

In submitting an application in response to this FOA the Applicant represents that:

(1) It is **not** a corporation that has been convicted of a felony criminal violation under any Federal law within the preceding 24 months; and

(2) It is **not** a corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

For purposes of these representations the following definition applies:

A Corporation includes any entity that has filed articles of incorporation in any of the 50 states, the District of Columbia, or the various territories of the United States [but not foreign corporations]. It includes both for-profit and non-profit organizations.

VI. Questions/Agency Contacts

A. Questions

Questions regarding the **content of the funding opportunity announcement** must be submitted through the FedConnect portal. You must register with FedConnect to respond as an interested party to submit questions, and to view responses to questions. It is recommended that you register as soon after release of the FOA as possible to have the benefit of all responses. Applicants are encouraged to review previously issued Questions and Answers prior to the submission of questions. DOE/NNSA will try to respond to a question within 3 business days, unless a similar question and answer have already been posted on the website.

Questions and comments concerning this FOA shall be submitted not later than **3** business days prior to the application due date. Questions submitted after that date may not allow the Government sufficient time to respond.

Questions relating to the **registration process, system requirements, how an application form works**, or the submission process must be directed to Grants.gov at 1-800-518-4726 or support@grants.gov. DOE/NNSA cannot answer these questions.

B. Agency Contact

Name: John Hatfield
E-mail: John.Hatfield@netl.doe.gov

VII. Other Information

A. Modifications

Notices of any modifications to this FOA will be posted on Grants.gov and the FedConnect portal. You can receive an email when a modification or an announcement message is posted by registering with FedConnect as an interested party for this FOA. It is recommended that you register as soon after release of the FOA as possible to ensure you receive timely notice of any modifications or other announcements.

B. Government Right to Reject or Negotiate

DOE reserves the right, without qualification, to reject any or all applications received in response to this FOA and to select any application, in whole or in part, as a basis for negotiation and/or award.

C. Commitment of Public Funds

The Contracting Officer is the only individual who can make awards or commit the Government to the expenditure of public funds. A commitment by anyone other than the Contracting Officer, either express or implied, is invalid.

Funding for all awards and future budget periods are contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority.

D. Treatment of Application Information (April 2023)

Applicants should not include trade secret or business sensitive, proprietary, or otherwise confidential information in their application unless such information is necessary to convey an understanding of the proposed project or to comply with a requirement in the FOA. Applicants are advised to not include any critically sensitive proprietary detail.

If an application includes trade secret or business sensitive, proprietary, or otherwise confidential information, it is furnished to the Federal Government in confidence with the understanding that the information shall be used or disclosed only for evaluation of the application. Such information will be withheld from public disclosure to the extent permitted by law, including the Freedom of Information Act. Without assuming any liability for inadvertent disclosure, DOE will seek to limit disclosure of such information to its employees and to outside

reviewers when necessary for merit review of the application or as otherwise authorized by law. This restriction does not limit the Government's right to use the information if it is obtained from another source.

If an applicant chooses to submit business sensitive, trade secrets, proprietary, or otherwise confidential information, the applicant must provide **two copies** of the submission (e.g., Concept Paper, Full Application). The first copy should be marked "non-confidential" with the information believed to be confidential deleted. The second copy should be marked "confidential" and must clearly and conspicuously identify the business sensitive, trade secrets, proprietary, or otherwise confidential information and must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The Government is not liable for the disclosure or use of unmarked information and may use or disclose such information for any purpose as authorized by law.

The cover sheet of the full application, and other applicant submission must be marked as follows and identify the specific pages business sensitive, trade secrets, proprietary, or otherwise confidential information:

> **Notice of Restriction on Disclosure and Use of Data**:
> Pages [**list applicable pages**] of this document may contain business sensitive, trade secrets, proprietary, or otherwise confidential information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes or in accordance with a financial assistance between the submitter and the Government. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source. [End of Notice]

In addition, (1) the header and footer of every page that contains business sensitive, trade secrets, proprietary, or otherwise confidential information must be marked as follows: "Contains Business Sensitive, Trade Secrets, Proprietary, Otherwise Confidential Information Exempt from Public Disclosure," and (2) every line or paragraph containing such information must be clearly marked with double brackets or highlighting. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

E. Evaluation and Administration by Non-Federal Personnel

In conducting the merit review, the Government may seek the advice of qualified non-Federal personnel as reviewers. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The applicant, by submitting its application, consents to the use of non-Federal

reviewers/administrators. Non-Federal reviewers must sign conflict of interest and non-disclosure agreements prior to reviewing an application. Non-Federal personnel conducting administrative activities must sign a non-disclosure agreement.

F. Intellectual Property Developed Under This Program (September 2021)

Patent Rights: The government will have certain statutory rights in an invention that is conceived or first actually reduced to practice under a DOE award. 42 U.S.C. 5908 provides that title to such inventions vests in the United States, except where 35 U.S.C. 202 provides otherwise for nonprofit organizations or small business firms. However, the Secretary of Energy may waive all or any part of the rights of the United States subject to certain conditions.

Class Patent Waiver: Pursuant to 10 CFR Part 784, the DOE has issued a class patent waiver that applies to this FOA. Under this class waiver, any domestic entity other than a domestic small business firm or domestic nonprofit organization may elect title to their subject inventions similar to the right provided to domestic small business firms and domestic nonprofit organization by law (see below). In order to avail itself of the class waiver, such an entity must agree, among other things, that any products embodying or produced through the use of a subject invention (first created or reduced to practice under this program) will be substantially manufactured in the United States, unless DOE agrees otherwise.

Right to Request Patent Waiver: If a selected entity does not qualify for the class patent waiver, a selected entity may request an advance waiver of all or any part of the rights of the United States in inventions conceived or first actually reduced to practice in performance of an agreement as a result of this announcement, in advance of or within 30 days after the effective date of the award. Even if such advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver of the rights of the United States in identified inventions, i.e., individual inventions conceived or first actually reduced to practice in performance of the award. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784 see https://www.energy.gov/gc/services/technology-transfer-and-procurement/office-assistant-general-counsel-technology-transf-1 for further information.

Domestic small businesses and domestic nonprofit organizations: Domestic small businesses and domestic nonprofit organizations will receive the patent rights clause at 37 CFR 401.14, i.e., the implementation of the Bayh-Dole Act. This clause permits domestic small business and domestic nonprofit organizations to retain title to

subject inventions. Therefore, small businesses and nonprofit organizations do not need to request a patent waiver.

- DEC: On June 07, 2021, DOE approved a DETERMINATION OF EXCEPTIONAL CIRCUMSTANCES (DEC) UNDER THE BAYH-DOLE ACT TO FURTHER PROMOTE DOMESTIC MANUFACTURE OF DOE SCIENCE AND ENERGY TECHNOLOGIES. In accordance with this DEC, all awards, including sub-awards, under this FOA shall include the U.S. Competitiveness Provision in accordance with Section IV, "Application and Submission Information; U.S. Competitiveness" of this FOA. A copy of the DEC can be found at https://www.energy.gov/gc/determination-exceptional-circumstances-decs.
- Pursuant to 37 CFR § 401.4, any nonprofit organization or small business firm as defined by 35 U.S.C. 201 affected by any DEC has the right to appeal it by providing written notice to DOE within 30 working days from the time it receives a copy of the determination.
- DOE may issue and publish on the website above further DECs prior to the issuance of awards under this FOA. DOE may require additional submissions or requirements as authorized by any applicable DEC.

G. Government Rights in Subject Inventions

Government Use License
The United States government retains a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States any subject invention throughout the world. This license extends to contractors doing work on behalf of the government.

March-In Rights
The United States government retains march-in rights with respect to all subject inventions. Through "march-in rights," the government may require a prime recipient or subrecipient who has elected to retain title to a subject invention (or their assignees or exclusive licensees), to grant a license for use of the invention to a third party. In addition, the government may grant licenses for use of the subject invention when a prime recipient, subrecipient, or their assignees and exclusive licensees refuse to do so.

DOE may exercise its march-in rights only if it determines that such action is necessary under any of the four following conditions:

- The owner or licensee has not taken or is not expected to take effective steps to achieve practical application of the invention within a reasonable time;
- The owner or licensee has not taken action to alleviate health or safety needs in a reasonably satisfied manner;

- The owner has not met public use requirements specified by federal statutes in a reasonably satisfied manner; or
- The United States manufacturing requirement has not been met.

Any determination that march-in rights are warranted must follow a fact-finding process in which the recipient has certain rights to present evidence and witnesses, confront witnesses and appear with counsel and appeal any adverse decision. To date, DOE has never exercised its march-in rights to any subject inventions.

Rights in Technical Data: Normally, the government has unlimited rights in technical data created under a DOE agreement. Delivery or third-party licensing of proprietary software or data developed solely at private expense will not normally be required except as specifically negotiated in a particular agreement to satisfy DOE's own needs or to ensure the commercialization of technology developed under a DOE agreement.

H. Program Covered Under Special Protected Data Statute (December 2014)

This program is covered by a special protected data statute. The provisions of the statute provide for the protection from public disclosure, for a period of ***up to 5 years*** from the date of the development of data that would be trade secret, or commercial or financial information that is privileged or confidential, if the information had been obtained from a non-Federal party. Generally, the provision entitled, Rights in Data--Programs Covered Under Special Protected Data Statutes (Item 4 under 2 CFR 910 Appendix A to Subpart D), would apply to an award made under this announcement. This provision will identify data or categories of data first produced in the performance of the award that will be made available to the public, notwithstanding the statutory authority to withhold data from public dissemination and will also identify data that will be recognized by the parties as protected data. Any entity receiving an award or subaward under this announcement has the right to opt out of such data protection.

I. Subject Invention Utilization Reporting

To ensure that prime recipients and subrecipients holding title to subject inventions are taking the appropriate steps to commercialize subject inventions, DOE may require that each prime recipient holding title to a subject invention submit annual reports for ten (10) years from the date the subject invention was disclosed to DOE on the utilization of the subject invention and efforts made by prime recipient or their licensees or assignees to stimulate such utilization. The reports must include

information regarding the status of development, date of first commercial sale or use, gross royalties received by the prime recipient, and such other data and information as DOE may specify.

J. Copyright

The prime recipient and subrecipients may assert copyright in copyrightable works, such as software, first produced under the award without DOE approval. When copyright is asserted, the government retains a paid-up nonexclusive, irrevocable worldwide license to reproduce, prepare derivative works, distribute copies to the public, and to perform publicly and display publicly the copyrighted work. This license extends to contractors and others doing work on behalf of the government.

K. Energy Data eXchange (EDX) Requirements (December 2022)

The DOE is required to improve access to federally funded research results, proper archiving of digital data, and expanded discovery and reuse of research datasets per DOE and Executive Orders. The Energy Data eXchange (EDX) is a data laboratory developed and maintained by NETL to find, connect, curate, use, and re-use data to advance fossil energy and environmental research and development (R&D).

Data products generated under the resulting award will be required to be submitted in the EDX at https://edx.netl.doe.gov/. Data products include but are not limited to software code, tools, applications, webpages, portfolios, images, videos, and datasets.

EDX uses federation and web services to elevate visibility for publicly approved assets in the system, including connections with DOE's Office of Scientific and Technical Information (OSTI) systems, Data.gov, and Re3Data. This ensures compliance with federal requirements, while raising visibility for researcher's published data products to promote discoverability and reuse.

EDX supports a wide variety of file types and formats including: 1) data, 2) metadata, 3) software/tools, and 4) articles (provided that there is an accompanying Government use license). A partial list of file formats accepted by EDX is provided below, however, EDX is designed for flexibility and accepts all types of file formats.

- Common Data Product Submission Formats: ASC, AmiraMesh, AVI, CAD, CSV, DAT, DBF, DOC, DSV, DWG, GIF, HDF, HTML, JPEG2000, JPG, MOV, MPEG4, MSH/CAS/DAT, NetCDF, PDF, PNG, PostScript, PPT, RTF, Surface, TAB, TIFF, TIFF Stacks, TXT, XLS, SML, Xradio, ZIP, and others.

- Geographic Formats: APR, DBF, DEM, DLG, DRG, DXF, E00, ECW, GDB, GeoPDF, GeoTIFF, GML, GPX, GRID, IMG, KML, KMZ, MOB, MrSID, SHP, and others.

Information provided to EDX will be made publicly available, unless authorized under the resulting award. Additional information on EDX is available at https://edx.netl.doe.gov/about.

When data products are submitted to EDX, the data product will need to be registered with a digital object identifier (DOI) through OSTI to ensure more visibility in other search repositories (i.e., osti.gov, data.gov, Google Scholar, etc.). The OSTI DOI can be established through an application programming interface (API) by completing just a few additional fields.
The Recipient or subrecipient should coordinate with the Project Manager on an annual basis to assess if there is data that should be submitted to EDX and identify the proper file formats prior to submission. All final data products shall be submitted to EDX by the Recipient prior to the completion of the project.

L. Notice Regarding Eligible/Ineligible Activities

Eligible activities under this program include those which describe and promote the understanding of scientific and technical aspects of specific energy technologies, but not those which encourage or support political activities such as the collection and dissemination of information related to potential, planned or pending legislation.

M. Notice of Right to Conduct a Review of Financial Capability

DOE reserves the right to conduct an independent third-party review of financial capability for applicants that are selected for negotiation of award (including personal credit information of principal(s) of a small business if there is insufficient information to determine financial capability of the organization).

N. Notice of Potential Disclosure Under Freedom of Information Act (FOIA)

Applicants should be advised that identifying information regarding all applicants, including applicant names and/or points of contact, may be subject to public disclosure under the Freedom of Information Act, whether or not such applicants are selected for negotiation of award.

O. Requirement for Full and Complete Disclosure

Applicants are required to make a full and complete disclosure of all information requested. Any failure to make a full and complete disclosure of the requested information may result in:

- The termination of award negotiations;
- The modification, suspension, and/or termination of a funding agreement;
- The initiation of debarment proceedings, debarment, and/or a declaration of ineligibility for receipt of Federal contracts, subcontracts, and financial assistance and benefits; and
- Civil and/or criminal penalties.

P. Retention of Submissions

DOE expects to retain copies of all submissions. No submissions will be returned. By applying to DOE for funding, applicants consent to DOE's retention of their submissions.

Q. Protected Personally Identifiable Information

In responding to this FOA, applicants must ensure that Protected Personally Identifiable Information (PII) is not included in the application documents. These documents will be used by the Merit Review Committee in the review process to evaluate each application. PII is defined by the Office of Management and Budget (OMB) as:

Any information about an individual maintained by an agency, including but not limited to, education, financial transactions, medical history, and criminal or employment history and information that can be used to distinguish or trace an individual's identity, such as their name, social security number, date and place of birth, mother's maiden name, biometric records, etc., including any other personal information that is linked or linkable to an individual.

This definition of PII can be further defined as: (1) Public PII and (2) Protected PII.

1. Public PII: PII found in public sources such as telephone books, public websites, business cards, university listing, etc. Public PII includes first and last name, address, work telephone number, email address, home telephone number, and general education credentials.

2. Protected PII: PII that requires enhanced protection. This information includes data that if compromised could cause harm to an individual such as identity theft.

Listed below are examples of Protected PII that applicants must not include in the application files listed above to be evaluated by the Merit Review Committee. This list is not all inclusive.

- Social Security Numbers in any form
- Place of Birth associated with an individual
- Date of Birth associated with an individual
- Mother's maiden name associated with an individual
- Biometric record associated with an individual
- Fingerprint
- Iris scan
- DNA
- Medical history information associated with an individual
- Medical conditions, including history of disease
- Metric information, e.g. weight, height, blood pressure
- Criminal history associated with an individual
- Employment history and other employment information associated with an individual
- Ratings
- Disciplinary actions
- Performance elements and standards (or work expectations) are PII when they are so intertwined with performance appraisals that their disclosure would reveal an individual's performance appraisal
- Financial information associated with an individual
- Credit card numbers
- Bank account numbers
- Security clearance history or related information (not including actual clearances held)

R. Annual Compliance Audits

If an institution of higher education, non-profit organization, or state/local government is a Prime Recipient or Subrecipient and has expended $750,000 or more of Federal funds during the non-Federal entity's fiscal year, then a single or program-specific audit is required. For additional information, please refer to 2 C.F.R. § 200.501 and Subpart F.

If a for-profit entity is a Prime Recipient and has expended $750,000 or more of DOE funds during the entity's fiscal year, an annual compliance audit performed by an

independent auditor is required. For additional information, please refer to 2 C.F.R. § 910.501 and Subpart F.

Applicants and subrecipients (if applicable) should propose sufficient costs in the project budget to cover the costs associated with the audit. DOE will share in the cost of the audit at its applicable cost share ratio.

S. Accounting System

If your application is selected for negotiation toward award, you should have an accounting system that meets government standards for recording and collecting costs. Reference 2 CFR 200 Subpart D for the applicable standards. If you have not had prior government awards or a recent accounting system review, DOE may request that the Defense Contract Audit Agency (DCAA) or an independent auditor verify that the accounting system is acceptable. A resulting award may contain a Term and Condition that prohibits DOE reimbursement until the system is deemed acceptable.

