Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy (EERE)

MODULAR CHEMICAL PROCESS INTENSIFICATION INSTITUTE FOR CLEAN ENERGY MANUFACTURING

Funding Opportunity Announcement (FOA) Number: DE-FOA-0001578
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FOA Issue Date:	May 5, 2016
Informational Webinar:	May 11, 2016 3:00pm ET
Submission Deadline for Concept Papers:	June 15, 2016 5:00pm ET
Submission Deadline for Full Applications:	August 17, 2016 5:00pm ET
Expected Submission Deadline for Replies to Reviewer Comments:	September 15, 2016 5:00pm ET
Expected Date for EERE Selection Notifications:	Fall 2016
Expected Timeframe for Award Negotiations	120 days

- Applicants must submit a Concept Paper by 5:00pm ET the due date listed above to be eligible to submit a Full Application.

- To apply to this FOA, Applicants must register with and submit application materials through EERE Exchange at https://eere-Exchange.energy.gov, EERE's online application portal.

- Applicants must designate primary and backup points-of-contact in EERE Exchange with whom EERE will communicate to conduct award negotiations. If an application is selected for award negotiations, it is not a commitment to issue an award. It is imperative that the Applicant/Selectee be responsive during award negotiations and meet negotiation deadlines. Failure to do so may result in cancelation of further award negotiations and rescission of the Selection.

- EERE will compile an optional Teaming Partner List to facilitate the formation of new project teams for this FOA, see Section I.B. of the FOA for more information.

MODIFICATIONS

All modifications to the Funding Opportunity Announcement are [HIGHLIGHTED] in yellow in the body of the FOA.

Mod. No.	Date	Description of Modifications
0001	6/10/16	Clarified units of measurement and definitions in Section I.B and technical goals in Section I.C. Corrected the compliance criteria for Concept Papers and Full Applications in Sections IV.C.i and IV.D.i respectively. Updated content requirements for Full Applications in Section IV.D.ii, and updated and clarified the Full Application Merit Review Criteria in Section V.A.ii.

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I. Funding Opportunity Description

A. Summary

The Office of Energy Efficiency and Renewable Energy (EERE), within the U.S. Department of Energy (DOE), invests in cutting-edge research, development, and demonstration (RD&D) activities focused on sustainable transportation, renewable power, and energy efficiency. A core element of EERE's mission is to enhance U.S. global competitiveness in innovation and manufacturing in emerging clean energy industries. To address this core element, EERE launched its Clean Energy Manufacturing Initiative (CEMI) in 2013 with the goal of significantly increasing U.S. manufacturing competitiveness in the production of clean energy products and in domestic manufacturing across the board by increasing industrial energy productivity. EERE's Advanced Manufacturing Office (AMO) plays a key role in executing the mission for CEMI by supporting research and development projects, shared research facilities and technical consortia, and technical assistance programs.

AMO partners with private and public stakeholders to support the research, development, demonstration, and deployment (RDD&D) of innovative technologies that can improve U.S. competitiveness, save energy, and ensure global leadership in manufacturing of clean energy technologies as well as improve energy efficiency and reduce energy consumption in manufacturing. Specifically, AMO invests in cost-shared RDD&D activities in support of cross-cutting next generation materials and manufacturing processes that hold high potential to significantly improve energy efficiency and reduce energy-related emissions, industrial waste, and the life-cycle energy consumption of manufactured products.

EERE's AMO establishes Manufacturing Innovation Institutes in the President's National Network for Manufacturing Innovation (NNMI) as shared research, development, and demonstration facilities to overcome cross-cutting challenges related to the manufacturing of clean energy and energy efficiency products, in addition to challenges associated with improving the energy efficiency of the manufacturing sector across the board.[1] This FOA supports the establishment of a Manufacturing Innovation Institute on *Modular Chemical Process Intensification for Clean Energy Manufacturing*. Modular chemical process intensification represents an emerging opportunity for processing industries in the U.S. manufacturing sector to improve energy efficiency, reduce feedstock waste, and improve productivity by merging and integrating separate unit processes (mixing, reactions, separation) into single modular hardware elements of reduced size, with higher efficiency and providing inherent scalability.

[1] The Revitalize American Manufacturing Innovation Act of 2014, (included as Section 2, Division B, Title VII of the Consolidates and Further Continuing Appropriations Act, 2015) https://www.gpo.gov/fdsys/pkg/BILLS-113hr83enr/pdf/BILLS-113hr83enr.pdf

B. Background

The manufacturing sector uses energy to convert a wide range of raw materials, components, and parts into finished goods that meet market needs and expectations. The manufacturing sector today provides about 12% of U.S. Gross Domestic Product (GDP), employs over 12 million Americans, and is critical to future U.S. global economic competitiveness.[2] Technology-based productivity improvements have consistently driven job growth over time across the economy.[3] The manufacturing sector develops and produces many of the technologies that advance the competitiveness and growth of the entire economy, including the service sector; every dollar spent in manufacturing generates over $1.35 in additional economic activity.[4] *Advanced manufacturing* is that segment of the manufacturing sector where technology provides a competitive advantage.