T. Indirect Rates

Potential recipients and major subrecipients will need to demonstrate how indirect rates are developed using an acceptable government methodology or current rate agreement. The Prime Recipient and major subrecipients may be subject to a DCAA or independent auditor indirect rate review if there has not been a certified rate audit within the previous twelve months. Additionally, annual indirect cost reconciliations are required, as applicable.

U. Prohibition on Certain Telecommunications and Video Surveillance Services or Equipment (April 2023)

As set forth in 2 CFR 200.216, recipients and subrecipients are prohibited from obligating or expending project funds (federal and recipient cost share) to procure or obtain; extend or renew a contract to procure or obtain; or enter into a contract (or extend or renew a contract) to procure or obtain equipment, services, or systems that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system. As described in Public Law 115-232, section 889, covered telecommunications equipment is telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities).

See Public Law 115-232, Section 889, 2 CFR 200.216, and 2 CFR 200.471 for additional information.

V. Prohibition Related to Foreign Government-Sponsored Talent Recruitment Programs (April 2023)

i. Prohibition

Persons participating in a Foreign Government-Sponsored Talent Recruitment Program of a Foreign Country of Risk are prohibited from participating in projects selected for Federal funding under this FOA. Should an award result from this FOA, the recipient must exercise ongoing due diligence to reasonably ensure that no individuals participating on the DOE-funded project are participating in a Foreign Government-Sponsored Talent Recruitment Program of a Foreign Country of Risk. Consequences for violations of this prohibition will be determined according to applicable law, regulations, and policy. Further, the recipient must notify DOE within five (5) business days upon learning that an individual on the project team is or is believed to be participating in a foreign government talent recruitment program of a foreign country of risk. DOE may modify and add requirements related to this prohibition to the extent required by law.

ii. Definitions

1) **Foreign Government-Sponsored Talent Recruitment Program**. An effort directly or indirectly organized, managed, or funded by a foreign government, or a foreign government instrumentality or entity, to recruit science and technology professionals or students (regardless of citizenship or national origin, or whether having a full-time or part-time position). Some foreign government-sponsored talent recruitment programs operate with the intent to import or otherwise acquire from abroad, sometimes through illicit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government. Many, but not all, programs aim to incentivize the targeted individual to relocate physically to the foreign state for the above purpose. Some programs allow for or encourage continued employment at U.S. research facilities or receipt of Federal research funds while concurrently working at and/or receiving compensation from a foreign institution, and some direct participants not to disclose their participation to U.S. entities. Compensation could take many forms including cash, research funding, complimentary foreign travel, honorific titles, career advancement opportunities, promised future compensation, or other types of remuneration or consideration, including in-kind compensation.

2) **Foreign Country of Risk**. DOE has designated the following countries as foreign countries of risk: Iran, North Korea, Russia, and China. This list is subject to change.

W. Implementation of Executive Order 13798, Promoting Free Speech and Religious Liberty (November 2020)

States, local governments, or other public entities may not condition sub-awards in a manner that would discriminate, or disadvantage subrecipients based on their religious character.

X. Affirmative Action and Pay Transparency Requirements

All applicants must comply with all applicable federal labor and employment laws, including but not limited to Title VII of the Civil Rights Act of 1964, the Fair Labor Standards Act, the Occupational Safety and Health Act, and the National Labor Relations Act, which protects employees' right to bargain collectively and engage in concerted activities for the purpose of workers' mutual aid or protection.

All federally assisted construction contracts exceeding $10,000 annually will be subject to the requirements of Executive Order 11246:

(1) Recipients, subrecipients, contractors, and subcontractors are prohibited from discriminating in employment decisions on the basis of race, color, religion, sex, sexual orientation, gender identity, or national origin.

(2) Recipients and contractors are required to take affirmative action to ensure that equal opportunity is provided in all aspects of their employment. This includes flowing down the appropriate language to all subrecipients, contractors, and subcontractors.

(3) Recipients, subrecipients, contractors, and subcontractors are prohibited from taking adverse employment actions against applicants and employees for asking about, discussing, or sharing information about their pay or, under certain circumstances, the pay of their co-workers.

DOL's Office of Federal Contractor Compliance Programs (OFCCP) uses a neutral process to schedule compliance evaluations. Consult OFCCP's Technical Assistance Guide[26] to gain an understanding of the requirements and possible

[26] See OFCCP's Technical Assistance Guide at: https://www.dol.gov/sites/dolgov/files/ofccp/Construction/files/ConstructionTAG.pdf?msclkid=9e39

actions the recipients, subrecipients, contractors, and subcontractors must take. Additional guidance may also be found in the National Policy Assurances, produced by DOE.

Y. Foreign Collaboration Considerations

a. Consideration of new collaborations with foreign entities and governments. The recipient will be required to provide DOE with advanced written notification of any potential collaboration with foreign entities or governments in connection with its DOE-funded award scope. The recipient will then be required to await further guidance from DOE prior to contacting the proposed foreign entity or government regarding the potential collaboration or negotiating the terms of any potential agreement.

b. Existing collaborations with foreign entities and governments. The recipient will be required to provide DOE with a written list of all existing foreign collaborations in which has entered in connection with its DOE-funded award scope.

c. Description of collaborations that should be reported. In general, a collaboration will involve some provision of a thing of value to, or from, the recipient. A thing of value includes but may not be limited to all resources made available to, or from, the recipient in support of and/or related to the DOE award, regardless of whether or not they have monetary value. Things of value also may include in-kind contributions (such as office/laboratory space, data, equipment, supplies, employees, students). In-kind contributions not intended for direct use on the DOE award but resulting in provision of a thing of value from or to the DOE award must also be reported. Collaborations do not include routine workshops, conferences, use of the recipient's services and facilities by foreign investigators resulting from its standard published process for evaluating requests for access, or the routine use of foreign facilities by awardee staff in accordance with the recipient's standard policies and procedures.

7d68c4b111ec9d8e6fecb6c710ec Also see the National Policy Assurances http://www.nsf.gov/awards/managing/rtc.jsp

VIII. Appendices

Appendix A – R&D Community Benefits Plan Guidance

The DOE is committed to pushing the frontiers of science and engineering; catalyzing high-quality domestic clean energy jobs through research, development, demonstration, and deployment; and ensuring energy equity and energy justice[27] for disadvantaged communities. Therefore, and in accordance with the Administration's priority to empower workers and harness opportunities to create good union jobs as stated in EO 14008 (Executive Order on Tackling the Climate Crisis at Home and Abroad)[28], it is important to consider the impacts of the successful commercial deployment of any innovations resulting from this FOA on the current and future workforce.

The goal of the R&D Community Benefits Plan is to allow the application to illustrate engagement in critical thought about implications of how the proposed work will benefit the American people and lead to broadly shared prosperity, including for workers and disadvantaged communities[29]. The three sections of the R&D Community Benefits Plans are considered together because there may be significant overlap among audiences considered in workforce and disadvantaged communities.

Example DEIA, Energy Equity, and Workforce Plan Elements

Outlined below are examples of activities that applicants might consider when developing their R&D Community Benefits Plan. Applicants are not required to implement any of these specific examples and should propose activities that best fits their research goals, institutional environment, team composition, and other factors. Creativity is encouraged.

DEIA

DOE strongly encourages applicants to involve individuals and entities from disadvantaged communities. Tapping all of the available talent requires intentional approaches and yields broad benefits.

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[27] DOE defines energy justice as "the goal of achieving equity in both the social and economic participation in the energy system, which also remediating social, economic, and health burdens on those disproportionately harmed by the energy system" (Initiative for Energy Justice, 2019). Aligned with that document refers to this as, 'energy equity,' and is meant to encompass energy justice as well as DOE's efforts related to Justice40. https://www.energy.gov/diversity/articles/how-energy-justice-presential-initiatives-and executive-orders-shape-equity

[28] https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad

[29] See footnote 2 for guidance on the definition and tools to locate and identify disadvantaged communities.

Equity extends beyond diversity to equitable treatment. Equitable access to opportunity for members of the project team is paramount. This includes ensuring that all members of the team, including students, are paid a living wage, provided appropriate working conditions, and provided appropriate benefits. In the execution of their project plan, applicants are asked to describe efforts in diversity, equity, inclusion, and accessibility. In this context, efforts toward DEIA are defined as:[30]

1) the practice of including the many communities, identities, races, ethnicities, backgrounds, abilities, cultures, and beliefs of the American people,
2) the consistent and systematic fair, just, and impartial treatment of all individuals, including protecting workers rights and adhering to Equal Employment Opportunity laws,
3) the recognition, appreciation, and use of the talents and skills of employees of all backgrounds, and
4) the provision of accommodations so that all people, including people with disabilities, can fully and independently access facilities, information, and communication technology, programs, and services.

Successful plans will not only describe how the project team seeks to increase DEIA, but will describe the overall approaches to retention, engagement, professional development, and career advancement. Specifically, they will demonstrate clear approaches to ensure all team members' strengths are meaningfully leveraged and all members are provided opportunities and paths for career development, especially including paths for interns and trainees to secure permanent positions. Diversity should be considered at all levels of the project team, not just leveraging early career individuals to meet diversity goals.

DOE strongly encourages applicants to consider partnerships to promote DEIA, justice, and workforce participation. Minority Serving Institutions, Minority Business Enterprises, Minority Owned Businesses, Disability Owned Business, Women Owned Business, Native American-owned Businesses, Veteran Owned Businesses, or entities located in an underserved community that meet the eligibility requirements are encouraged to lead these partnerships as the prime applicant or participate on an application as a proposed partner to the prime applicant.

When crafting the DEIA section of the Plan, applicants should describe how they will act to promote each of the four DEIA efforts above into their investigation. It is important to note that diversity, equity, inclusion, and accessibility are four different but related concepts that should not be conflated. For instance, you can achieve diversity without equity; all four must be addressed. Applicants could discuss how the proposed investigation could contribute to training and developing a diverse

[30] https://www.whitehouse.gov/wp-content/uploads/2021/11/Strategic-Plan-to-Advance-Diversity-Equity-Inclusion-and-Accessibility-in-the-Federal-Workforce-11.23.21.pdf

scientific workforce. Applicants could describe the efforts they plan to take or will continue to take, to create an inclusive workplace, free from retaliation, harassment, and discrimination. Applicants could outline any barriers to creating an equitable and inclusive workplace and address the ways in which the team will work to overcome these barriers within the bounds of the specific research project. This plan could detail specific efforts to inform project team members in any capacity of their labor rights and rights under Equal Employment Opportunity laws, and their free and fair chances to join a union. Note that this inclusion of informing project team members is also incorporated into awards through the National Policy Assurances.

Equal treatment of workers, including students, is necessary but overcoming institutional bias requires intentionally reducing sometimes hidden barriers to equal opportunity. Applicants could consider measures like childcare, flexible schedules, paid parental leave, pay transparency, and other supports to ensure that societal barriers are not hindering realization of DEIA intentions. Some of these considerations may result in common approaches in different sections of the plan, and that is acceptable, as long as the submission is not a singular approach to all sections.

DOE especially encourages applicants to form partnerships with divers and often underrepresented institutions, such as Minority Serving Institutions, labor unions, community colleges that otherwise meet the eligibility requirements.

Underrepresented institutions that meet the eligibility requirements are encouraged to lead these partnerships as the prime applicant. The DEIA section of the Plan could include engagement with underrepresented institutions to broaden the participation of disadvantaged communities and/or with local stakeholders, such as residents and businesses, entities that carry out workforce development programs, labor unions, local government, and community-based organizations that represent, support, or work with disadvantaged communities. Applicants should ensure there is transparency, accountability, and follow-through when engaging with community members and stakeholders.

Specific examples include:

- Building collaborations and partnerships with researchers and staff at Minority Serving Institutions
- Addressing barriers identified in climate surveys to remove inequities
- Providing anti-basis training and education in the project design and implementation teams
- Offering training, mentorship, education, and other support to students and early/mid-career professionals from disadvantaged communities
- Providing efforts toward improving a workplace culture of inclusion

- Developing technology and technology integration innovations to meet the needs of disadvantaged communities
- Creating partnerships with local communities, especially under-resourced and disadvantaged communities
- Voluntary recognition of a union and informing employees of their rights, regardless of their classification
- Making research products and engagement materials accessible in a greater variety of formats to increase accessibility of research outputs
- Implementing training or distributing materials to reduce stigma towards individuals with disabilities
- Designing technologies that strategically fit within the existing workforce for installation and maintenance of the potential innovation

Energy Equity

The Energy Equity section should articulate how project proposals will drive equitable access to, participation in, and distribution of the benefits produced from successful technology innovations to disadvantaged communities and groups. Intentional inclusion of energy equity requires evaluating the anticipated long-term costs and benefits that will accrue to disadvantaged groups as a result of the project, and how research questions and project plans are designed for and support historically disadvantaged communities' engagement in clean energy decisions. Similar to potential cost reductions or groundbreaking research findings resulting from the research, energy equity and justice benefits may be uncertain, occur over a long period of time, and have many factors within and outside the specific proposed research influencing them.

Applicants should describe the influencing factors, and the most likely energy equity implications of the proposed research. Applicants should describe any long-term constraints the proposed technology may pose to communities' access to natural resources and Tribal Cultural resources. There may be existing equity research available to use and citation in this description or the applicant could describe milestone-based efforts toward developing that understanding through this innovation. These near and long term outcomes may include, but are not limited to: a decrease in the percent of income a household spends on energy costs (energy burden[31]); an increase in access to low-cost capital; a decrease in environmental exposure and burdens; increases in clean energy enterprise creation and contracting (e.g., women or minority-owned business enterprises); increased parity in clean energy technology access and adoption; increases in energy democracy, including community ownership; and an increase in energy resilience.

[31] Energy burden in defined as the percentage of gross household income spent on energy costs: https://www.energy.gov/eere/slsc/low-income-community-energy-solutions

Specific examples include:

- Describing how successful innovation will support economic development in diverse geographic or demographic communities
- Creating a plan to engage equity and justice stakeholders in evaluation the broader impacts of the innovation or in the development of the research methodology
- Describe how the proposed research strategy and methodology was informed by input from a wide variety of stakeholders
- Creating a literature review of the equity and justice implications of the outcomes of the specific research if the innovation is successful, or a plan with dedicated budget and expertise (staffing or subawardee) to evaluate the potential equity implications of successful innovation outcomes.

Workforce

The Workforce section of the R&D Community Benefits Plan should articulate the future workforce implications of the innovation or a milestone-driven plan for understanding those implications. This includes documenting the skills, knowledge, and abilities that would be required of workers installing, maintaining, and operating the technology that may be derivative of the applicant's research, as well as the training pathways and their accessibility for workers to acquire the necessary skills. There may be field-specific or relevant existing research that could be cited in this section. In addition, applicants could detail the process they will use to evaluate long-term impacts on jobs, including job growth or job loss, a change in job quality, disruptions to existing industry and resulting changes to relationships between employers and employees and improvements or reductions in the ability of workers to organize for collective representation, and anything else that could result in changes to regional or national labor markets.

For additional support with developing the Workforce section of the R&D Community Benefits Plan, please refer to DOE's Community Benefits Plan Frequently Asked Questions (FAQs) webpage (https://www.energy.gov/bil/community-benefits-plan-frequently-asked-questions-faqs). This new resource, though created primarily for BIL-funded demonstration and deployment projects, may be useful for R&D projects.

Applicants will find section 2 of the FAQ ("Investing in America's Workforce") particularly helpful for understanding key federal policies, terms and concepts, as well as workforce development strategies relevant to examination of the workforce implications of applicant's proposed research.

Specific examples include:

- Outlining the challenges and opportunities for commercializing the technology in the US

- Creating a literature review of the workforce implications of the outcomes of the specific research if the innovation is successful or a plan with dedicated budget and expertise (staffing or subawardee) to evaluate the potential equity implications of successful innovation outcomes
- Creating a plan and milestones for assessing how a successful innovation will have implications for job savings for loss, either at the macroeconomic level or within specific industries
- Describing how the project will support workforce training to address needs of successful innovation
- Voluntary recognition of a union and informing employees of their rights, regardless of their classification
- Creating a plan to evaluate how a successful innovation will result in potential workforce shifts between industries or geographies

Inclusion of SMART milestones

DOE requires that the applicant's R&D Community Benefits Plan include on Specific, Measurable, Achievable, Relevant, and Timely (SMART) milestone for each budget period. An exemplar SMART milestone clearly answers the following questions:

- What needs to be accomplished?
- What measures and deliverables will be used to track progress toward accomplishment?
- What evidence suggests that the accomplishment is achievable?
- Why choose this milestone?
- When will the milestone be reached?

Appendix B – State Point Data Tables

APPLICANT REMINDER: State-Point Data Table(s) are required to be completed and submitted with your application.