The manufacturing sector, a subset of the industrial sector, consumes 24 quads of primary energy annually in the United States - about one quarter of total US energy use and roughly three-quarters of total industrial energy use.[5,6] Within the manufacturing sector, the energy-intensive subsectors of chemicals, refining, primary metals, pulp and paper, food production, and glass and concrete consume nearly two-thirds of the primary energy used in all manufacturing.[7,8]

DOE works to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions.[9] The DOE mission in clean energy manufacturing involves the minimization of

[2] Department of Labor, Bureau of Labor Statistics (2015) http://www.bea.gov/iTable/iTable.cfm?ReqID=51&step=1#reqid=51&step=51&isuri=1&5114=a&5102=15

[3] National Science and Technology Council. "A National Strategic Plan for Advanced Manufacturing." Web. February 2012. http://www.whitehouse.gov/sites/default/files/microsites/ostp/iam_advancedmanufacturing_strategicplan_2012.pdf

[4] President's Council of Advisors on Science and Technology. "Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing." Web. July 2012. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_amp_steering_committee_report_final_july_17_2012.pdf

[5] http://energy.gov/sites/prod/files/2015/09/f26/QTR2015-06-Manufacturing.pdf

[6] Non-manufacturing sectors within the industrial sector of the economy includes: agriculture, construction, forestry, fishing, and mining.

[7] Energy Intensive Industries are defined as "industry that uses significant (total) quantities of energy as part of its primary economic activity." Energy Independence and Security Act (2007) PL 110-140 Title IV Sec 452.

[8] Energy and Environmental Profiles of Manufacturing Subsectors are available at: http://energy.gov/eere/amo/energy-analysis-sector

[9] U.S. Department of Energy. 2014-2018 Strategic Plan. http://www.energy.gov/downloads/2014-2018-strategic-plan

the energy and environmental impacts from the production, use, and disposal of manufactured goods, which range from fundamental commodities such as metals, fibers, and chemicals, to sophisticated end-use products such as energy-efficient automobiles and wind turbines. To address this mission, DOE's two-pronged approach supports technologies that a) increase U.S. competitiveness in manufacturing across the board by boosting energy productivity and leveraging clean affordable domestic energy resources and feedstocks into manufacturing, and b) increase U.S. competitiveness in manufacturing clean energy technologies, by partnering with private and public stakeholders to support their research, development, demonstration, and deployment.[10]

DOE launched its Clean Energy Manufacturing Initiative (CEMI) as a cross-cutting DOE-wide effort to strengthen U.S. clean energy manufacturing competitiveness and to increase U. S. manufacturing competitiveness across the board by boosting industrial energy productivity and leveraging abundant and low-cost domestic energy resources as fuels and feedstocks.[11] Within CEMI, DOE uses Manufacturing Innovation Institutes in areas where a consortium for research, development, and demonstration has been determined through public engagement, requests for information, and internal DOE analysis, to have high potential to address a significant and potentially impactful clean energy-related advanced manufacturing opportunity.[12,13,14] To date, DOE has established two Manufacturing Innovation Institutes, led by AMO.[15,16] The first Institute, PowerAmerica, is focused on wide bandgap semiconductor technologies for next generation power electronics.[17] The second Institute, the Institute for Advanced

[10] U.S. Department of Energy. Quadrennial Technology Review. Chapter 6: Innovating Clean Energy Technologies in Advanced Manufacturing. http://www.doe.gov/qtr

[11] U.S. Department of Energy. Clean Energy Manufacturing Initiative website. http://energy.gov/eere/cemi/about-clean-energy-manufacturing-initiative

[12] The terms "Manufacturing Innovation Institutes (MIIs)," "Institutes for Manufacturing Innovation (IMIs)", "Centers for Manufacturing Innovation" and "Clean Energy Manufacturing Innovation Institutes" have all been used in different framing documents to refer to participating institutes for inclusion in the National Network for Manufacturing Innovation (NNMI). For consistency, the individual institutes will be referred to in this FOA as "Manufacturing Innovation Institutes".

[13] "U.S. DOE and DOD Manufacturing Innovation Multi-Topic Workshop" http://energy.gov/sites/prod/files/2015/04/f21/AMO-DoD-Multi-Topic-Workshop-Summary.pdf

[14] A research consortium is defined in Energy Policy Act of 2005 (PL109-58, Sec 989B) as a merit-based, competitively awarded combination of one or more: institutions of higher education, national laboratories, nonprofit and for-profit private entities, and state and local governments.

[15] U.S. Department of Energy. Advanced Manufacturing Office website. http://energy.gov/eere/amo/advanced-manufacturing-office

[16] The Advanced Manufacturing Office (AMO) is a technology office within Energy Efficiency and Renewable Energy Office of the US Department of Energy. AMO is participant in the Clean Energy Manufacturing Initiative (CEMI) of EERE and DOE. AMO will be responsible in leading the establishment and management of federal sponsorship for this Manufacturing Innovation Institute.