***Instructions for completing data tables*:** The tables that follow in this attachment shall be populated with data provided by the applicant and included as part of an application's Scientific and Technical Merit section. Applicants proposing projects shall complete the appropriate combinations of Tables that relate to their proposed process concept. *Merit scoring of application will correspond to the completeness of the data table and supporting information.*

Key data or estimates provided in the table(s) shall be supported with short narratives in bullet form within the Scientific and Technical Merit section. These bullets shall describe the sources for the individual data provided. This may be measurements made directly by the applicant and shall identify the apparatus and methodology used in the measurement(s). Due to page limitations, citations may be utilized to describe the sources for the individual data provided by the applicant or others, or by example calculations for noncritical data. Other acceptable sources of data are the open literature (with citation and description), or estimated or extrapolated data (with description of method/model used for the estimate, or the procedure used for extrapolation). Arguments supported by theory/mechanisms shall be provided for projected performance for new, advanced solvent, sorbent, or membrane materials. If there are any differences between the gas stream(s) used for the prior scale technology development and the gas stream(s) to be used in the proposed project, applicants must discuss these differences and any potential impacts on the proposed project.

For **AOI-1,** Applicants are required to provide the demonstrated performance data for their BiCRS technology (Table B1). Additionally, Applicants that are capturing CO_2 from a gas stream are required to out the applicable table (Table B.2, B.3, or B.4) for the solvent, sorbent, or membrane CO_2 capture technology to be utilized in the BiCRS facility for relevant feed gas conditions.

For **AOI-2**, Applicants are required to provide the demonstrated performance data for their mineralization technology. Applicants shall prepare the State Point Data Table for air capture relevant flue gas conditions.

For **AOI-3**, Applicants are required to provide the demonstrated performance data for all technologies and technology types being considered for the test bed. Applicants shall prepare the State Point Data Table(s) that best represent their technology and facility capabilities being proposed. More than one table may be required depending on the technology(ies) being proposed.

Any adjustments to the tables should be explained in the related Project Narrative section. The choice of table used for the technology description should also be justified if adjustments are made.

Table B1. State-Point Data for BiCRS Systems

	Units	Measured/ Estimated Performance	Projected Performance
Biomass Source			
Biomass Category	-	e.g. Logging Residue, whole trees, crop residues, etc.	
Biomass type	-	e.g. Forest residue, hybrid poplar, corn stover, etc.	
% Carbon, Raw	% mass		
Pre-treatment method	-		
% Carbon, after pre-treatment	% mass		
BiCRS Technology			
Technology/CO_2 storage method.	-	e.g. pyrolysis with CCS, gasification with CCS, combustion with CCS, conversion, burial, sinking, bioliquid injection	
Products produced		e.g. hydrogen, grid electricity, liquid fuels, biochar, etc.	
Prior Testing			
Location	-		
Scale	tCO_2e removed/d		
Technology Readiness Level	-		
Hours of continuous operation	hrs.		
Total Energy Required	kJ/kg product		
Total Heat Energy Required	kJ/kg product		

Required Temperature of Thermal energy	°C		
Total Electricity Required	kWh/kg product		
Land Requirements	m^2 or acres		
Water requirements	Tonnes/yr or (gallons per minute)		

Table B2. State-Point Data for Solvent Based Systems

	Units	Measured/ Estimated Performance	Projected Performance
Pure Solvent			
Molecular Weight	mol^{-1}		
Standard Boiling Point	°C		
Standard Freezing Point	°C		
Vapor Pressure @ 15°C	bar		
Working Solution			
Concentration	kg/kg		
Specific Gravity (15 °C/15 °C)	-		
Specific Heat Capacity @ STP	kJ/kg·K		
Viscosity @ STP	cP		
Surface Tension @ STP	dyn/cm		
CO_2 Mass Transfer Rate [K_L]	m/s		
CO_2 Reaction Rate	-		
Thermal Conductivity	W/(m·K)		
Absorption			
Pressure	bar		
Temperature	°C		
Equilibrium CO_2 Loading	gmol CO_2/kg		
Heat of Absorption	kJ/kg CO_2		
Solution Viscosity	cP		
Desorption			
Pressure	bar		
Temperature	°C		
Equilibrium CO_2 Loading	gmol CO_2/kg		
Heat of Desorption	kJ/kg CO_2		
Prior Testing			
Location			
Scale	tCO_2/d		
CO_2 concentration in feed stream (e.g, flue gas, process stream)	%		
Hours of continuous operation	hrs		
CO_2 capture efficiency during longest test	%		
Solvent Make-up rate	%/yr.		

***Definitions for State-Point Data for Solvent Based Systems*:**
STP – Standard Temperature and Pressure (15 °C, 1 atm)
Pure Solvent – Agent(s), working alone or as a component of a working solution, responsible for enhanced CO_2 absorption. For example: the amine monoethanolamine (MEA) in an aqueous solution.
Working Solution – The solute-free (*i.e.,* CO_2-free) liquid solution used as the working solvent in the absorption/desorption process. For example: the liquid mixture of MEA and water.
Absorption – The conditions of interest for absorption are those that prevail at maximum solvent loading, which typically occurs at the bottom of the absorption column. Measured data are preferable to estimated data.
Desorption – The conditions of interest for desorption are those that prevail at minimum solvent loading, which typically occurs at the bottom of the desorption column. Operating pressure and temperature for the desorber/stripper are process dependent. Measured data are preferable to estimated data.
Pressure – The pressure of CO_2 in equilibrium with the solution. If the vapor phase is pure CO_2, this is the total pressure, and if it is a mixture of gases, this is the partial pressure of CO_2.
Concentration – Mass fraction of pure solvent in working solution.
Loading – The basis for CO_2 loading is moles of pure solvent.
Mass Transfer Rate – Overall liquid phase mass transfer coefficient.
CO_2 Reaction Rate – A characterization of the CO_2 absorption trend with respect to time, as complete in the range of time as possible.

Table B3. State-Point Data for Sorbent Based Systems

	Units	Measured Performance (Powder form)	Projected or Measured Performance (structured material system)
Sorbent			
True Density @ STP	kg/m^3		
Bulk Density	kg/m^3		
Average Particle Diameter	mm		
Particle Void Fraction	m^3/m^3		
Packing Density	m^2/m^3		
Solid Heat Capacity @ STP	kJ/kg·K		
Crush Strength	kg_f		
Attrition Index	-		
Thermal Conductivity	W/(m·K)		
Adsorption			
Pressure	bar		
Temperature	°C		
Equilibrium Loading	gmol CO_2/kg		
Heat of Adsorption	kJ/gmol CO_2		
CO_2 Adsorption Kinetics	gmol/time		
Desorption			
Pressure	bar		
Temperature	°C		
Equilibrium Loading	gmol CO_2/kg		
Heat of Desorption	kJ/gmol CO_2		
CO_2 Desorption Kinetics	gmol/time		
Prior Testing			
Location			
Scale	tCO_2/d		
CO_2 concentration in feed stream (e.g, flue gas, process stream)	%		
Hours of continuous operation	hrs		
CO_2 capture efficiency during longest test	%		
Sorbent Make-up rate	%/yr.		
Sorbent Lifetime	yr.		

Working capacity	Wt. % CO_2/g-sorbent		
Cycle time (Adsorption + Regeneration)	minutes		

***Definitions for State-Point Data for Sorbent Based Systems*:**
Attirtion Index – [Add a definition]
STP – Standard Temperature and Pressure (15 °C, 1 atm)
Sorbent – Adsorbate-free (*i.e.,* CO_2-free) and dry material as used in adsorption/desorption cycle.
Adsorption – The conditions of interest for adsorption are those that prevail at maximum sorbent loading. Measured data are preferable to estimated data.
Desorption – The conditions of interest for desorption are those that prevail at minimum sorbent loading. Operating pressure and temperature for the desorber/stripper are process dependent. Measured data are preferable to estimated data.
Pressure – The pressure of CO_2 in equilibrium with the sorbent. If the vapor phase is pure CO_2, this is the total pressure, and if it is a mixture of gases, this is the partial pressure of CO_2.
Packing Density – Ratio of the active sorbent area to the bulk sorbent volume.
Loading – The basis for CO_2 loading is mass of dry sorbent.
Kinetics – A characterization of the CO_2 adsorption/desorption trend with respect to time, as complete in the range of time as possible.

Table B4. State-Point Data for Membrane Based Systems

	Units	Measured/ Estimated Performance	Projected Performance
Materials Properties			
Materials of Fabrication for Selective Layer			
Materials of Fabrication for Support Layer (if applicable)			
Nominal Thickness of Selective Layer (μm)			
Membrane Geometry			
Max Trans-Membrane Pressure	bar		
Hours tested without significant degradation			
Membrane Performance			
Temperature	°C		
Pressure Standardized Flux for Permeate (CO_2)	GPU or equivalent		
CO_2/H_2O Selectivity	-		
CO_2/N_2 Selectivity	-		
Type of Measurement (Ideal or mixed gas)	-		
Proposed Module Design			
Flow Arrangement	-		
Packing Density	m^2/m^3		
Shell-Side Fluid	-		
Prior Testing			
Location			
Scale	tCO_2/d		
CO_2 concentration in feed stream (e.g, flue gas, process stream)	%		
Hours of continuous operation	hrs		
CO_2 capture efficiency during longest test	%		
Membrane Performance Degradation	%/year		

***Definitions for State-Point Data for Membrane Based Systems*:**
Membrane Geometry – Flat discs or sheets, hollow fibers, tubes, etc.
Pressure Standardized Flux – For materials that display a linear dependence of flux on partial pressure differential, this is equivalent to the membrane's permeance.
GPU – Gas Permeation Unit, which is equivalent to 10^{-6} $cm^3/(cm^2 \cdot s \cdot cmHg)$ at 1 atm and 0 °C. For non-linear materials, the dimensional units reported shall be based on flux measured in $cm^3/(cm^2 \cdot s)$ (at 1 atm and 0 °C) with pressures measured in cm Hg. Note: 1 GPU = 3.3464×10^{-6} $kgmol/(m^2 \cdot s \cdot kPa)$ [SI units]
Type of Measurement – Either mixed or pure gas measurements; projected permeance and selectivities shall be for mixture of gases found in de-sulfurized flue gas.
Flow Arrangement – Typical gas-separation module designs include spiral-wound sheets, hollow-fiber bundles, shell-and-tube, and plate-and-frame, which result in either co-current, counter-current, cross-flow arrangements, or some complex combination of these.
Packing Density – Ratio of the active surface area of the membrane to the volume of the module.
Shell-Side Fluid – Either the permeate or retentate stream.

Table B5. State Point Data Table for Electrochemical Marine CDR

	Units	Measured/Current Performance	Projected/Target Performance
Reaction Thermodynamics			
Chemical Equation	mol^{-1}	Balanced chemical equation	
$\Delta H°_{rxn}$	kJ/mol	Calculated from standard enthalpies of formation	
$\Delta G°_{rxn}$	kJ/mol	Calculated from standard free energies of formation	
Cell Operating Conditions			
Nominal Cell Potential	V		
Nominal Current Density	mA/cm^2		
Nominal Power Density	mW/cm^2		
Nominal Operating Temperature	°C		
ΔT Across Cell	°C		
Operating Pressure	(atm)		
Cell/System Performance			
Degradation Rate	(%/1000 h)		
Electricity Production (Fuel Cell)	(kW)		
Product Production (Electrolysis)	(kg/h)		
Electrical Efficiency (Fuel Cell)	(%)		
Faradaic Efficiency (Electrolysis)	(%)		
Prior Testing			
Location			
Scale	tCO_2/d		
CO_2 concentration in feed stream (e.g, flue gas, process stream)	%		
Hours of continuous operation	hrs		
CO_2 capture efficiency during longest test	%		

Table B6. State Point Data Table for Algae-based marine CDR

	Units	Measured/Current Performance	Projected/Target Performance
Algae Characteristics			
Proposed Algae Strain	-		
Algae Cultivation			
Method of Cultivation	-	(Pond, PBR or other-describe)	
Water Source			
Nutrient Source - N			
Nutrient Source - P			
Scale of prior operation – CO_2 fed	Kg/h		
Tested surface area	m^2		
Test depth of water	cm		
Algae Productivity			
Peak Productivity	$g/m^2/day$		
Annual Average Productivity	$g/m^2/day$		
Prior Testing			
Location			
Scale	tCO_2 removed/d		
Hours of continuous operation	hrs		

Table B7. State-Point Data for Mineralization Based Systems

	Units	Measured Performance (Powder form)	Projected or Measured Performance (structured material system)
Reaction Thermodynamics			
Chemical Equation	mol^{-1}	Balanced chemical equation	
$\Delta H°_{rxn}$	kJ/mol	Calculated from standard enthalpies of formation	
$\Delta G°_{rxn}$	kJ/mol	Calculated from standard free energies of formation	
Solid material as contacted with air			
True Density @ STP	kg/m^3		
Bulk Density	kg/m^3		
Average Particle Diameter	mm		
Particle Void Fraction	m^3/m^3		
Packing Density	m^2/m^3		
Solid Heat Capacity @ STP	kJ/kg·K		
Crush Strength	kg_f		
Attrition Index	-		
Thermal Conductivity	W/(m·K)		
Adsorption			
Pressure	bar		
Temperature	°C		
Equilibrium Loading	gmol CO_2/kg		
Heat of Adsorption	kJ/gmol CO_2		
CO_2 Adsorption Kinetics	gmol/time		
Desorption (if utilized)			
Pressure	bar		
Temperature	°C		
Equilibrium Loading	gmol CO_2/kg		
Heat of Desorption	kJ/gmol CO_2		
CO_2 Desorption Kinetics	gmol/time		
Prior Testing			
Location			
Scale	tCO_2/d		

CO_2 concentration in feed stream (e.g, flue gas, process stream)	%		
Hours of continuous operation	hrs		
CO_2 capture efficiency during longest test	%		
Mineral Make-up rate	%/yr.		

***Definitions for State-Point Data for Mineralization Based Systems*:**
Attirtion Index – [Add a definition]
STP – Standard Temperature and Pressure (15 °C, 1 atm)
Sorbent – Adsorbate-free (*i.e.,* CO_2-free) and dry material as used in adsorption/desorption cycle.
Adsorption – The conditions of interest for adsorption are those that prevail at maximum sorbent loading. Measured data are preferable to estimated data.
Desorption – The conditions of interest for desorption are those that prevail at minimum sorbent loading. Operating pressure and temperature for the desorber/stripper are process dependent. Measured data are preferable to estimated data.
Pressure – The pressure of CO_2 in equilibrium with the sorbent. If the vapor phase is pure CO_2, this is the total pressure, and if it is a mixture of gases, this is the partial pressure of CO_2.
Packing Density – Ratio of the active sorbent area to the bulk sorbent volume.
Loading – The basis for CO_2 loading is mass of dry sorbent.
Kinetics – A characterization of the CO_2 adsorption/desorption trend with respect to time, as complete in the range of time as possible.

Appendix C – Technology Gap Analysis Guidelines

A Technology Gap Analysis (TGA) is required as part of the final deliverables for awarded projects. An analysis of the current state of development of all the major/critical CDR process components in the proposed process must be completed during project execution. The purpose of this effort is to provide the realistic view of all the research needs required to fully develop the technology to commercialization. The results of this analysis should indicate which components or systems should be the focus of future R&D efforts. The TGA should be coordinated and consistent with the CDR process evaluated in the TEA and LCA.

Required elements for the TGA include:

1. Brief review of CDR process under investigation. This should include a summary of the potential advantages of the process in terms of the Performance, Cost, Emissions, Market, and Safety Metrics.
2. A summary of the current level of research on key components or smaller-scale integrated systems. For each of the key process components, report the current Technology Readiness Level (definitions provided in an **Appendix G** of the FOA) along with information and testing required for process scale-up and commercialization.
3. Summary table of the R&D gaps identified in #2 that should be the focus of future R&D efforts and those that are being investigated through other R&D programs. A summary description of the other R&D programs and how they are attempting to close the associated gaps should be included.
4. For commercially-available equipment, the potential vendors should be identified. A description of how the equipment offered by the vendor fits the requirements of the process should also be included.

Appendix D – Basis for Techno-Economic Analysis

The Techno-Economic Analysis (TEA) required as part of the final deliverables for projects selected under DE-FOA-0003082 shall follow the analysis procedures documented in NETL's "*Quality Guidelines for Energy System Studies: Performing a Techno-Economic Analysis for Power Generation Plants*"[32] to the greatest extent possible.