[17] PowerAmerica website: http://energy.gov/eere/amo/power-america

Composites Manufacturing Innovation, is focused on composite manufacturing technologies for vehicles, wind turbine blades, and compressed gas storage tanks.[18] A funding opportunity announcement for a third Institute focused on Smart Manufacturing was released in September 2015.[19] The FOA described within this document is for DOE's fourth Manufacturing Innovation Institute focused on Modular Chemical Processing Intensification for Clean Energy. These DOE led Manufacturing Innovation Institutes are participants in the Administration's broader National Network for Manufacturing Innovation (NNMI).[20]

Overview of the Manufacturing Innovation Institutes

In recognition of the vital role the advanced manufacturing sector plays and will continue to play in driving the U.S. economy and our national security, and to support a growing resurgence of U.S. manufacturing after years of decline, in 2012 the Administration proposed a National Network for Manufacturing Innovation (NNMI).[21] The vision was the creation of a network of Manufacturing Innovation Institutes to enable the transition of products and technologies from research to the marketplace.[22] The goal for these Institutes and the interagency Network is to revitalize American manufacturing and support domestic manufacturing competitiveness.

According to the National Science and Technology Council (NSTC) foundational design document for the NNMI ("National Network for Manufacturing Innovation: A Preliminary Design"),[23] Manufacturing Innovation Institutes are designed to bring together industry, universities and community colleges, federal agencies, states, and localities to accelerate manufacturing innovation and scale-up by investing in industry-relevant, cross-cutting product and process technologies. In parallel, Manufacturing Innovation Institutes provide education and training opportunities to build and enhance the skills of the American manufacturing workforce. Each Manufacturing Innovation

[18] Institute for Advanced Composite Materials Innovation website: http://energy.gov/eere/amo/institute-advanced-composites-manufacturing-innovation

[19] U.S. Department of Energy. Manufacturing Innovation Institute for Smart Manufacturing. https://eere-exchange.energy.gov/ DE-FOA-0001263

[20] Advanced Manufacturing National Program Office, National Network for Manufacturing Innovation (NNMI) website http://www.manufacturing.gov/welcome.html

[21] The White House. Office of the Press Secretary. "President Obama to Announce New Efforts to Support Manufacturing Innovation, Encourage Insourcing." March 9, 2012. http://www.whitehouse.gov/the-press-office/2012/03/09/president-obama-announce-new-efforts-support-manufacturing-innovation-en

[22] The National Network of Manufacturing Innovation (NNMI) was authorized through the Revitalizing American Manufacturing and Innovation Act of 2014. (passed as Title VII amended to the Omnibus Appropriations Act of 2014) http://www.gpo.gov/fdsys/pkg/BILLS-113hr83enr/pdf/BILLS-113hr83enr.pdf

[23] National Science and Technology Council, "National Network for Manufacturing Innovation: A Preliminary Design," January 2013. http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc_nnmi_prelim_design_final.pdf

Institute is expected to be fully independent of federal funds approximately 5 years after launch (also referred to as "self-sustaining").

Through shared research, development, and demonstration (RD&D) infrastructure and capabilities at its core, an Institute enables development, refinement, demonstration, and early industry adoption of advanced manufacturing technologies at a scale significant enough to establish feasibility while significantly reducing both the cost and uncertainty of commercializing the technologies. Institutes are expected to focus primarily on TRL/MRL 4-7 activities. (See for example Appendix E: Definition of Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs) as a systematic framework for identifying progress of technology maturation).[24]

Each Institute is organized to foster an open exchange of pre-competitive manufacturing best-practices and know-how -- including design and processing tools, qualification and certification approaches, and fabrication costing methods -- while protecting participating company-proprietary intellectual property. Each Institute includes business models to allow manufacturers of all sizes access to and use of the shared RD&D infrastructure. The Institute also provides the opportunity for its members to improve their own technologies by learning from other members. An Institute engages the manufacturing community at all levels of the supply chain, from technology developers to implementers to users, including researchers, educators, large businesses, and small and medium-sized enterprises (SMEs) to transition relevant advanced manufacturing technologies to commercial applications. The Institute must be focused on relevant problems in manufacturing.[25]

The Institutes also engage with the broader community by hosting research internships and developmental assignments for individuals from industry, academia, and government to accelerate pre-competitive development of advanced manufacturing technologies, as well as to support technical educational and workforce development of the manufacturing community around the Institute. Each Institute interacts and engages with other national, regional, and local resources and facilities, and participates in the NNMI.

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[24] Technology Readiness Levels (TRLs) were initially developed by NASA and used as milestones to assess the progression and maturation of a technology towards adoption. http://esto.nasa.gov/files/trl_definitions.pdf Analogous Manufacturing Readiness Levels (MRLs) were initially developed by the Department of Defense and used as milestones to assess the progression and maturation of a technology towards production worthiness. http://www.dodmrl.com/MRL_Deffinitions_2010.pdf The National Science and Technology Counsel (NSTC) has correlated TRLs and MRL as a framework for the NNMIs. (Reference 29, page 8). For the purposes of this FOA, the term Technology Readiness Level (TRL) will be used as reference to the combined framework for measuring technology maturation towards manufacturing adoption, as provided in Appendix F.