The TEA shall provide the cost of the proposed capture technology to achieve a carbon negative system as developed in its LCA. Sizing of the plant is established by the AOI description. It is highly recommended that the TEA present both the gross CO_2 removed from the system configuration presented (relevant to equipment sizing), as well as the net CO_2 removed when accounting for other emission sources within the total plant boundary and overall LCA (informative for system efficiency relating to CO_2 captured). TEAs should follow the form and function of the items included in the carbon capture technology at a reference NGCC plant described in NETL's "Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity", Case B31B. [33]

Specific required elements of a complete TEA that will provide detail beyond the previously mentioned Baseline example include, but are not limited to:

- General block flow diagram identifying all major process equipment for the CDR technology and accompanying stream tables
- Materials and energy balances around the complete process, including electric power requirements, heating and/or cooling requirements, etc.
- System performance summary
- Complete stream tables showing operating pressures, temperatures, compositions, and enthalpies for all streams entering or leaving major process equipment
- Economic analysis including capital cost estimation and operation and maintenance costs
    - Include list of equipment used to develop capital cost estimate including
        - Key sizing parameters and their value for equipment costing (i.e., height, diameter, heat duty, delta Temperature, power, etc.)
        - Individual component cost (e.g., absorber, regenerator, etc.)
- The developer will prepare estimates for equipment and consumables unique to the process being developed. If possible, capital cost estimates for unique equipment will be made based on similar equipment that may exist for other type processes.

[32] Quality Guidelines for Energy System Studies: Performing a Techno-Economic Analysis for Power Generation Plants, National Energy Technology Laboratory, DOE/NETL-2015/1726, July 2015, https://netl.doe.gov/energy-analysis/details?id=711

[33] Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity, National Energy Technology Laboratory, DOE/NETL-2023/4320, October 2022, https://netl.doe.gov/projects/files/CostAndPerformanceBaselineForFossilEnergyPlantsVolume1BituminousCoalAndNaturalGasToElectricity_101422.pdf

If equipment analogs do not exist for unique equipment the developer must do a bottoms-up estimate of the unique equipment.

- Final summary report

Assumptions and methodology to be used for the study are discussed below.

System Boundaries (as/if applicable to the technology proposed):

1) Delivered fuel or biomass entering the plant, through high-pressure, high-purity CO_2 stream crossing the plant boundary.
2) Combustion air or intake air to air separation unit
3) Ambient air conditions
4) Flue gas to stack
5) Net electricity conditioned and sent to electric grid
6) Raw make-up water
7) Waste streams generated by the plant, including the CO_2 capture system, shall be adequately treated on-site prior to disposal either by landfill or other commercial disposal options.

Process Design Assumptions (as/if applicable to the technology proposed):

The study should include at a minimum the following:

1) Site Characteristics and Ambient Conditions for each location
2) Delivered fuel or biomass Specification and Analysis (if incorporated)
3) Cryogenic Air Separation Unit Design (if incorporated)
4) Boiler or Gasifier Design (if incorporated)
5) Steam or Gas Turbine Cycle Conditions (if incorporated)
6) CO_2 utilization unit design (if incorporated)
7) Energy storage Unit design (if incorporated)
8) Environmental Controls and Performance
9) Balance of Plant
10) Economic Assumptions and Methodology
11) Reporting Requirements (including significant process figures, stream and performance tables, equipment lists, and cost accounts)

Design Basis for CO_2 Capture and Compression:

CO_2 Purity (for storage)	**Satisfy 'Conceptual Design Limits' for Enhanced Oil Recovery as listed in Exhibit 2-1 of the NETL "*Quality Guidelines for Energy System Studies: CO_2 Impurity Design Parameters.*"**
CO_2 Delivery Pressure	**2,215 psia**

Steam quality/quantity, if used	**Give location from steam source design**

For your reference, the Quality Guidelines document includes additional pertinent information including, but not limited to:

- Description of common missteps and omissions
- Guidance on system boundaries
- Example performance summary and cost tables
- Sensitivity analysis identifying critical parameters and their impact on overall performance and economics. This analysis shall include the sensitivity of cost of CO_2 capture to the capital cost of the capture and compression system, as well as carbon capture cost as a function of carbon capture efficiency.

Involvement of a variety of stakeholders is seen as an important facet to developing an effective carbon capture technology. It is considered critical that a qualified organization with professional experience in performing this type of work conduct the TEA. *This activity shall not be viewed as a training exercise for inexperienced personnel.*

Appendix E – Life Cycle Analysis

LCA

A Life Cycle Analysis (LCA) is required as part of the deliverables. The approach and boundaries for the LCA depend on the ultimate fate of the carbon-containing output of the BiCRS or mineralization facilities, based on one of the two following options. If the fate of the CO_2 is unknown, complete the LCA based on the guidance for Option 1.

Option 1. In this option, the captured CO_2 from the BiCRS or mineralization facility is permanently stored in a material or medium that is not meant to serve as marketable product. Most of the necessary inputs for the LCA should be leveraged from the Techno-Economic Analysis (TEA) (e.g., materials and energy balances, block flow diagrams, etc.). The following provides additional clarity and specificity for some items in the Best Practices.

- Required data:
  i. Include technical/physical flow amounts (e.g., kWh of electricity, MJ of heat) as key outputs in addition to the LCA impacts
  ii. Energy inputs to the facility including fuels and electricity
     1. For electricity inputs, a minimum of six scenarios should be modeled corresponding to different grid mix carbon intensities, available in the NETL CO2U openLCA LCI Database and the NETL CO2U LCA Documentation Spreadsheet as:
        a. Regional grid consumption mix (modeled as the Balancing Authority) based on proposed location of the BiCRS or mineralization facility
        b. Current U.S. grid mix
        c. 100% renewables
        d. 100% grid average coal
        e. 100% Natural Gas Combined Cycle (NGCC) with CCS
        f. 2050 U.S. grid mix
     2. For heat inputs, the following scenarios shall be assessed using the data provided by NETL:
        a. Regional source of natural gas
        b. National average natural gas
        c. If external low-grade/waste heat is utilized for the process, describe the source and availability
  iii. For AOI 1, the following profiles for both biomass emissions profiles and ultimate analyses should be used or a justification should be provided for the use of any alternative profiles. The biomass emissions shown in the table below are available in the NETL CO2U openLCA LCI Database and the NETL CO2U LCA Documentation Spreadsheet. Note that the carbon intensities of the biomass profiles are significantly influenced by the carbon content in the ultimate analyses, so any significant deviations from the ultimate analysis will likely require new emissions profiles for the biomass to be developed.

Table E-1: Availability of biomass emissions in the NETL CO2U openLCA LCI Database and Documentation spreadsheet

Biomass Category	Biomass Type	Name of profile		
		Raw	Chipped	Torrefied
Logging Residue	Forest Residue	Forest residue, raw	Forest residue, chipped	Forest residue, torrefied
Whole Trees	Southern Yellow Pine	Southern yellow pine, raw	Southern yellow pine, chipped	Southern yellow pine, torrefied
	Hybrid Poplar	Hybrid poplar, raw	Hybrid poplar, chipped	Hybrid poplar, torrefied
Herbaceous Energy Crops	Switchgrass	Switchgrass, raw	N/A	N/A
Crop Residues	Corn Stover	Corn stover, raw	N/A	N/A

Table E-2: Ultimate analyses of the biomass types contained in the NETL CO2U openLCA LCI Database and Documentation spreadsheet

Specification	Forest Residue (Raw), Hybrid Poplar (Raw, Chipped)[2]	Forest Residue (torrefied), Hybrid Poplar (torrefied), Southern Yellow Pine (torrefied)[1]	Southern Yellow Pine (Raw, Chipped)[1]	Switchgrass[3]	Corn Stover[4]
HHV (kJ/kg)	15,396	22,676	11,449	15,396	14,884
H_2O %mass	50.00	5.72	43.30	15.00	15.00
C %mass	26.18	59.89	30.55	36.21	37.83
H %mass	2.80	5.11	3.02	5.57	4.73
N %mass	0.19	0.41	0.23	1.11	0.52
Cl %mass	0.00	0	0.00	0.00	0.00
S %mass	0.02	0	0.02	0.01	0.01
Ash %mass	0.74	0.51	0.62	6.33	5.11
O %mass	20.08	28.36	22.25	35.77	36.81

1. Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass Volume 2: Pulverized Coal Plants - https://netl.doe.gov/energy-analysis/details?id=7c4b39c3-65c3-4996-b602-1242262ae494. Hybrid poplar and ultimate analysis, used also as proxy for forest residue.
2. Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass: Volume 1 - https://netl.doe.gov/energy-analysis/details?id=e734a801-c5ad-4495-a0a5-3fd7dba964d2 (switchgrass characteristics – Exhibit 2-5. Note that the source provided dry-basis ultimate analysis. This has been adjusted to 15% moisture)

3. Characterization of Biomass Feedstocks, by David S. Ortiz, Henry H. Willis, Asha Pathak, Preethi Sama, and James T. Bartis, unpublished research, 2008.

iv. The biomass emissions profiles do not include transportation. Results should be provided without transportation and with transportation over the expected distance. The sensitivity analyses should include an analysis for transportation distance. These analyses will use at a minimum the "Truck, transport" profile available in the NETL CO2U openLCA LCI Database and the NETL CO2U LCA Documentation Spreadsheet. It is encouraged to also model the expected modes of transportation.
v. Combustion and other emissions at the facility
vi. Chemical inputs to the facility
vii. Construction of the facility and manufacturing impacts for the required materials/equipment (e.g., structural steel, concrete, etc.)
viii. Carbon dioxide transport and saline aquifer storage life cycle inventory values (gate-to-grave emissions data to be used for all projects using saline storage) are available in the NETL CO2U openLCA LCI Database and the NETL CO2U LCA Documentation Spreadsheet as "Saline aquifer transport and storage." The transport and storage for other mediums or material will be documented as appropriate (e.g., truck transport of carbonized mineral to permanent location).

- LCA results:
  i. Shall be normalized to 1 kg of CO2 removed from the atmosphere and permanently stored.
  ii. A contribution analysis shall be provided so that impacts can be differentiated by major operation/input
- Emissions scope:
  i. The scope of environmental impacts shall include all the additional impact categories listed in Section 2.1.8.2 of the CO2U LCA Guidance Document. To accomplish this the environmental inventory will need to include data beyond greenhouse gas emissions, as discussed in Section 2.2.2.2 of the CO2U LCA Guidance Document.
  ii. For GHG emissions, the global warming potential shall be reported using the 100-year global warming potential (GWP) characterization factors as the default values from the Intergovernmental Panel on Climate Change (IPCC) Forth Assessment Report (AR5) and the Sixth Assessment Report (AR6), sensitivity cases using the 20-year GWP values is required:

Table E-3: Global Warming Potentials

GHG	AR5 (IPCC 2007)[34]		AR6 (IPCC 2021)[35]	
	100-year (Default)	20-year	100-year (Default)	20-year
CO_2	1	1	1	1
CH_4-fossil	36	87	29.8	82.5
CH_4-non-fossil	34	86	27.2	80.8
N_2O	298	268	273	273
SF_6	26,087	17,783	25,200	18,300

Note: These GWP characterization factors may be updated by NETL to reflect the latest science.

- Additional Resources – NETL has tools that may be helpful in completing the LCA requirement. These tools are not exhaustive but can be used to provide some life cycle inventory data for some energy and material inputs. The version of tools used for the life cycle analysis should be clearly specified in the report. The following resources are recommended:
  i. Additional General LCA guidance - CO2U LCA Guidance Document
  ii. NETL Life Cycle Inventory Data – NETL CO2U openLCA LCI Database
  iii. Electricity Consumption LCI Data – NETL Grid Mix Explorer
- LCA Submission Requirements for Phase Deliverables
  i. LCA Report – see CO2U LCA Guidance Document, Chapter 6 "Completing the NETL CO2U LCA Report Template"
  ii. LCA Model with Life Cycle Inventory Data – see CO2U LCA Guidance Document, for modeling guidance (no specific LCA software type is required)
  iii. List of all licensed LCA data used within the model (DOE will confirm or obtain license to access licensed data within the LCA model)

Option 2. If the BiCRS or mineralization facility carbon-containing output will be utilized to make a product, the LCA shall follow the guidelines set forth in the NETL report - "Carbon Dioxide Utilization Life Cycle Analysis Guidance for the U.S. DOE Office of Fossil Energy," known as the CO2U LCA Guidance Document, or simply, the guidance document. The guidance document is part of the NETL LCA CO2U Guidance

[34] IPCC (2013). Climate Change 2013 The Physical Science Basis. New York: Cambridge University Press: Intergovernmental Panel on Climate Change Retrieved December 12, 2013, from https://www.ipcc.ch/report/ar5/wg1/

[35] IPCC. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press: Intergovernmental Panel on Climate Change Retrieved May 18, 2022, from https://www.ipcc.ch/report/ar6/wg1/

Toolkit, which provides additional support for the creation of the required LCA. The guidance document outlines the analysis requirements and how to use the supporting data and tools. As outlined in the guidance document, the LCA must compare a proposed product system, the supply chain of the proposed BiCRS or mineralization project, to an appropriate comparison product system using a multiproduct functional unit and system expansion. All materials, including the guidance document can be accessed at www.netl.doe.gov/LCA/CO2U. **In addition to the LCA requirements outlined for Option 1, the following shall also be accounted for**:

- Development of a Comparison Product System LCA – greenhouse gas benefits of capture and utilization technologies requires a comparison to the current commercial process for developing the same product or service as derived from the carbon utilization product proposed in the project. Guidance on how to develop the Comparison Product System are contained within the CO2U LCA Guidance Document.

Preliminary LCA

LCA Submission Requirements for Preliminary LCAs

- Applicants shall provide a screening-level, greenhouse-gas only analysis with GWPs defined above (Table E-3) and a contribution analysis showing at a minimum the impacts from fuel extraction and delivery; mineralization or biomass conversion facility direct emissions; and transport and storage of either CO_2, carbon-containing BiCRS products, or carbonized minerals.
  - The functional unit will be whatever amount of BiCRS product (MWh, stored biochar) or carbonized minerals is required to result in net a net GWP of -500,000 tonnes CO_2e for AOI-1 and -100,000 tonnes CO_2e for AOI-2. For example,
    - If the carbonized mineral contains 14% by weight carbon then roughly 1.9 kg of carbonized mineral reflects 1kg of CO2 uptake and storage.

$$\frac{1}{0.1425\,\frac{kg_C}{kg_{mineral}}} \cdot \frac{12\,kg_C}{44\,kg_{CO_2}} = 1.9\,\frac{kg_{mineral}}{kg_{co2uptake}}$$

    - If upstream and downstream (e.g., emissions from electricity used to power mineral crushing and diesel combustion for transport/storage of carbonized mineral) are 0.2 kg CO2e/kg of carbonized mineral, then those emissions will be scaled according to the amount of carbonized mineral being produced to get 1 kg CO_2 uptake: 0.38 per kg of CO2 uptake and storage.

$$0.2\,\frac{kg\ CO_2e}{kg_{mineral}} \cdot 1.9\,\frac{kg_{mineral}}{kg_{CO2uptake}} = 0.38\,\frac{kg_{CO_2e}}{kg_{CO2uptake}}$$

- This means that for every 1.9 kg of carbonized mineral, there is a net CO_2e stored of 0.62 kg CO_2. In order to reach the goal of -100,000 tonnes CO_2e, the mass of carbonized mineral would be 309,000 tonnes, which would be the functional unit.

$$\frac{-100{,}000{,}000\ kg_{net\ CO_2e}}{-0.62\ kg\ \frac{kg_{netCO_2e}}{kg_{CO2uptake}}} \cdot 1.914 \frac{kg_{mineral}}{kg_{CO2uptake}} = 309{,}000\ tonnes$$

- The documentation and report do not necessarily need to follow the NETL CO2U LCA Guidance Document, all sources of life cycle inventory should be clearly documented in the application.
- Applicants must use NETL data where possible. Any alternative sources of life cycle inventory will need to be justified. The following is a list of NETL life cycle inventory data sources:
  i. Upstream dashboard version 3
  ii. Grid Mix Explorer 4.2
  iii. NETL CO2U openLCA LCI Database Version 2.1 (or latest)
  iv. NETL CO2U Documentation Spreadsheet
- The option of using the GREET LCA (https://greet.anl.gov/) tool may be considered during award negotiation for hydrogen production projects.

Appendix F - Basis for Technology EH&S Risk Assessment

An assessment of EH&S risks is required as part of the final deliverables. The final EH&S assessment shall be coordinated and consistent with the project activities.

The purpose of the EH&S activity is to assess the environmental friendliness and safety of any future process based on the materials and process being proposed under the subject DOE FOA. This is the major concern for solvents in use today. Exposure to nanoparticles is also coming under increasing scrutiny by the U.S. Environmental Protection Agency (EPA), National Institute for Occupational Safety and Health (NIOSH) and others. The EH&S risk assessments shall be conducted by qualified and experienced organizations and professionals (*e.g.* environmental scientists, industrial hygienists, safety engineers). *Unanticipated or uncontrolled EH&S risks will impede commercialization of CDR technologies, and the EH&S assessment is a critical element of the development project.*

Required elements for the EH&S Assessment are:

1) All potential ancillary or incidental air and water emissions, and solid wastes produced from the proposed technology shall be identified and their magnitude estimated. In addition to solvents or sorbents used, researchers shall consider possible by-products of side reactions that might also occur in the system, accumulated waste products, and the fate of contaminants from the feed gas stream. Environmental degradation products shall be addressed. Bioaccumulation, soil mobility, and degradability shall be considered. Conditions at the point of discharge shall be examined.

2) If possible, a concise but complete and comprehensible description of the various toxicological effects of the substances identified in (1) above shall be provided. A thorough literature search shall be conducted to examine potential human health effects and ecotoxicity. Where information is lacking for a particular material, it shall be compared to similar substances or classes of substances.

3) Properties related to volatility, flammability, explosivity, other chemical reactivity, and corrosivity shall also be collected from existing databases or if necessary, through direct measurement in cases where the substance is not in common use.

4) The compliance and regulatory implications of the proposed technology shall be addressed with reference to applicable U.S. EH&S laws and associated standards including the Comprehensive Environmental Response and Liability Act of 1980 (CERCLA), Toxic Substances Control Act (TSCA), Clean Water Act (CWA), Clean Air Act (CAA), Superfund Amendments and Reauthorization Act (SARA) Title III, and the Occupational Safety and Health Act (OSHA).

5) An engineering analysis shall be conducted for any potentially hazardous materials identified

to look for ways their use can be eliminated or minimized. Less hazardous materials should be substituted where possible. For any new materials being proposed, synthetic options shall be examined that may lead to similar, less-hazardous compounds with the required functionality. Possible engineering controls and other mitigation strategies shall be described as appropriate.

6) Precautions for safe handling and conditions for safe storage shall be identified, including any incompatibilities with other materials that may be used in the process. Waste treatment and offsite disposal options shall be examined. Accidental release measures shall also be discussed.

Appendix G – Technology Maturation Plan and Technology Readiness Levels

TECHNOLOGY MATURATION PLAN
for {insert project title}
{Date Prepared}

SUBMITTED UNDER FUNDING OPPORTUNITY ANNOUNCEMENT

DE-FOA-#######

SUBMITTED BY

{Organization Name}
{Organization Address}
{City, State, Zip Code}

PRINCIPAL INVESTIGATOR

{Name}
{Phone Number}
{E-mail}

SUBMITTED TO

U.S. Department of Energy
National Energy Technology Laboratory

A technology maturation plan (TMP) is a planning tool that summarizes the necessary research and development (R&D) steps to advance the maturation of a specified technology to a targeted technology readiness level (TRL) and defines the key performance metrics that will be used to determine if the targeted TRL has been successfully achieved. A TMP also documents the current TRL of the specified technology, defines the ultimate commercial application of the technology, and conceptualizes a future commercialization pathway in terms of additional R&D, resources and schedule. A TMP is a high-level summary document. It is not a collection of detailed test plans.

The National Energy Technology Laboratory (NETL) uses TMPs to enhance its stewardship of R&D project portfolios and improve the value of the technologies it develops. TMPs help NETL to:

- ensure that research questions are resolved in the least expensive and least risky R&D setting (i.e., scale, degree of integration, environment, fidelity)
- focus technology development on the performance metrics that are most important for technical and economic success (at component and system levels)
- identify R&D gaps and critical components that are lagging in maturity
- ensure that R&D projects address what is required for integration into higher-level systems
- make informed decisions at critical stages of research (e.g., moving a technology from a laboratory project to a larger-scale pilot project)
- improve the balance of project portfolios in terms of technology types, pathways, TRLs, redundancy, etc., to mitigate risks and increase the likelihood of R&D success, and
- forecast the cost and duration of technology development through demonstration and commercialization.

The below template should be used to complete a TMP. Instructions, shown in italics, should be deleted/replaced in the completed TMP. Section 3 is provided solely for reference but should be retained as-is in the completed TMP.

1.0 INTRODUCTION

1.1 Purpose of the Project

Provide a brief summary of the project's objectives as related to maturation of the proposed technology.

1.2 Technology Readiness Assessment System

Technology maturation is quantified by a performing a technology readiness assessment (TRA) on the specified technology system.

- Identify the specified "TRA System" and describe all the critical components and/or subsystems that comprise it. See "TRA System" definition under Section 3.1.
- State whether the current project will test: (1) the total, integrated TRA System, or (2) one or more critical subsystems or components of the TRA System. If the latter, identify which critical subsystems and/or components will be tested.

1.3 Commercial Application

Provide a one-paragraph description of the targeted commercial application(s) of the TRA System.

2.0 MATURATION OF THE TRA SYSTEM

2.1 Beginning Technology Readiness Level (TRL) of the TRA System

Briefly summarize the prior research that matured the technology to its current state.

Using the Technology Readiness Levels (TRL) descriptions in Sections 3.2 and 3.3, specify the current (i.e., pre-project) TRL of the TRA System. To attain a certain TRL, all aspects of the associated TRL description must be met.

Justify the specified TRL by explaining how all the required TRL aspects have been achieved.

2.2 Proposed Research to Mature the TRA System

Identify the TRL that the project plans to attain.

- Note that the targeted TRL could be the same as the beginning TRL if the project is aimed at making only incremental progress toward achieving the next TRL.
- If the project proposes to advance the TRL by more than one level, explain if that will be accomplished in stages (i.e., first one TRL, then the next) or by skipping a TRL. If the latter, explain how any increased technical, cost and schedule risks associated with skipping a TRL will be mitigated.

Identify each of the key performance attributes that will be assessed during the research along with the corresponding, quantifiable performance requirements that must be achieved to attain the targeted TRL(s). Explain how the key performance attributes were selected and how the corresponding requirements were determined. Be as specific as practical on any supporting technical/economic assessments (see Section 3.4 for NETL's Systems Analysis Best Practices). As a general principle, all key performance requirements that may be appropriately tested at a particular TRL must be substantially met, thereby supporting the feasibility of commercial success/goal achievement, prior to proceeding to the subsequent TRL.

Briefly summarize the proposed research steps and how they will mature the TRA System to the targeted TRL(s).

2.3 Potential Post-Project Maturation and Commercialization of the TRA System

Assuming the project successfully attains the targeted TRL(s), describe what additional (post-project) work would be required to mature the TRA System to the next TRL. Identify the key performance requirements and goals/measures that

would need to be achieved. If possible, provide rough estimates of the cost and duration of the research required to attain the next TRL.

Describe your organization's potential role in a commercialization strategy for the TRA system.

3.0 REFERENCE MATERIAL

3.1 Definition of TRA System

NETL's interpretation (Section 3.2) of the DOE TRL definitions (Section 3.3) is based on a view of technology maturation in which "components" are integrated into a "system" that is being assessed for its technology readiness. To clearly and consistently apply the DOE TRL definitions, one must first precisely identify what "system" is being assessed, defined herein as the "Technology Readiness Assessment (TRA) System." Since most technologies can be viewed as subsystems within larger systems, multiple choices are available for defining the TRA System. However, note that the choice of the "level" of the TRA System affects how TRLs are assessed:

- A TRL 3 is achieved for the specified TRA System when analytical performance predictions for each of the TRA System's critical[36] components have been validated in separate experiments (i.e., without integration across components). Accordingly, the table in Section 3.2 shows the required scope of TRL 3 as "single component" and the required integration of TRL 3 as "none."
- A TRL 4 or 5 is achieved for a given TRA System when the targeted performance requirements for each of its critical, multi-component subsystems (or the entire TRA system) have been validated in a laboratory environment (TRL 4) or relevant environment (TRL 5) with integration of some or all components.
- Achieving TRLs 6 to 9 requires testing of the entire, fully integrated, TRL system.

To further clarify, consider, for example, a fuel cell stack. Its critical components are multiple, identical fuel cells. In turn, the critical components of each fuel cell are an anode, cathode and electrolyte. If one wished to assess the technology readiness of the fuel cell stack, the TRA System would be defined as an integrated system of multiple fuel cell subsystems, and a TRL 6 could only be achieved by successfully testing an entire stack of integrated fuel cells. However, if one instead wished to

[36] A component or subsystem of a TRA System is considered critical if it is new, novel, and necessary for the TRA System to meet its anticipated operational performance requirements or poses major cost, schedule, or performance risk during design or demonstration. Note that a component that is fully mature and non-critical for an established application or operational environment may be considered critical if it is incorporated into a new application or operational environment.

assess the technology readiness of only the fuel cell, the TRA System would be defined as an integrated system of cathode, anode and electrolyte components, and a TRL 6 could be achieved by successfully testing just a single, integrated fuel cell. In both cases, achievement of TRL 6 could be claimed, but only in the context of the properly specified TRA System.

3.2 NETL Interpretations of DOE Technology Readiness Levels in the Context of Fossil Energy and Carbon Management R&D

<table>
<tr><th rowspan="2">TRL</th><th rowspan="2">DOE Definition</th><th colspan="6">Minimum Simultaneous Requirements to Achieve TRL
based on NETL Interpretation of DOE Definitions & Descriptions</th></tr>
<tr><th>Scope</th><th>Integration</th><th>Fidelity</th><th>Scale</th><th>Environment</th><th>Metrics</th></tr>
<tr><td>1</td><td>Basic principles observed and reported</td><td colspan="5" rowspan="2">Any experimentation is limited to discovery and validation of fundamental scientific principles. Formulation of the technology that applies the fundamental science is initiated in conceptual paper studies but experiments on the applied technology have not begun.</td><td>NA</td></tr>
<tr><td>2</td><td>Technology concept and/or applications formulated</td><td rowspan="9">Project-specific TMPs should define cost and/or performance metrics for relevant TRLs. To attain a given TRL, the technology must achieve the metrics for that TRL (or show a likely potential to do so).</td></tr>
<tr><td>3</td><td>Analytical and experimental critical function and/or characteristic proof of concept</td><td>Single Component</td><td>None</td><td rowspan="2">Low (ad-hoc hardware)</td><td rowspan="3">Lab</td><td rowspan="2">Lab
(simulated conditions)</td></tr>
<tr><td>4</td><td>Component and/or system validation in laboratory environment</td><td rowspan="2">Total system or multi-component subsystem</td><td rowspan="2">Integration of some or all components</td></tr>
<tr><td>5</td><td>Laboratory scale, similar system* validation in relevant environment</td><td>High (nearly a prototype)</td><td rowspan="4">Relevant
(regulated expected conditions)</td></tr>
<tr><td>6</td><td>Engineering/pilot-scale, similar (prototypical) system validation in relevant environment</td><td rowspan="4">Total system

(The total system is equivalent to the "TRA System," which is the system or subsystem for which technology readiness is being assessed)</td><td rowspan="4">All components and subsystems integrated</td><td rowspan="2">Prototype</td><td>Small Pilot**</td></tr>
<tr><td>7</td><td>Full-scale, similar (prototypical) system demonstrated in relevant environment</td><td>Large Pilot or Full**</td></tr>
<tr><td>8</td><td>Actual system completed and qualified through test and demonstration. Technology has been proven to work in its final form and under expected conditions.</td><td>Actual system in final form</td><td rowspan="2">Full</td><td rowspan="2">Operational
(unregulated actual conditions)</td></tr>
<tr><td>9</td><td>Actual operation of the technology in its final form, under the full range of conditions.</td><td>Commercially warranted</td><td>NA</td></tr>
</table>

* The DOE TRL 5 description states that the "similar system" matches the final application in "almost all respects" and is "almost prototypical." This table interprets the similar, but not fully prototypical, system as being either: a) the total system for which readiness is being evaluated, or b) a multi-component subsystem of the total system. This interpretation is supported by the DOE TRL 6 description which states that "TRL 6 begins true engineering development of the technology as an operational system."

** DOE defines TRL 6 as a pilot-scale prototype and TRL 7 as a full-scale prototype. DOE defines TRLs 8 and 9 as involving "actual" systems at full scale. This table assumes that the scale of the TRL 7 full-scale prototype could be less than or equal to the scale of the TRL 8 full-scale actual system. At a minimum, the scale of the TRL 7 prototype must be sufficiently large to support subsequent testing of a TRL 8 full-scale actual system without the need for testing at an intervening scale.

3.3 Description of DOE Technology Readiness Levels

Source: U.S. Department of Energy, “Technology Readiness Assessment Guide”. Office of Management. 2011.

Relative Level of Technology Development	TRL	TRL Definition	Description
System Operations	9	Actual system operated over the full range of expected mission conditions.	The technology is in its final form and operated under the full range of operating mission conditions. Examples include using the actual system with the full range of wastes in hot operations.
System Commissioning	8	Actual system completed and qualified through test and demonstration.	The technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental testing and evaluation of the system with actual waste in hot commissioning. Supporting information includes operational procedures that are virtually complete. An Operational Readiness Review (ORR) has been successfully completed prior to the start of hot testing.
	7	Full-scale, similar (prototypical) system demonstrated in relevant environment	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning (1). Supporting information includes results from the full-scale testing and analysis of the differences between the test environment, and analysis of what the experimental results mean for the eventual operating system/environment. Final design is virtually complete.

Relative Level of Technology Development	TRL	TRL Definition	Description
Technology Demonstration	6	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	Engineering-scale models or prototypes are tested in a relevant environment. This represents a major step up in a technology's demonstrated readiness. Examples include testing an engineering scale prototypical system with a range of simulants.(1) Supporting information includes results from the engineering scale testing and analysis of the differences between the engineering scale, prototypical system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. TRL 6 begins true engineering development of the technology as an operational system. The major difference between TRL 5 and 6 is the step up from laboratory scale to engineering scale and the determination of scaling factors that will enable design of the operating system. The prototype should be capable of performing all the functions that will be required of the operational system. The operating environment for the testing should closely represent the actual operating environment.
Technology Development	5	Laboratory scale, similar system validation in relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects. Examples include testing a high-fidelity, laboratory scale system in a simulated environment with a range of simulants (1) and actual waste (2). Supporting information includes results from the laboratory scale testing, analysis of the differences between the laboratory and eventual operating system/environment, and analysis of what the experimental results mean for the eventual operating system/environment. The major difference between TRL 4 and 5 is the increase in the fidelity of the system and environment to the actual application. The system tested is almost prototypical.
Technology Development	4	Component and/or system validation in laboratory environment	The basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of ad hoc hardware in a laboratory and testing with a range of simulants and small scale tests on actual waste (2). Supporting information includes the results of the integrated experiments and estimates of how the experimental components and experimental test results differ from the expected system performance goals. TRL 4-6 represent the bridge from scientific research to engineering. TRL 4 is the first step in determining whether the individual components will work together as a system. The laboratory system will probably be a mix of on hand equipment and a few special purpose components that may require special handling, calibration, or alignment to get them to function.

Relative Level of Technology Development	TRL	TRL Definition	Description
Research to Prove Feasibility	3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development (R&D) is initiated. This includes analytical studies and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative tested with simulants.(1) Supporting information includes results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems. At TRL 3 the work has moved beyond the paper phase to experimental work that verifies that the concept works as expected on simulants. Components of the technology are validated, but there is no attempt to integrate the components into a complete system. Modeling and simulation may be used to complement physical experiments.
Basic Technology Research	2	Technology concept and/or application formulated	Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies. Supporting information includes publications or other references that outline the application being considered and that provide analysis to support the concept. The step up from TRL 1 to TRL 2 moves the ideas from pure to applied research. Most of the work is analytical or paper studies with the emphasis on understanding the science better. Experimental work is designed to corroborate the basic scientific observations made during TRL 1 work.
	1	Basic principles observed and reported	This is the lowest level of technology readiness. Scientific research begins to be translated into applied R&D. Examples might include paper studies of a technology's basic properties or experimental work that consists mainly of observations of the physical world. Supporting Information includes published research or other references that identify the principles that underlie the technology.

[1] Simulants should match relevant chemical and physical properties.
[2] Testing with as wide a range of actual waste as practicable and consistent with waste availability, safety, ALARA, cost and project risk is highly desirable.

3.4 NETL Systems Analysis Best Practices

NETL has developed Systems Analysis Best Practices (SABP) as an accompaniment to the DOE Technology Readiness Level (TRL) definitions. The SABP serve as a guide for the Principal Investigator/researcher to inform on the level of systems and economic analysis rigor appropriate at each TRL.

System and economic analyses are an essential component of research and development (R&D). They are used to determine appropriate experimental conditions, inform R&D targets and technology maturation plans, assess R&D progress, and estimate the benefits of successful technology development in commercial applications.

Systems analysis is the analytic process used to evaluate the behavior and performance of processes, equipment, subsystems, and systems. Such analyses serve to characterize the relationships between independent (e.g., design parameters and configurations, material properties, etc.) and dependent variables (e.g., thermodynamic state points, output, etc.) through the creation of models representative of the envisioned process, equipment, subsystem, or system. These analyses are used to determine the important variables (i.e., performance attributes) and the associated targets (i.e., performance requirements) that must be achieved through R&D and testing to realize commercial and/or program goals.

The performance requirements are selected such that the equipment, subsystem, or system meets the envisioned objectives in the target commercial application. The target commercial application refers to one specific use for the advanced technology, at full commercial scale. A project may include more than one target commercial application. For example:

1. Technologies that reduce the cost of gasification may be useful for both liquid fuels and power production.
2. Technologies that may be useful to monitor CO2 storage in more than one type of storage site.

The modeling and simulation effort may use one or more of a variety of tools, such as Excel, MATLAB, Aspen Plus, Aspen Plus Dynamics, Thermoflow, CHEMCAD, etc., depending upon suitability to the specific processes, the scope of the development effort, and the stage of development.