[25] Advanced Manufacturing National Program Office, National Network for Manufacturing Innovation (NNMI) website: https://www.manufacturing.gov/nnmi-institutes/

Institute leadership manages a national collaborative for advanced manufacturing technology and workforce development activity that strongly leverages industry consortia, regional clusters, and other resources in science, technology, and economic development. Institutes must have a strong management team and a strong organizational director. Governance of the Institute shall be clearly defined and the Institute shall have a well-defined operational plan to enable efficient operations that demonstrate value to Institute stakeholders. Institutes are expected to become financially self-sustaining after five years through activities including member fees, intellectual property licenses, contract research, and fee-for-service activities (as possible examples).

Participants in the Institute engage and conduct work at the Institute using a variety of contracting and collaboration instruments. The Institutes should be of an adequate size and scale to provide significant long-term economic impact both regionally and nationally.

With a compelling advanced manufacturing vision, an engaged industry and research partnership, a supportive local and regional economic community, a focused and capable leadership team, and a shared RD&D infrastructure, an Institute is structured to effectively and sustainably support the challenge of moving an emerging advanced manufacturing concept/capability from proof-of-principle laboratory results to private sector market opportunity in a way that has broad impact on increased U.S. manufacturing competitiveness. In doing so, each Institute, and a resulting network of Institutes, significantly enhances the competitiveness of domestic manufacturing.

Overview of Modular Chemical Process Intensification

Modular Chemical Process Intensification for Clean Energy Manufacturing is the topic of this Manufacturing Innovation Institute. Modular chemical process intensification is a set of technologies that bring significant reduction in equipment size, and improvement in energy efficiency, for the manufacturing of products requiring chemical processes. Through modularization, parallel integration, and combination of processes, process intensification approaches lead to significant benefits in energy efficiency, capital and operating expenses, quality, waste reduction, and process safety.[26] Process intensification frequently involves combining separate unit operations (such as reaction and separation) into a single piece of equipment, resulting in a more efficient, cleaner, and more economical manufacturing process. At the molecular level, process intensification technologies significantly enhance mixing, which improves mass and heat transfer, reaction kinetics, yields, and selectivity. At the core of process intensification is the optimization of process performance by focusing on molecular level kinetics,

[26] A. Stankiewicz, J.A. Moulijn. "Process Intensification" *Ind. Eng. Chem. Res.*, **2002**, *41* (8), pp 1920–1924

thermodynamics, and heat and mass transfer. These improvements translate into reductions in: complexity, equipment requirements, and facility footprint, and thereby, minimize risk and uncertainty of construction and operation in chemical manufacturing facilities, for both existing and new products.

Modular chemical process intensification has been identified by leaders from industry, government, and the research community, as a key emerging opportunity for clean energy manufacturing and advanced manufacturing more broadly (per the Department of Energy's Quadrennial Technology Review (QTR)).[27] Highlighting the connection between modular chemical process intensification and the energy mission, seventy-two (72) specific process intensification technologies were evaluated in the QTR for their potential energy benefits, of which thirty-two (32) were rated as having high or medium potential for energy efficiency and savings.[28,29,30]

Specifically, process intensification has the potential for significant benefits to many commercially relevant attributes of chemical processes,[31] such as:

- Improved energy productivity ($/kWh)
- Improved energy efficiency (% energy use reduction to produce a unit of output)
- Reduction in operating expense ($/kg of product)
- Reduction in capital expense ($/(kg of product per day))
- Improved quality (% product yield improvement)
- Waste reduction (% feedstock loss)
- Improved process safety (% unplanned downtime)

In selecting this topic, EERE has openly engaged a wide array of external stakeholders from industry (large as well as small/medium), National Laboratories, institutions of higher education, and other government agencies, in a Multi-Topic Workshop in October 2014 that included a section on High-Efficiency Modular Chemical Processes, as well as a more focused Workshop in September 2015 on Chemical and Thermal Process

[27] U.S. Department of Energy, Quadrennial Technology Review (QTR), Chapter 6, 2015. http://energy.gov/quadrennial-technology-review-2015

[28] 2007 Roadmap for Chemical Engineering. http://www.gospi.fr/IMG/pdf/roadmap2007-GP.pdf http://www.cefic.org/Documents/PolicyCentre/Reports-and-Brochure/Energy-Roadmap-The%20Report-European-chemistry-for-growth.pdf

[29] Technology Roadmap Energy and GHG Reductions in the Chemical Industry via Catalytic Processes, IEA (2013) https://www.iea.org/publications/freepublications/publication/Chemical_Roadmap_2013_Final_WEB.pdf

[30] DOE QTR Process Intensification Technology Assessment, Appendix 1.