An integral part of systems analysis is economic analysis - the process of estimating and assigning costs to equipment, subsystems, and systems corresponding to models of and specifications for the commercial embodiment of the technology. Such analyses include the estimation of capital costs, as well as operating and maintenance costs. Component service life and corresponding replacement costs are often a crucial aspect of these analyses. See Performing a Techno-economic Analysis for Power Generation Plants, DOE/NETL-2015/1726, July 2015, for further guidance.

As a technology matures, the systems analyses are frequently updated, and are expected to increase in fidelity and complexity commensurate with the available technical understanding, experimental data, and overall level of effort (cost of R&D).

The results are used to inform the next stage of development and provide specific experimental and analysis success criteria (the performance requirements).

As a general principle, the performance requirements that may be appropriately tested at a particular TRL must be substantially met, thereby supporting the feasibility of commercial success/goal achievement, prior to proceeding to the subsequent TRL. Note that, as with the TRL descriptions, these SABP are "gate-in;" that is, prerequisites to achieving the associated TRL.

NETL supports a wide range of RD&D projects, from small, short-duration materials development and property characterization projects up to large-scale power plant demonstrations. The nature and complexity of the technology under development and the scope of the project must be taken into account when applying the SABP – they may not be strictly applicable as written to every project. For example, it is an unreasonable expectation for a project developing a sensor, or fuel cell cathode, or thermal boundary coating for a turbine airfoil to perform a full-scale power plant simulation to determine the performance requirements of the specific technology in the course of pursuing TRL 4. However, the project must explicitly tie the quantitative goals/objectives for the technology to referenced system studies as well as relevant industry and/or market requirements in such a manner that their pedigree is readily traceable. On the other hand, a project endeavoring to develop a full system concept incorporating novel components and process integration is expected to perform more robust, extensive analyses.

Descriptions of the SABP associated with each TRL are provided in the table below.

TRL	DOE Definition	Systems Analysis Best Practices
1	Basic principles observed and reported	Assessment: Perform an assessment of the core technology resulting in (qualitative) projected benefits of the technology, a summary of necessary R&D needed to develop it into the actual technology, and principles that support of the viability of the technology to achieve the projected benefits.
2	Technology concept and/or applications formulated	White Paper: A white paper describing the intended commercial application, the anticipated environment the actual technology will operate in, and the results from the initiation of a detailed analysis (that will at least qualitatively justify expenditure of resources versus the expected benefits and identify initial performance attributes).
3	Analytical and experimental critical function and/or characteristic proof of concept	Performance Model and Initial Cost Assessment: This performance model is a basic model of the technology concept, incorporating relevant process boundary conditions, that provides insight into critical performance attributes and serves to establish initial performance requirements. These may be empirically- or theoretically-based models represented in Excel or other suitable platforms. In addition, an initial assessment and determination of performance requirements related to cost is completed.

TRL	DOE Definition	Systems Analysis Best Practices
4	Component and/or system validation in laboratory environment	System Simulation and Economic Analysis: These models incorporate a performance model of the technology (may be a simple model as developed for TRL 3, or something more detailed – either should be validated against empirical data gathered in the laboratory) into a model of the intended commercial system (e.g., power plant). In addition, an economic analysis (e.g., cost-of-electricity) of the technology is performed, assessing the impact of capital costs, operating and maintenance costs, and life on the impact of the technology and its contributions to the viability of the overall system in a commercial environment. These analyses serve to assess the relative impact of known performance attributes (through sensitivity analyses) and refine performance requirements in the context of established higher-level technical and economic goals (e.g., programmatic or DOE R&D goals). These models are typically created in process simulation software (e.g., ASPEN Plus) or other suitable platforms. DOE maintains guidance on the execution of techno-economic analyses [1].
5	Laboratory scale, similar system* validation in relevant environment	System Simulation and Economic Analysis Refinement: A more detailed process model for the technology, validated against empirical data gathered in the laboratory, will be developed and incorporated into system simulations. This provides greater fidelity in the performance and cost estimation for the technology, facilitating updates to performance attributes and requirements (including updates to the economic analysis). This also allows greater evaluation of other process synergy claims (e.g., state-of-the-art technology is improved by the use of the new technology). Cost estimation should be either vendor-based or bottom-up costing approaches for novel equipment.
6	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	System Simulation and Economic Analysis Refinement: Performance and cost models are refined based upon relevant environment laboratory results, leading to updated performance attributes and requirements. Preliminary steady-state and dynamic (if appropriate for the technology) modeling of all critical process parameters (i.e., upper and lower operating limits) of the system prototype is completed. Cost estimation should be either vendor-based or bottom-up costing approaches for novel equipment. Key process equipment should be specified to the extent that allows for bottom-up estimating to support a feasibility study of the integrated system.
7	Full-scale, similar (prototypical) system demonstrated in relevant environment	System Simulation and Economic Analysis Refinement: Performance and cost models are refined based upon relevant environment and system prototype R&D results. The refined process, system and cost models are used to project updated system performance and cost to determine if the technology has the potential to meet the project goals. Performance attributes and requirements are updated as necessary. Steady-state and dynamic modeling all critical process parameters of the system prototype covering the anticipated full operation envelope (i.e., upper and lower operating limits) is completed. Cost models should be based on vendor quotes and traditional equipment estimates should be minimal.

TRL	DOE Definition	Systems Analysis Best Practices
8	Actual system completed and qualified through test and demonstration. Technology has been proven to work in its final form and under expected conditions.	System Simulation and Economic Analysis Validation: The technology/system process models are validated by operational data from the demonstration. Economic models are updated accordingly.
9	Actual operation of the technology in its final form, under the full range of conditions.	Commercial Use: Models are used for commercial scaling parameters.

Appendix H – Data Management Plan

A Data Management Plan ("DMP") explains how data generated in the course of the research or work performed under an assistance award will be shared and preserved or, when justified, explains why data sharing or preservation is not possible or scientifically appropriate.

DMP Requirements

In order for a DMP to be considered acceptable, the DMP must address the following:

At a minimum, the DMP must describe how data sharing and preservation will enable validation of the results from the proposed work, or how results could be validated if data are not shared or preserved.

The DMP must provide a plan for making all research data displayed in publications resulting from the proposed work digitally accessible at the time of publication. This includes data that are displayed in charts, figures, images, etc. In addition, the underlying digital research data used to generate the displayed data should be made as accessible as possible in accordance with the principles stated above. This requirement could be met by including the data as supplementary information to the published article, or through other means. The published article should indicate how these data can be accessed.

The DMP should consult and reference available information about data management resources to be used in the course of the proposed work. In particular, a DMP that explicitly or implicitly commits data management resources at a facility beyond what is conventionally made available to approved users should be accompanied by written approval from that facility. In determining the resources available for data management at DOE User Facilities, researchers should consult the published description of data management resources and practices at that facility and reference it in the DMP. Information about other DOE facilities can be found in the additional guidance from the sponsoring program.

The DMP must protect confidentiality, personal privacy, Personally Identifiable Information, and U.S. national, homeland, and economic security; recognize proprietary interests, business confidential information, and intellectual property rights; avoid significant negative impact on innovation, and U.S. competitiveness; and otherwise be consistent with all laws (i.e., export control laws), and DOE regulations, orders, and policies.

Data Determination for a DMP

The Principal Investigator should determine which data should be the subject of the DMP and, in the DMP, propose which data should be shared and/or preserved in accordance with the DMP Requirements noted above.

For data that will be generated through the course of the proposed work, the Principal Investigator should indicate what types of data should be protected from immediate public disclosure by DOE (referred to as "protected data") and what types of data that DOE should be able to release immediately. Similarly, for data developed outside of the proposed work at private expense that will be used in the course of the proposed work, the Principal Investigator should indicate whether that type of data will be subject to public release or kept confidential (referred to as "limited rights data"). Any use of limited rights data or labeling of data as "protected data" must be consistent with the DMP Requirements noted above.

Suggested Elements for a DMP

The following list of elements for a DMP provides suggestions regarding the data management planning process and the structure of the DMP:

Data Types and Sources: A brief, high-level description of the data to be generated or used through the course of the proposed work and which of these are considered digital research data necessary to validate the research findings or results.

Content and Format: A statement of plans for data and metadata content and format including, where applicable, a description of documentation plans, annotation of relevant software, and the rationale for the selection of appropriate standards. Existing, accepted community standards should be used where possible. Where community standards are missing or inadequate, the DMP could propose alternate strategies for facilitating sharing, and should advise the sponsoring program of any need to develop or generalize standards.

Sharing and Preservation: A description of the plans for data sharing and preservation. This should include, when appropriate: the anticipated means for sharing and the rationale for any restrictions on who may access the data and under what conditions; a timeline for sharing and preservation that addresses both the minimum length of time the data will be available and any anticipated delay to data access after research findings are published; any special requirements for data sharing, for example, proprietary software needed to access or interpret data, applicable policies, provisions, and licenses for re-use and re-distribution, and for the production of derivatives, including guidance for how data and data products

should be cited; any resources and capabilities (equipment, connections, systems, software, expertise, etc.) requested in the research proposal that are needed to meet the stated goals for sharing and preservation (this could reference the relevant section of the associated research proposal and budget request); and whether/where the data will be preserved after direct project funding ends and any plans for the transfer of responsibilities for sharing and preservation. A description of how the recipient intends to make the results of any resulting DOE-funded work available to the public, including the relevant technical community.

Protection: A statement of plans, where appropriate and necessary, to protect confidentiality, personal privacy, Personally Identifiable Information, and U.S. national, homeland, and economic security; recognize proprietary interests, business confidential information, and intellectual property rights; and avoid significant negative impact on innovation, and U.S. competitiveness.

Rationale: A discussion of the rationale or justification for the proposed data management plan including, for example, the potential impact of the data within the immediate field and in other fields, and any broader societal impact.

Additional Guidance

In determining which data should be shared and preserved, researchers must consider the data needed to validate research findings as described in the Requirements and are encouraged to consider the potential benefits of their data to their own fields of research, fields other than their own, and society at large.

DMPs should reflect relevant standards and community best practices and make use of community accepted repositories whenever practicable.

Costs associated with the scope of work and resources articulated in a DMP may be included in the proposed research budget as permitted by the applicable cost principles.

To improve the discoverability of and attribution for datasets created and used in the course of research, DOE encourages the citation of publicly available datasets within the reference section of publications, and the identification of datasets with persistent identifiers such as Digital Object Identifiers (DOIs). In most cases, DOE can provide DOIs free of charge for data resulting from DOE-funded research through its Office of Scientific and Technical Information (OSTI) DataID Service.

Definitions

Data Preservation: Data preservation means providing for the usability of data beyond the lifetime of the research activity that generated them.

Data Sharing: Data sharing means making data available to people other than those who have generated them. Examples of data sharing range from bilateral communications with colleagues, to providing free, unrestricted access to anyone through, for example, a web-based platform.

Digital Research Data: The term digital data encompasses a wide variety of information stored in digital form including: experimental, observational, and simulation data; codes, software and algorithms; text; numeric information; images; video; audio; and associated metadata. It also encompasses information in a variety of different forms including raw, processed, and analyzed data, published and archived data.

Research Data: The recorded factual material commonly accepted in the scientific community as necessary to validate research findings, but not any of the following: preliminary analyses, drafts of scientific papers, plans for future research, peer reviews, or communications with colleagues. This 'recorded' material excludes physical objects (e.g., laboratory samples). Research data also do not include:

(A) Trade secrets, commercial information, materials necessary to be held confidential by a researcher until they are published, or similar information which is protected under law; and

(B) Personnel and medical information and similar information the disclosure of which would constitute a clearly unwarranted invasion of personal privacy, such as information that could be used to identify a particular person in a research study."

Validate: In the context of DMPs, validate means to support, corroborate, verify, or otherwise determine the legitimacy of the research findings. Validation of research findings could be accomplished by reproducing the original experiment or analyses; comparing and contrasting the results against those of a new experiment or analyses; or by some other means.

Appendix I – Waiver Requests: Foreign Entity Participation and Performance of Work in the United States

i. Waiver for Foreign Entity Participation as the Prime Recipient

As set forth in Section III, "Eligibility Information", all Prime Recipients receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a State or territory of the United States. To request a waiver of this requirement, an applicant must submit an explicit waiver request in the Full Application.

Overall, the applicant must demonstrate to the satisfaction of DOE that it would further the purposes of this FOA and is otherwise in the economic interests of the United States to have a foreign entity serve as the Prime Recipient. A request to waive the *Foreign Entity Participation as the Prime Recipient* requirement must include the following:

- Entity name;
- The rationale for proposing a foreign entity to serve as the Prime Recipient;
- Country of incorporation; and the extent, if any, the entity is state owned or controlled;
- A description of the project's anticipated contributions to the US economy;
    - How the project will benefit U.S. research, development and manufacturing, including contributions to employment in the U.S. and growth in new markets and jobs in the U.S.;
    - How the project will promote domestic American manufacturing of products and/or services;
- A description of how the foreign entity's participation as the Prime Recipient is essential to the project;
- A description of the likelihood of Intellectual Property (IP) being created from the work and the treatment of any such IP;
- Countries where the work will be performed (Note: if any work is proposed to be conducted outside the U.S., the applicant must also complete a separate request for waiver of the Performance of Work in the United States requirement).

DOE may require additional information before considering the waiver request.

The applicant does not have the right to appeal DOE's decision concerning a waiver request.

ii. Waiver for Performance of Work in the United States (Foreign Work Waiver)

As set forth in Section IV, "Application and Submission Information", all work under DOE funding agreements must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment, so a waiver is not required for foreign purchases of these items. However, the Prime Recipient should make every effort to purchase supplies and equipment within the United States. There may be limited circumstances where it is in the interest of the project to perform a portion of the work outside the United States. To seek a waiver of the Performance of Work in the United States requirement, the applicant must submit an explicit waiver request in the Full Application. A separate waiver request must be submitted for each entity proposing performance of work outside of the United States.

Overall, a waiver request must demonstrate to the satisfaction of DOE that it would further the purposes of this FOA and is otherwise in the economic interests of the United States to perform work outside of the United States. A request to waive the *Performance of Work in the United States* requirement must include the following:

- The rationale for performing the work outside the U.S. ("foreign work");
- A description of the work and the percentage of the direct labor (including subrecipients) proposed to be performed outside the U.S.;
- An explanation as to how the foreign work is essential to the project;
- A description of the anticipated benefits to be realized by the proposed foreign work and the anticipated contributions to the US economy;
    - The associated benefits to be realized and the contribution to the project from the foreign work;
    - How the foreign work will benefit U.S. research, development and manufacturing, including contributions to employment in the U.S. and growth in new markets and jobs in the U.S.;
    - How the foreign work will promote domestic American manufacturing of products and/or services;
- A description of the likelihood of Intellectual Property (IP) being created from the foreign work and the treatment of any such IP;
- The total estimated cost (DOE and Recipient cost share) of the proposed foreign work;
- The countries in which the foreign work is proposed to be performed; and
- The name of the entity that would perform the foreign work, by country (if more than one foreign country is proposed).
- Information about the entity(ies) involved in the work proposed to be conducted outside the United States. (i.e., entity seeks a waiver and the entity(ies) that will conduct the work).

DOE may require additional information before considering the waiver request.
The applicant does not have the right to appeal DOE's decision concerning a waiver request.

Appendix J – Cost Share Information

Cost Sharing or Cost Matching

The terms "cost sharing" and "cost matching" are often used synonymously. Even the DOE Financial Assistance Regulations, 2 CFR 200.306, use both of the terms in the titles specific to regulations applicable to cost sharing. DOE almost always uses the term "cost sharing," as it conveys the concept that non-federal share is calculated as a percentage of the Total Project Cost. An exception is the State Energy Program Regulation, 10 CFR 420.12, State Matching Contribution. Here "cost matching" for the non-federal share is calculated as a percentage of the Federal funds only, rather than the Total Project Cost.

How Cost Sharing Is Calculated

As stated above, cost sharing is calculated as a percentage of the Total Project Cost. FFRDC/NL costs must be included in Total Project Costs.

The following is an example of how to calculate cost sharing amounts for a project with $1,000,000 in federal funds with a minimum 20% non-federal cost sharing requirement:

- Formula: Federal share ($) divided by Federal share (%) = Total Project Cost
  Example: $1,000,000 divided by 80% = $1,250,000

- Formula: Total Project Cost ($) minus Federal share ($) = Non-federal share ($)
  Example: $1,250,000 minus $1,000,000 = $250,000

- Formula: Non-federal share ($) divided by Total Project Cost ($) = Non-federal share (%)
  Example: $250,000 divided by $1,250,000 = 20%

What Qualifies For Cost Sharing

While it is not possible to explain what specifically qualifies for cost sharing in one or even a couple of sentences, in general, if a cost is allowable under the cost principles applicable to the organization incurring the cost and is eligible for reimbursement under an DOE grant or cooperative agreement, then it is allowable as cost share. Conversely, if the cost is not allowable under the cost principles and not eligible for reimbursement, then it is not allowable as cost share. In addition, costs may not be counted as cost share if they are paid by the Federal Government under another award unless authorized by Federal statute to be used for cost sharing.