[31] A. Stankiewicz, J.A. Moulijn. "Process intensification: Transforming Chemical Engineering" *Chemical Engineering Progress,* 96 (1) (2000), pp. 22–34

Intensification.[32,33] EERE also participated in an inter-agency workshop hosted by the National Science Foundation (NSF) to identify foundational research challenges and opportunities related to Process Intensification.[34] EERE partnered with the National Institute of Science and Technology (NIST) through the Advanced Manufacturing National Program Office (AMNPO) on the Advanced Manufacturing Technology Consortia (AMTech) program to support the development of several industry driven roadmaps relevant to modular chemical process intensification, including sector-specific and cross-cutting technology roadmaps, as well.[35,36,37,38]

With a *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing*, EERE seeks to support applied research, development, demonstration, and transition to industry of advanced equipment and methods and new technical capabilities related to the modularization, multifunctional combination, and system integration of highly efficient reaction, separation, mixing, and heating/cooling in manufacturing processes.[39,40,41] Modular chemical process intensification has significant potential for impact in multiple industrial sectors, including energy intensive industries (Chemicals, Refining, Pulp/Paper, Primary Metals, Food, etc.);[42,43] modularized and decentralized manufacturing (On-site Natural Gas Upgrading, Distributed Biorefining,

[32] EERE/AMO Multitopic Workshop 2014 Report, http://energy.gov/eere/amo/downloads/manufacturing-innovation-multi-topic-workshop Note: Listed as "Chemical Process Intensification" sessions
[33] EERE/AMO Process Intensification Workshop 2015 Report, http://energy.gov/eere/amo/downloads/process-intensification-workshop-september-29-30-2015
[34] NSF Process Intensification Workshop (2014) http://www.aiche.org/sites/default/files/docs/conferences/pi_workshop_report_11-10_a-2-final.pdf
[35] Example Roadmap in Amtech program: Sustainable Separation Processes, Creating a Roadmap to Accelerate Industrial Application of Less Energy-Intensive Alternative Separations, http://altsep.org
[36] Example Roadmap in AmTech program: Electrochemical Pathway for Sustainable Manufacturing (EPSuM) Consortium, http://nist.gov/amo/amtech/70nanb14h052.cfm
[37] Example Roadmap in AmTech program: Technologies for Advanced Manufacturing of Pulp and Paper Products, http://nist.gov/amo/amtech/70nanb14h040.cfm
[38] NIST Advanced Manufacturing Technology (AmTech) program. (through 2015) http://nist.gov/amo/amtech
[39] D.Reay, C.Ramshaw, A.Harvey "Process Intensification: Engineering for Efficiency, Sustainability and Flexibility" IChemE, (2013).
[40] J-C.Charpentier "In the Frame of Globalization and Sustainability, Process Intensification, A Path to the Future of Chemical and Process Engineering (molecules into money)" Chemical Engineering Journal 134:1 84-92 (2007).
[41] F.M.Dautzenberg, M.Mukherjee "Process Intensification Using Multifunctional Reactors" Chemical Engineering Science 56:2 251-267 (2001).
[42] Energy Analysis by Sector, (including 2015) Bandwidth Studies of Energy Intensive Industries http://energy.gov/eere/amo/energy-analysis-sector
[43] F.Friedler "Process Integration, Modelling and Optimisation for Energy Saving and Pollution Reduction" Applied Thermal Engineering 30:16 2270-2280 (2010)

etc.);[44,45,46,47,48] and cross-cutting industries within DOE's mission space (Gasification, Carbon-Capture, Tank Waste Processing, Helium-4 Separation, Wastewater Treatment, etc.). [49,50,51,52,53,54,55,56]

The benefits of process intensification are derived from combining multiple unit operations. For example, reaction and separation can be combined into a single modular piece of equipment, resulting in a more efficient, cleaner, and more economical manufacturing processes in both building and operating the resulting facilities.[57] Process intensification enables optimization of process performance via improved molecular level kinetics, thermodynamics, and heat and mass transfer. These improvements translate into reductions in process complexity, equipment requirements, scale-up costs, and facility footprint -- thereby minimizing cost and risk in manufacturing facilities. In specific applications, process intensification has been shown to have the potential for an order of magnitude reduction in capital cost, as well as achieving over 50% improvement in energy or feedstock efficiency. The domestic

[44] ARPA-E REMOTE Program. http://arpa-e.energy.gov/?q=arpa-e-programs/remote
[45] D.A.Wood, C.Nwaoha, B.F.Towler "Gas-to-Liquids (GTL): A Review of an Industry Offering Several Routes for Monetizing Natural Gas" Journal of Natural Gas Science and Engineering 9 196-208 (2012).
[46] W.M.Jack "Scaling Laws and Technology Development Strategies for Biorefineries and Bioenergy Plants" Bioresource Technology 100:24, 6324-6330 (2009)
[47] J.P.M.Sanders, J.H.Clark, G.J.Harmsenc, H.J.Heeres, J.J.Heijnend, S.R.A.Kerstene, W.P.M.van Swaaij, J.A.Moulijn "Process Intensification in the Future Production of Base Chemicals from Biomass", Chemical Engineering and Processing: Process Intensification, 51 117-136 (2012).
[48] "Equipment Design and Cost Estimation for Small Modular Biomass Systems, Synthesis Gas Cleanup, and Oxygen Separation Equipment, Task 1: Cost Estimates of Small Modular Systems", Nexant Inc., NREL/SR-510-39943 (2006)
[49] A.Qi, B.Peppley, K.Karan, "Integrated Fuel Processors for Fuel Cell Application: A Review" Fuel Processing Technology 88:1 3-22(2007)
[50] J.Klaehn, E.Peterson, C.Orme et. al."Water-Gas-Shift Membrane Reactor for High-Pressure Hydrogen Production: A Comprehensive Project Report (FY 2010 – FY 2012)" Report Number: INL/EXT-12-27377 Under Contract DE-AC07-05ID14517 (2013)
[51] E.Favre "Membrane Processes and Post-Combustion Carbon Dioxide Capture: Challenges and Prospects", Chemical Engineering Journal 171:3 782-793 (2011)
[52] D.G.Vlachos, S.Caratzoulas "The Roles of Catalysis and Reaction Engineering in Overcoming the Energy and the Environment Crisis", Chemical Engineering Science 65:1 18-29 (2010)
[53] J.Flouret, Y.Barré, H.Muhr, E.Plasari "Design of an Intensified Co-precipitation Reactor for the Treatment of Liquid Radioactive Wastes", Chemical Engineering Science, 77 176-183 (2012)
[54] Helium Stewardship Act (2013), https://www.congress.gov/113/plaws/publ40/PLAW-113publ40.pdf
[55] B.VanDerBruggen, E.Curcio, E.Drioli "Process Intensification in the Textile Industry: the Role of Membrane Technology" Journal of Environmental Management, 73:3 267-274 (2004)
[56] US. Department of Energy, "The Water-Energy Nexus: Challenges and Opportunities" (2014) http://energy.gov/downloads/water-energy-nexus-challenges-and-opportunities
[57] The improved operation of an intensified manufacturing process would result in increased energy efficiency and/or increased energy productivity for operating a facility, as compared to non-intensified facilities of the same scale (annual production volume) for the same end-product (ex: % energy efficiency and/or $/kwH). The improvement in economics for building such a facility is the cost per unit productivity of the resulting product. (ex: $ / product per day capacity)

research, development, and demonstration of a broad set of process intensification methods and equipment, applicable widely across the US manufacturing sectors, would have significant potential impact in energy and feedstock efficiency as well as manufacturing competitiveness.

The modularity of these intensified unit process technologies holds the promise to enable innovative new chemical processes to be introduced to the marketplace by scaling through manufacturing cost-reduction in the production of identical modules, rather than the existing capital intensive approach that scales up individual unit processes to larger size units. As described below, this provides a new pathway to overcome the capital intensive demonstration scale-up barrier that has traditionally slowed innovation in chemical process related industries.

Existing approaches to capital cost reduction for chemical process industries are through plant-size economies of scale, which follow a well-known square-cube empirical scaling rule relating the capital investment per unit production capacity to the total capacity of a facility. The square-cube (2/3) empirical scaling law (measured in units $/product per day) follows the relationship: $CapEx_2 = CapEx_1 (Product\ Capacity_2/Product\ Capacity_1)^{-b}$ where $b \approx 2/3$. It has long been surmised that the empirical 2/3 scaling law is related to the area/volume ratio of a facility that in turn governs the boundary conditions for mass and heat transfer in a manufacturing facility.[58]

The declining capital investment per unit production with increased total plant capacity has three relevant impacts. First, the most cost effective producer tends to be the largest scale manufacturer, assuming the resulting production capacity is full. This is particularly the case in energy intensive production of commodity products. Second, the most cost-effective large scale production facilities also result in high total capital requirements and investment risk, raising the economic barrier to demonstrating new technologies where uncertainty corresponds to potentially unacceptable capital exposure. This is borne out in a barrier to scaling of technologies such as new catalysts and new approaches to capital equipment, particularly in energy intensive industries where the role of innovation is expected to provide a cost-effective pathway to greater energy efficiency and lessen the environmental impact of manufacturing.

As shown in Figure 1, there appears to be an empirical limit to the square-cube scaling law for some very-large production facilities, where system complexity, safety costs related to the volume of entrained reactants, and uncertainty in maintaining a high factory utilization rate, limits the ability to continuously decrease capital cost with the

[58] F.T. Moore "Economies of Scale: Some Statistical Evidence" *Quarterly Jour. of Economics* v73 (1959) p232-245

size of the facility.[59] Modular production is one possible pathway to overcoming this limit to the economic scaling of chemical based production facilities.