The rules associated with what is allowable as cost share are specific to the type of organization that is receiving funds under the grant or cooperative agreement, though are generally the same for all types of entities. The specific rules applicable to:

- FAR Part 31 for For-Profit entities, (48 CFR Part 31); and
- 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

In addition to the regulations referenced above, other factors may also come into play such as timing of donations and length of the project period of performance. For example, the value of ten years of donated maintenance on a project that has a project period of performance of five years would not be fully allowable as cost share. Only the value for the five years of donated maintenance that corresponds to the project period of performance is allowable and may be counted as cost share.

Additionally, DOE generally does not allow pre-award costs for either cost share or reimbursement when these costs precede the signing of the appropriation bill that funds the award. In the case of a competitive award, DOE generally does not allow pre-award costs prior to the signing of the Selection Statement by the DOE Selection Official.

General Cost Sharing Rules on a DOE Award

1. Cash Cost Share – encompasses all contributions to the project made by the recipient or subrecipient(s), for costs incurred and paid for during the project. This includes when an organization pays for personnel, supplies, equipment for their own company with organizational resources. If the item or service is reimbursed for, it is cash cost share. All cost share items must be necessary to the performance of the project.

2. In-Kind Cost Share – encompasses all contributions to the project made by the recipient or subrecipient(s) that do not involve a payment or reimbursement and represent donated items or services. In-Kind cost share items include volunteer personnel hours, donated existing equipment, donated existing supplies. The cash value and calculations thereof for all In-Kind cost share items must be justified and explained in the Cost Share section of the project Budget Justification. All cost share items must be necessary to the performance of the project. If questions exist, consult your DOE contact before filling out the In-Kind cost share section of the Budget Justification.

3. Funds from other federal sources MAY NOT be counted as cost share. This prohibition includes FFRDC subrecipients. Non-federal sources include any source not originally derived from federal funds. Cost sharing commitment letters from subrecipients must be provided with the original application.

4. Fee or profit, including foregone fee or profit, are not allowable as project costs (including cost share) under any resulting award. The project may only incur those costs that are allowable and allocable to the project (including cost share) as determined in accordance with the applicable cost principles prescribed in FAR Part 31 for For-Profit entities and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

DOE Financial Assistance Rules 2 CFR Part 200 as amended by 2 CFR Part 910

As stated above, the rules associated with what is allowable cost share are generally the same for all types of organizations. Following are the rules found to be common, but again, the specifics are contained in the regulations and cost principles specific to the type of entity:

(A) Acceptable contributions. All contributions, including cash contributions and third party in-kind contributions, must be accepted as part of the Prime Recipient's cost sharing if such contributions meet all of the following criteria:

(1) They are verifiable from the recipient's records.

(2) They are not included as contributions for any other federally-assisted project or program.

(3) They are necessary and reasonable for the proper and efficient accomplishment of project or program objectives.

(4) They are allowable under the cost principles applicable to the type of entity incurring the cost as follows:

a. For-profit organizations. Allowability of costs incurred by for-profit organizations and those nonprofit organizations listed in Attachment C to OMB Circular A–122 is determined in accordance with the for-profit cost principles in 48 CFR Part 31 in the Federal Acquisition Regulation, except that patent prosecution costs are not allowable unless specifically authorized in the award document. (v) Commercial Organizations. FAR Subpart 31.2—Contracts with Commercial Organizations

b. Other types of organizations. For all other non-federal entities, allowability of costs is determined in accordance with 2 CFR Part 200 Subpart E.

(5) They are not paid by the Federal Government under another award unless authorized by Federal statute to be used for cost sharing or matching.

(6) They are provided for in the approved budget.

(B) Valuing and documenting contributions

(1) Valuing recipient's property or services of recipient's employees. Values are established in accordance with the applicable cost principles, which mean that amounts chargeable to the project are determined on the basis of costs incurred. For real property or equipment used on the project, the cost principles authorize depreciation or use charges. The full value of the item may be applied when the item

will be consumed in the performance of the award or fully depreciated by the end of the award. In cases where the full value of a donated capital asset is to be applied as cost sharing or matching, that full value must be the lesser or the following:

a. The certified value of the remaining life of the property recorded in the recipient's accounting records at the time of donation; or
b. The current fair market value. If there is sufficient justification, the Contracting Officer may approve the use of the current fair market value of the donated property, even if it exceeds the certified value at the time of donation to the project. The Contracting Officer may accept the use of any reasonable basis for determining the fair market value of the property.

(2) Valuing services of others' employees. If an employer other than the recipient furnishes the services of an employee, those services are valued at the employee's regular rate of pay, provided these services are for the same skill level for which the employee is normally paid.

(3) Valuing volunteer services. Volunteer services furnished by professional and technical personnel, consultants, and other skilled and unskilled labor may be counted as cost sharing or matching if the service is an integral and necessary part of an approved project or program. Rates for volunteer services must be consistent with those paid for similar work in the recipient's organization. In those markets in which the required skills are not found in the recipient organization, rates must be consistent with those paid for similar work in the labor market in which the recipient competes for the kind of services involved. In either case, paid fringe benefits that are reasonable, allowable, and allocable may be included in the valuation.

(4) Valuing property donated by third parties.

a. Donated supplies may include such items as office supplies or laboratory supplies. Value assessed to donated supplies included in the cost sharing or matching share must be reasonable and must not exceed the fair market value of the property at the time of the donation.

b. Normally only depreciation or use charges for equipment and buildings may be applied. However, the fair rental charges for land and the full value of equipment or other capital assets may be allowed, when they will be consumed in the performance of the award or fully depreciated by the end of the award, provided that the Contracting Officer has approved the charges. When use charges are applied, values must be determined in accordance with the usual accounting policies of the recipient, with the following qualifications:

i. The value of donated space must not exceed the fair rental value of comparable space as established by an independent appraisal of comparable space and facilities in a privately-owned building in the same locality.
ii. The value of loaned equipment must not exceed its fair rental value.

(5) Documentation. The following requirements pertain to the recipient's supporting records for in-kind contributions from third parties:

a. Volunteer services must be documented and, to the extent feasible, supported by the same methods used by the recipient for its own employees.

b. The basis for determining the valuation for personal services and property must be documented.

Appendix K – Required Use of American Iron, Steel, Manufactured Products, and Construction Materials - Buy America Requirements for Infrastructure Projects (April 2023)

A. Definitions
For purposes of the Buy America Requirement, the following definitions apply:

Components See 2 CFR 184.3 Definitions

Construction Materials See 2 CFR 184.3 Definitions

Domestic Content Procurement Preference Requirement – means a requirement that no amount of funds made available through a program for federal financial assistance may be obligated for an infrastructure project unless—

(A) all iron and steel used in the project are produced in the United States;
(B) the manufactured products used in the project are produced in the United States; or
(C) the construction materials used in the project are produced in the United States.

Also referred to as the Buy America Requirement.

Infrastructure See 2 CFR 184.4(c) and (d).

Manufactured Products See 2 CFR 184.3 Definitions

Predominantly of iron or steel See 2 CFR 184.3 Definitions.

Project – means the construction, alteration, maintenance, or repair of infrastructure in the United States.

Public – The Buy America Requirement does not apply to non-public infrastructure. For purposes of this guidance, infrastructure should be considered "public" if it is: (1) publicly owned or (2) privately owned but utilized primarily for a public purpose. Infrastructure should be considered to be "utilized primarily for a public purpose" if it is privately operated on behalf of the public or is a place of public accommodation.

B. Buy America Requirement for Infrastructure Projects (Buy America Requirement)
None of the award funds (includes federal share and Recipient cost share) may be used for a project for infrastructure unless:

(1) all iron and steel used in the project is produced in the United States—this means all manufacturing processes, from the initial melting stage through the application of coatings, occurred in the United States;

(2) all manufactured products used in the project are produced in the United States—this means the manufactured product was manufactured in the United States; and the cost of the components of the manufactured product that are mined, produced, or manufactured in the United States is greater than 55 percent of the total cost of all components of the manufactured product, unless another standard for determining the minimum amount of domestic content of the manufactured product has been established under applicable law or regulation. See 2 CFR 184.5 for determining the cost of components for manufactured products; and

(3) all construction materials[1] are manufactured in the United States—this means that all manufacturing processes for the construction material occurred in the United States. See 2 CFR 184.6 for construction material standards.

The Buy America Requirement only applies to those articles, materials, and supplies that are consumed in, incorporated into, or affixed to the infrastructure in the project. As such, it does not apply to tools, equipment, and supplies, such as temporary scaffolding, brought to the construction site and removed at or before the completion of the infrastructure project. Nor does the Buy America Requirement apply to equipment and furnishings, such as movable chairs, desks, and portable computer equipment, that are used at or within the finished infrastructure project but are not an integral part of the structure or permanently affixed to the infrastructure project.

The Buy America Requirement only applies to an article, material, or supply classified into one of the following categories* based on its status at the time it is brought to the work site for incorporation into an infrastructure project:

(i) Iron or steel products;
(ii) Manufactured products; or
(iii) Construction materials;

The Buy America Requirement only applies to the iron or steel products, manufactured products, and construction materials used for the construction, alteration, maintenance, or repair of public infrastructure in the United States when those items are consumed in, incorporated into, or permanently affixed to the infrastructure. An article, material, or supply incorporated into an infrastructure project should not be considered to fall into multiple categories, but rather must meet the Buy America Preference Requirement for only the single category in which it is classified.

All iron and steel, manufactured products, and construction materials used in the infrastructure project must be produced in the United States.

* Section 70917(c) Materials are cement and cementitious materials; aggregates such as stone, sand, or gravel; or aggregate binding agents or additives as provided in section 70917(c) of BABA. Section 70917 (c) materials are excluded from Construction materials. Asphalt concrete pavement mixes are typically composed of asphalt cement (a binding agent) and aggregates such as stone, sand, and gravel. Accordingly, asphalt is also excluded from the definition of Construction materials.

Section 70917(c) materials, on their own, are not manufactured products. Further, Section 70917(c) materials should not be considered manufactured products when they are used at or combined proximate to the work site—such as is the case with wet concrete or hot mix asphalt brought to the work site for incorporation. However, certain Section 70917(c) materials (such as stone, sand, and gravel) may be used to produce a manufactured product, such as is precast concrete. Precast concrete is made of components, is processed into a specific shape or form, and is in such state when brought to the work site. Furthermore, wet concrete should not be considered a manufactured product if not dried or set prior to reaching the work site.

Further clarification is provided in 2 CFR 184 on the circumstances under which a determination is made that Section 70917(c) materials should be treated as components of a manufactured product. That determination is based on consideration of: (i) the revised definition of the "manufactured products" at 2 CFR 184.3; (ii) a new definition of "section 70917(c) materials" at 2 CFR 184.3; (iii) new instructions at 2 CFR 184.4(e) on how and when to categorize articles, materials, and supplies; and (iv) new instructions at 2 CFR 184.4(f) on how to apply the Buy America preference by category.

The Buy America Requirement does not statutorily apply to Prime Recipients that are For-Profit Entities. However, the Buy America Requirement is applicable to a For-Profit Entity if: (1) it is a sub-recipient or sub-awardee under an award that contains the Buy America Requirement term and condition, or (2) it is the Prime Recipient that voluntarily chooses to use domestically sourced iron, steel, manufactured products, and constructions materials by stating so in its proposed application containing an infrastructure project. If the For-Profit Entity specifically states that it will comply with the Buy America Requirements in its application and it is selected for award, its award will contain a Buy America Requirement for Infrastructure Projects term and condition.

The Prime Recipient is responsible for flowing the Buy America Requirement down to all sub-awards, all contracts, subcontracts, and purchase orders for work performed under the proposed infrastructure project, including to For-Profit Entities when the For-Profit Entity is a sub-recipient or sub-awardee.

Recipients must certify or provide equivalent documentation for proof of compliance that a good faith effort was made to solicit bids for domestic products used in the infrastructure project under this award.

Recipients must also maintain certifications or equivalent documentation for proof of compliance that those articles, materials, and supplies that are consumed in, incorporated into, affixed to, or otherwise used in the infrastructure project, not covered by a waiver, are produced in the United States. The certification or proof of compliance must be provided by the suppliers or manufacturers of the iron, steel, manufactured products and construction materials and flow up from all subawardees, contractors and vendors to the recipient. Recipients must keep these certifications with the award/project files and be able to produce them upon request from DOE, auditors or Office of Inspector General.

C. DOE Submission Requirements for Full Application

Within the first two pages of the workplan or project description, applicants must provide a short statement on whether the project will involve the construction, alteration, maintenance and/or repair of infrastructure in the United States. The ultimate determination about whether a project includes infrastructure remains with DOE, but the applicant's statement will assist project planning and integration of the Buy America Requirement, which may impact the project's proposed budget and/or schedule.

D. Waivers

In limited circumstances, DOE may waive the application of the Buy America Requirement in an award where DOE determines that:

> (1) applying the Buy America requirements would be inconsistent with the public interest (Public Interest);
>
> (2) the types of iron, steel, manufactured products, or construction materials are not produced in the United States in sufficient and reasonably available quantities or of a satisfactory quality (Non-Availability); or
>
> (3) the inclusion of iron, steel, manufactured products, or construction materials produced in the United States will increase the cost of the overall project by more than 25 percent (Unreasonable Cost).

DOE will only process waiver requests after an award has been made and for which the requests have been submitted in accordance with the term and conditions of the award. Waiver requests must be reviewed by DOE and the Office of Management and Budget's Made in America Office and are subject to a public comment period of no less than 15 calendar days.

DOE or OMB may request additional information for consideration of the wavier. DOE may reject or grant waivers in whole or in part depending on its review, analysis, and/or feedback from OMB or the public. DOEs final determination regarding approval or rejection of the waiver request may not be appealed by a Recipient.

Requests to waive the Buy America Requirement must include the following:

- Waiver type (Public Interest, Non-Availability, or Unreasonable Cost);
- Recipient name and Unique Entity Identifier (UEI);
- Award information (Federal Award Identification Number, Assistance Listing number);
- A brief description of the project, its location, and the specific infrastructure involved;
- Total estimated project cost, with estimated federal share and recipient cost share breakdowns;
- Total estimated infrastructure costs, with estimated federal share and recipient cost share breakdowns;
- List and description of iron or steel item(s), manufactured goods, and/or construction material(s) the recipient seeks to waive from the Buy America Requirement, including name, cost, quantity(ies), country(ies) of origin, and relevant Product Service Codes (PSC) and North American Industry Classification System (NAICS) codes for each;
- A detailed justification as to how the non-domestic item(s) is/are essential the project;
- A certification that the recipient made a good faith effort to solicit bids for domestic products supported by terms included in requests for proposals, contracts, and non-proprietary communications with potential suppliers;
- A justification statement—based on one of the applicable justifications outlined above—as to why the listed items cannot be procured domestically, including the due diligence performed (e.g., market research, industry outreach, cost analysis, cost-benefit analysis) by the recipient to attempt to avoid the need for a waiver. This justification may cite, if applicable, the absence of any Buy America-compliant bids received for domestic products in response to a solicitation;
- A description of the market research conducted that includes who conducted the market research, when it was conducted, sources that were used, and the methods used to conduct the research; and Anticipated impact to the project if no waiver is issued.

The following principles should be incorporated as minimum requirements in waiver request:

- Time-limited: Consider a waiver constrained principally by a length of time, or phased-out over time, rather than by the specific project/award to which it applies. Waivers of this type may be appropriate, for example, when an item that is “non-available” is widely used in the project. When requesting such a waiver, the recipient should identify a reasonable, definite time frame (e.g., no more than one to two years) designed so that the waiver is reviewed to ensure the condition for the waiver (“non-availability”) has not changed (e.g., domestic supplies have become more available).

- Targeted: Waiver requests should apply only to the item(s), product(s), or material(s) or category(ies) of item(s), product(s), or material(s) as necessary and justified. Waivers should not be overly broad as this will undermine domestic preference policies.

- Conditional: The recipient may request a waiver with specific conditions that support the policies of IIJA/BABA and Executive Order 14017.

[1] Excludes cement and cementitious materials, aggregates such as stone, sand, or gravel, or aggregate binding agents or additives.

Appendix L – Statement of Project Objectives Template

REMINDER: APPLICANTS SHOULD DOUBLE SPACE THE STATEMENT OF PROJECT OBJECTIVES (INCLUDING THE REQUIRED SECTIONS INDICATED BELOW) IN ACCORDANCE WITH THE FORM AND CONTENT REQUIREMENTS IN SECTION IV, "APPLICATION AND SUBMISSION INFORMATION" AND REMOVE THIS BLOCK PRIOR TO SUBMISSION.

STATEMENT OF PROJECT OBJECTIVES
Title of Project
(Insert the title of the work to be performed. Be concise and descriptive)

This should be a standalone document that states the work to be conducted and should not include any proprietary/confidential information.