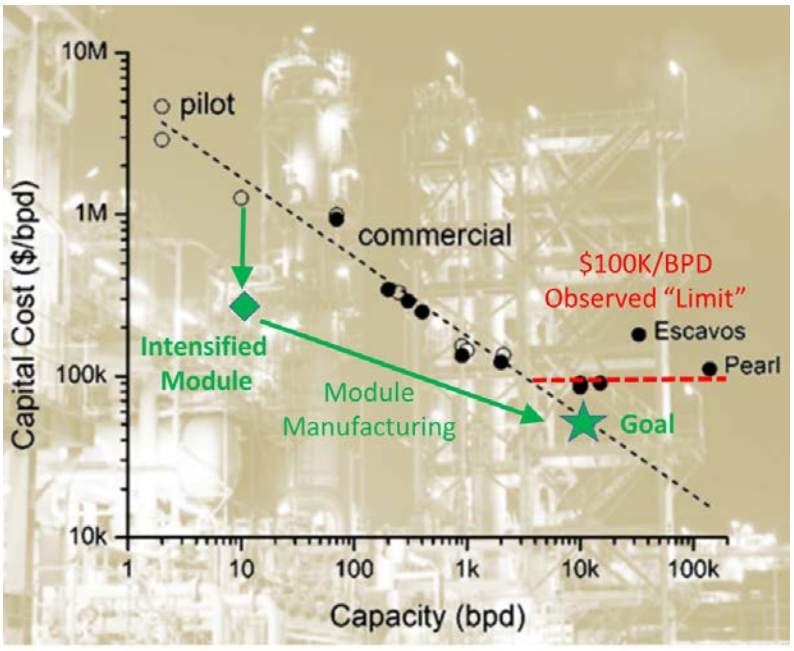

Figure 1. Example of the empirical square-cubed scaling law for the capital cost of gas-to-liquids production facilities relative to the production capacity of equivalent facilities. Note there is an observed limit to scaling at about $100K/barrels per day (BPD). However, through the modular intensification of a smaller scale chemical process, and the economies of scale in mass manufacturing the resulting modules, the observed economic limit to large scale production has the potential to be overcome. This is a significant motivation for the focus on modular chemical process intensification in this proposed Institute.

With mass production of individual modules to achieve large total production scale, declining capital costs are achieved through a learning curve (experience curve) in the production of the modules themselves. This approach to scaling chemical processes provides a possible new pathway to overcoming the limits to economic scaling, as well as providing a capital-efficient opportunity to overcome the barriers to the introduction of new technology.[60,61] Also referred to as 'scaling out', achieving economies of scale

[59] Modified from D.Boysen "Modular Chemical Processes: A Revolution in Process Technology to Capture America's Natural Gas Opportunity" Gas Technology Institute (2015). https://www.biorenew.iastate.edu/files/2015/05/Modular-Chemical-Processing.pdf

[60] L. Argote and D.Epple "Learning Curves in Manufacturing" *Science*; 247, 4945 (Feb 23, 1990) p. 920

[61] A learning curve is described by $Y_i=AX_{of}^{-r}$ where Yi is the production cost of the Xi the cumulative unit. A is a scaling constant and r is the learning constant. This corresponds to a production cost relationship of $F= 2^{-r}$, with F being the percentage the unit cost is reduced to for every doubling of cumulative production. A cost reduction of

through capital cost reduction, as a function of the cumulative units of equipment production, has been observed in many energy related products, including solar photovoltaics, wind turbines, and fuel cells.[62,63,64] It is projected that an economically viable technology for subsequent private sector adoption will require two things: an order of magnitude reduction in capital cost through process intensification for a module, and a minimum 20% reduction in modelled unit-cost for each doubling in cumulative production of the process module units.[65] The proposed *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing* will address technology and workforce development challenges in achieving this vision for new and fundamentally more scalable processes for application in clean energy manufacturing.

To achieve this vision, it is recognized that high fidelity modeling and simulation are essential to advancement of modular chemical process intensification, and it is expected that a proposed Institute might openly leverage existing public investment supporting the use of High Performance Computing (HPC) in manufacturing applications.[66] Similarly, it is recognized that advanced sensors, process controls, and communication platforms, are essential to realizing modular chemical process intensification for real-time operation, and it is expected that a proposed Institute might leverage (on an open and fair basis) a pending Smart Manufacturing Institute, as well as other Institutes in the NNMI.[67,68] Plans for partnership and engagement with these two activity areas (without duplicating efforts) would be expected as a part of any Institute management plan, including partnerships through the NNMI.[69]

While some elements of modular chemical process intensification technology exist in some form and level of maturity today, the scale of the required industry collaboration

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one order of magnitude (90% reduction to 10% of the initial unit cost) over a cumulative production of three orders of magnitude (1,000th unit) corresponds to a doubling cost reduction to F=80% and learning rate of r=.32. This illustrative example corresponds to a learning rate needed to reduce costs from $500/BPD at 10 BPD to $50/BPD at 10,000 BPD using parallel modules.

[62] A.McDonald, L.Schrattenholzer "Learning rates for energy technologies" Energy Policy 29 (2001) 255-261

[63] K. Ibenholt "Explaining learning curves for wind power" Energy Policy 30 (2002) 1181–1189

[64] H. Tsuchiya and O. Kobayashi "Mass production cost of PEM fuel cell by learning curve" International Journal of Hydrogen Energy 29 (2004) 985 – 990.

[65] For comparison, the automotive (piece part) industry experiences a 10%-15% in cost reduction for doubling of cumulative production. The semiconductor industry can experience nearly a 30%-50% decline in cost per every doubling in cumulative production.