A. OBJECTIVES

Include one paragraph on the overall objective(s) of the work. Note: if the project will be performed in phases, include specific objective(s) for each phase of the work.

B. SCOPE OF WORK

This section should not exceed one-half page and should summarize the effort and approach to achieve the objective(s) of the work. Note: if the project will be performed in phases, includes specific scope statement(s) for each phase.

C. TASKS TO BE PERFORMED

This section provides a brief summary of the planned approach to this project. Tasks/subtasks, concisely written, should be provided in a logical sequence and should be divided into the phases of the project, as appropriate. In writing the Statement of Project Objectives (SOPO), avoid 1) the use of proper nouns to minimize SOPO modifications in the event of changes to the project team, facilities, etc.; 2) figures and equations; 3) references to other documents and publications; and 4) details about past work and discussion of technical background (which should be covered elsewhere in the application narrative).

Task 1.0 - Project Management and Planning (REQUIRED; APPLICANT INSERT THIS TASK)

Subtask 1.1 – Project Management Plan (PMP) (REQUIRED; ALL APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES. SEE THE "PROJECT MANAGEMENT PLAN TEMPLATE" **APPENDIX M** FOR FORMAT.)

"The Recipient shall manage and direct the project in accordance with a Project Management Plan to meet all technical, schedule and budget objectives and requirements. The Recipient will coordinate activities in order to effectively accomplish the work. The Recipient will ensure that project plans, results, and decisions are appropriately documented and project reporting and briefing requirements are satisfied.

The Recipient shall update the Project Management Plan 30 days after award and as necessary throughout the project to accurately reflect the current status of the project. Examples of when it may be appropriate to update the Project Management Plan include: (a) project management policy and procedural changes; (b) changes to the technical, cost, and/or schedule baseline for the project; (c) significant changes in scope, methods, or approaches; or (d) as otherwise required to ensure that the plan is the appropriate governing document for the work required to accomplish the project objectives.

Management of project risks will occur in accordance with the risk management methodology delineated in the Project Management Plan in order to identify, assess, monitor and mitigate technical uncertainties as well as schedule, budgetary and environmental risks associated with all aspects of the project. The results and status of the risk management process will be presented during project reviews and in quarterly progress reports with emphasis placed on the medium- and high-risk items."

Subtask 1.2 – Technology Maturation Plan (TMP) (REQUIRED FOR AOI-1 AND AOI-2 ONLY; APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES. REFERENCE THE "TECHNOLOGY MATURATION PLAN" **APPENDIX G** FOR FORMAT.)

"The Recipient shall develop a Technology Maturation Plan (TMP) that describes the current technology readiness level (TRL) of the proposed technology/technologies, relates the proposed project work to maturation of the proposed technology, describes the expected TRL at the end of the project, and describes any known post-project research and development necessary to further mature the technology. The initial TMP is due 90 days after award and should be updated as needed throughout the project period of performance. A final TMP should be submitted 90 days prior to project completion."

Subtask 1.3 – State Point Data Table (REQUIRED; ALL APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES. REFERENCE THE "STATE POINT DATA TABLE" APPENDIX FOR FORMAT.)

"The Recipient shall update the State Point Data Table(s) in the format provided in **Appendix B**, for submission 90 days prior to project completion based on the experimental data acquired."

Subtask 1.4 – Technology Gap Analysis (TGA) (REQUIRED; APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES. REFERENCE THE "TECHNOLOGY GAP ANALYSIS" APPENDIX FOR FORMAT.)

"The Recipient shall prepare a Technology Gap Analysis (TGA), in the format provided in **Appendix C**, for submission 90 days prior to project completion."

Subtask 1.5 – Environmental Health & Safety (EHS) Analysis (REQUIRED; APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES. REFERENCE THE "ENVIRONMENTAL HEALTH & SAFETY (EHS) ANALYSIS" APPENDIX FOR FORMAT.)

"The Recipient shall prepare an EHS analysis that will be submitted 90 days prior to project completion in the format provided in **Appendix F**"

Subtask 1.6 – Techno-Economic Analysis (TEA) (REQUIRED; APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES. REFERENCE THE "BASIS FOR TECHNO-ECONOMIC ANALYSIS" APPENDIX FOR FORMAT.)

"The Recipient shall prepare an initial TEA that will be submitted 12 months after award and a final TEA that will be submitted 90 days prior to project completion. The initial TEA and final TEA shall be completed in accordance with the format provided in **Appendix D**."

Subtask 1.7 – Life Cycle Analysis (LCA) (REQUIRED; APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES. REFERENCE THE "LIFE CYCLE ANALYSIS" APPENDIX FOR FORMAT.)

"The Recipient shall prepare an initial LCA that will be submitted 12 months after award and a final LCA that will be submitted 90 days prior to project completion. The initial LCA and final LCA shall be completed in accordance with the format provided in **Appendix E**."

Task 2.0 – R&D Community Benefits Plan (CBP) (REQUIRED; APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES. ADD ADDITIONAL SUBTASKS AS NECESSARY. REFERENCE THE "R&D COMMUNITY BENEFITS PLAN" **APPENDIX A** FOR CBP PREPARATION GUIDANCE.)

"The Recipient shall complete work in accordance with the completed R&D Community Benefits Plan."

Budget Period 1

Task 3.0 – Host Site Agreement (REQUIRED FOR AOI-1 AND AOI-2 ONLY; APPLICANTS INSERT THE LANGUAGE PROVIDED BELOW IN QUOTES.)

"The Recipient shall submit a finalized host site agreement 6 months after award."

APPLICANTS continue with tasks/sub-tasks as necessary. If the project is structured in Phases, clearly delineate which tasks/subtasks are in each Phase.

Task 4.0 - (Title)
Task descriptions should include a concise description of the work to be conducted for each task. If the task includes subtasks, provide a general description of how each subtask is related to the overall scope of the task.

Subtask 4.1 - (Title)
Subtask descriptions should include a concise description of the work to be conducted for each subtask.

Subtask 4.2 - (Title)

Budget Period 2

Task X.X - (Title)

Budget Period 3

Task X.X - (Title)

D. DELIVERABLES (Required: Applicant insert the Language provided below in quotes and continue to complete.)

"The periodic and final reports shall be submitted in accordance with the "Federal Assistance Reporting Checklist" and the instructions accompanying the checklist. In addition to the reports specified in the "Federal Assistance Reporting Checklist", the Recipient must provide the following to the NETL Project Manager (identified in Block 15 of the Assistance Agreement as the Program Manager)**."**

Task / Subtask Number	Deliverable Title	Due Date
1.1	Project Management Plan	Update due 30 days after award. Revisions to the PMP shall be submitted as requested by the NETL Project Manager.
1.2	Technology Maturation Plan (TMP) (AOI-1 and AOI-2 ONLY)	The initial TMP is due 90 days after award. Updates to the TMP shall be submitted, as needed, throughout the project period of performance. A final TMP is due 90 days prior to project completion.
X	State Point Data Table	Due 90 days prior to project completion
X	Technology Gap Analysis (TGA)	Due 90 days prior to project completion
X	Environmental Health & Safety (EHS) Analysis	Due 90 days prior to project completion
X	Initial Techno-economic Analysis (TEA)	Due 12 months after award
X	Final TEA	Due 90 days prior to project completion
X	Initial LCA	Due 12 months after award
X	Final LCA	Due 90 days prior to project completion
X	Market Analysis (if applicable)	Due 90 days prior to project completion
3.0	Host-Site Agreement (AOI 1 and 2 ONLY)	Due 6 months after award

APPLICANT continue to identify deliverables (other than those identified on the "Federal Assistance Reporting Checklist") that will be delivered using the format provided in the table above. Ensure the delivery date to NETL is also identified. For examples: Delivery to NETL X months after completion of task/subtask X.

NOTE: If the application is selected for award, DOE may require the Recipient to include additional deliverables, provided that such deliverables are consistent with the budget, schedule, and scope of the project.

E. BRIEFINGS/TECHNICAL PRESENTATIONS (Required: Applicant insert the language provided below in quotes and continue to complete.)

"The Recipient shall prepare detailed briefings for presentation to the DOE Project Manager at their facility or virtually. The Recipient shall make a presentation to the DOE Project Manager at a project kick-off meeting held within ninety (90) days of the project start date. At a minimum, the Recipient shall provide one annual public briefing at a DOE sponsored meeting to explain the plan, progress, and results of the technical effort. A final project briefing at the close of the project shall also be given."

At the Applicant's discretion, other briefings/presentations may be added to Section E of the SOPO.

NOTE: If the application is selected for award, DOE may require the Recipient to include additional briefings/presentations, provided that such briefings/presentations are consistent with the budget, schedule, and scope of the project.

Appendix M – Project Management Plan Template

REMINDER: APPLICANTS SHOULD DOUBLE SPACE THE PROJECT MANAGEMENT PLAN IN ACCORDANCE WITH THE FORM AND CONTENT REQUIREMENTS IN SECTION IV, "APPLICATION AND SUBMISSION INFORMATION AND REMOVE THIS BLOCK PRIOR TO SUBMISSION.

The Applicant's Project Management Plan (PMP) is an approved document that defines how the Applicant will execute, monitor, and control the project to accomplish the objectives. The specific contents, level of detail, and inclusion of subsidiary planning documents are tailored according to the needs of the project. Consequently, every PMP will be different based on the risk, visibility, and/or complexity of the project and the Recipient's established processes, procedures, and systems.

Title Page:

PROJECT MANAGEMENT PLAN

{Insert Project Title}

{Date Prepared}

SUBMITTED BY
{Organization Name}
{Organization Address}
{City, State, Zip Code}

PRINCIPAL INVESTIGATOR
{Name}
{Phone Number}
{E-mail}

SUBMITTED TO
U.S. Department of Energy
National Energy Technology Laboratory

This plan should be formatted to include the following sections with each section to include the information as described below:

A. Executive Summary:

Provide a description of the project that includes the objective, project goals, and expected results. For purposes of the application, this information is included in the

Project Narrative and should be simply copied to this document for completeness, so that the Project Management Plan is a stand-alone document.

B. Project Organization and Structure:

Provide the following information in this section:

- Organizational Chart(s): Include a complete project organizational chart and sub-organization charts (if applicable), accompanied by a discussion of how the organizational structure will facilitate the performance of the Tasks and achievement of the objectives described in the SOPO within the time frame specified in the application.
- Roles and Responsibilities of Participants: Provide a discussion of key project team members, and the capacity in which each team member will assist in achieving the overall objective(s) of the proposed project. For multi-organizational or multi-investigator projects, describe the roles to be performed by each participant/investigator within the context of the Task/subtask structure contained in the SOPO. Include descriptions of any business agreements or intellectual property issues between the applicant and other members of the project team, and how these agreements will be integrated and managed.
- Decision-making and Communication Strategy: Provide a discussion of how communication and decision-making will occur within the context of the organizational structure, with particular emphasis on scientific/technical direction and mechanisms for controlling project scope, cost, and schedule. Include a discussion of how the project team will communicate with DOE and external stakeholders during the performance of the project.
- Management Capabilities: Provide information relevant to the capabilities and experience of the PI and key project team members in managing technical projects of similar nature and complexity. If applicable, include examples that demonstrate the ability to successfully meet research objectives within scope, budget and schedule.

C. Risk Management Plan:

Provide a summary description of the proposed approach to identify, analyze, and respond to perceived risks associated with the proposed project. Project risk events are uncertain future events that, if realized, impact the success of the project. Risk is inherent to all projects regardless of complexity, cost, or visibility. An effective Risk Management Plan will identify perceived risks and explain mitigation strategies for each risk. At a minimum, the Risk Management Plan shall include the initial identification of significant financial, cost/schedule, technical/scope, management, planning and oversight, ES&H, external factors, and management issues that have the potential to impede project progress and strategies to minimize impacts from those issues.

The following table format is provided but is not required:

Perceived Risks and Mitigation Strategies

Perceived Risk	Risk Rating			Mitigation/Response Strategy
	Probability	Impact	Overall	
	(Low, Med, High)			
Financial Risks:				
Cost/Schedule Risks:				
Technical/Scope Risks:				
Management, Planning, and Oversight Risks:				
ES&H Risks:				
External Factor Risks:				

D. Milestone Log:

Provide milestones for each budget period of the project. Each milestone should be linked to a specific Task or Subtask and include a title, planned completion date, and a description of the method/process/measure used to verify completion. Milestones should be quantitative and show progress toward budget period and/or project goals. Conversely, periodic, mandatory progress reports are not considered to be Milestones.

Milestones are presumed to lie on the critical path of the project, i.e., unless all milestones are achieved, the Objectives as defined in the SOPO cannot be met completely. Applicants must provide at least two milestones per year throughout the course of the project.

Milestone Format

Task/ Subtask	Milestone Title & Description	Planned Completion Date	Verification method

[Note: During project performance, the Recipient will report the Milestone Status as part of the required quarterly progress report as prescribed under the Federal Assistance Reporting Checklist. The Milestone Status will present actual performance in comparison with Planned Milestones, and include:

(1) the actual status and progress of the project,
(2) specific progress made toward achieving the project's milestones, and,
(3) any proposed changes in the project's schedule required to complete milestones.]

E. Costing Profile:

Provide a table (the Spend Plan) that projects the expenditures of government funds by fiscal year for each project team member.

Spend Plan by Fiscal Year Format

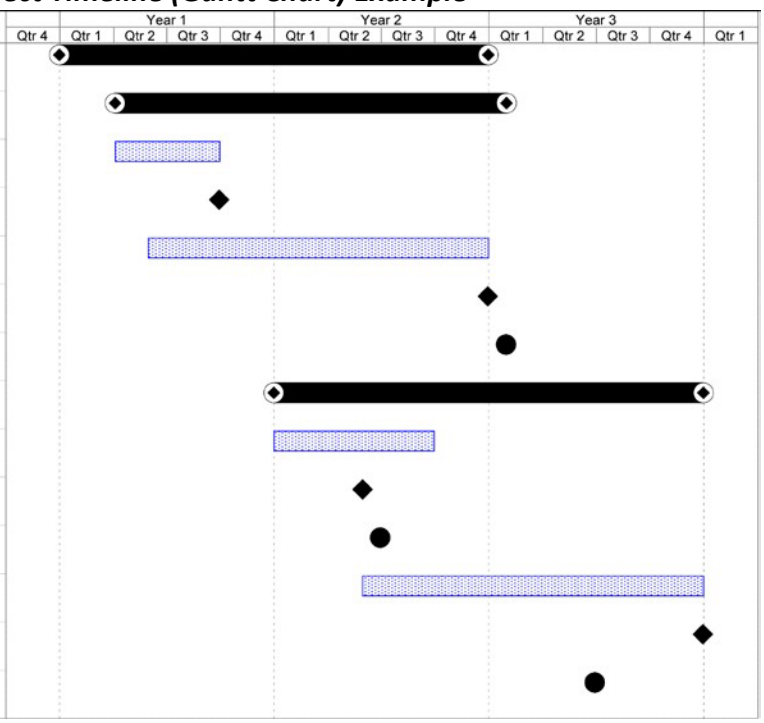
	FY 20XX		FY 20XX		FY 20XX		FY 20XX		Total	
	DOE Funds	Cost Share	DOE Funds	Cost Share	DOE Funds	Cost Share	DOE Funds	Cost Share	DOE Funds	Cost Share
Applicant										
Subrecipient A, if proposed										
Subrecipient B, if proposed										
FFRDC/NL, if proposed										
Total ($)										
Total Cost Share %										

F. Project Timeline:

Provide a timeline of the project (similar to a Gantt chart) broken down by each task and subtask, as described in the Statement of Project Objectives. The timeline should include for each task, a start date, and end date. The timeline should show interdependencies between tasks and include the milestones that are identified in the Milestone Log (Section C).

Project Timeline (Gantt Chart) Example

Task Name	Assigned Resources
Task 1.0 - Project Management and Planning	**Team Member**
Task 2.0 - Descriptive Title	**Team Member**
Subtask 2.1 Descriptive Title	Team Member
Milestone A	Team Member
Subtask 2.2 Descriptive Title	Team Member
Milestone B	Team Member
Decision Point 1	Team
Task 3.0 - Descriptive Title	**Team Member**
Subtask 3.1 Descriptive Title	Team Member
Milestone C	Team Member
Decision Point 2	Team
Subtask 3.2 Descriptive Title	Team Member
Milestone D	Team Member
Decision Point 3	Team



G. Success Criteria:

Success criteria are used by the DOE to determine if specific goals and objectives were met at the end of budget period(s), go/no-go decision points, and/or project completion. The success criteria should be objective and stated in terms of specific, measurable, and repeatable data. Usually, the success criteria pertain to desirable outcomes, results, and observations from the project.

[Note: As the first task in the Statement of Project Objectives, successful applicants will revise the version of the Project Management Plan that is submitted with their applications by including details from the negotiation process. This Project Management Plan will be updated by the Recipient as the project progresses, and the Recipient must use this plan to report scope, schedule, and budget variances.]