[66] High Performance Computing for Manufacturing (HPC4MFG), https://hpc4mfg.llnl.gov/

[67] DOE Funding Opportunity Announcement: DE-FOA-0001263 Manufacturing Innovation Institute for SMART Manufacturing: Advanced Sensors, Controls, Platforms, and Modeling for Manufacturing, https://eere-exchange.energy.gov/ DE-FOA-0001263

[68] National Network for Manufacturing Innovation (NNMI) Institutes, https://www.manufacturing.gov/nnmi-institutes/ (2016)

[69] National Network for Manufacturing Innovation (NNMI) Preliminary Design, NSTC/PCAST (2013) https://www.manufacturing.gov/files/2015/12/NNMI_prelim_design.pdf

and development needed to advance the enabling technologies, test-bed platforms, and widespread cost-effective adoption of these technologies, is beyond the scope of individual private sector organizations (particularly for small- and medium-sized enterprises). Global leadership in technology development and workforce training is expected to result from the development of modular chemical process intensification in a public-private partnership with the U.S. manufacturing enterprise, resulting in significant positive impacts on the U.S. economy and the overall state of domestic manufacturing, while reducing energy consumption and greenhouse gas emissions (GHG) in energy-related manufacturing industries, and creating new business opportunities for small, medium, and large sized enterprises.

Teaming Partner List

In order to facilitate the widest possible national participation in an Institute, EERE is compiling a Teaming Partner List to facilitate the formation of new project teams for this FOA. The Teaming Partner List will be available on EERE Exchange at https://eere-Exchange.energy.gov under FOA, DE-FOA-0001578. The Teaming Partner List will be updated periodically until the close of the Full Application period, to reflect new Teaming Partners who have provided their information. Any organization that would like to be included on this list should submit the following information to ModularChemicalPI@ee.doe.gov with the subject line "Teaming Partner Information":

> Organization Name, Contact Name, Contact Address, Contact Email, Contact Phone, Organization Type, Area of Technical Expertise, and Brief Description of Capabilities.

By submitting the above Teaming Partner Information, you consent to the publication of the above-referenced information as part of the Teaming Partner List. By facilitating this Teaming Partner List, EERE does not endorse or otherwise evaluate the qualifications of the entities that self-identify themselves for placement on the Teaming Partner List. EERE will not pay for the provision of any information, nor will it compensate any respondents for the development of such information.

C. Focus Areas and FOA Goals

The opportunity to be addressed in this FOA is the applied research, development, and demonstration, of Modular Chemical Process Intensification technology for processing industries in the U.S. manufacturing sector, to improve energy efficiency, reduce feedstock waste, increase scalability, increase potential for the use of distributed energy resources and feedstocks, and improve productivity.

Process intensification is framed around four technical principles: maximized effectiveness of intramolecular and intermolecular interactions; uniformity of molecular

scale experience through process modules; optimized driving force for reactions at all scales and surface areas, at relevant scales within modules; and maximized synergistic chemical and thermal effects throughout modules to reduce energy usage, reduce carbon intensity, and improve feedstock utilization on an economically competitive basis.[70] Modular chemical process intensification approaches that achieve all or some of these molecular-level optimizations are likely to be transformative by merging and integrating separate unit processes (mixing, reactions, separation) into single modular hardware elements of reduced size, higher efficiency, and scalability.

As described above, modular chemical process intensification also represents an opportunity to transform industrial process economics from a scale-up paradigm (where cost declines at a square-cube scaling law) to a scale-out approach, where the learning from and new manufacturing technologies for the production of multiple parallel modules leads to cost-effective economics.[71,72,73] As a result, it is expected that new technologies will be developed in this Institute for both the intensification of chemical processes in modular systems, and the potentially cost effective / high-throughput manufacturing of chemical process modules and components.

Application Focus Areas for Modular Chemical Process Intensification

Three energy related application focus areas for modular chemical process intensification are: 1) energy intensive industries, 2) modular and decentralized manufacturing, and 3) other energy related industries. It would be expected that a *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing* would have a balanced portfolio of technologies and workforce development, resulting in positive and direct benefit in all three of these impact areas. Applicants must address how they will engage with and have impact in all of these areas, as well as any other well justified application areas to be pursued by an Institute. Within these application focus areas, a non-exhaustive set of specific candidate opportunities for an Institute are given below:

[70] T.VanGerven, A.Stankiewicz "Structure, Energy, Synergy, Time – The Fundamentals of Process Intensification" Ind. Eng. Chem. Res. 48, 5 (2009).

[71] A.Qi, B.Peppley, K.Karan, "Integrated Fuel Processors for Fuel Cell Application: A Review" Fuel Processing Technology 88:1 3-22 (2007)

[72] D.Boysen "Modular Chemical Processes: A Revolution in Process Technology to Capture America's Natural Gas Opportunity" Gas Technology Institute (2015). https://www.biorenew.iastate.edu/files/2015/05/Modular-Chemical-Processing.pdf

[73] C.Bramsiepea, S.Sievers, T.Seifert, G.D.Stefanidis, D.G.Vlachos, H.Schnitzer, B.Muster, C. Brunner, J.P.M.Sanders, M.E. Bruins, G.Schembecker "Low-Cost Small Scale Processing Technologies for Production Applications in Various Environments—Mass Produced Factories" Chemical Engineering and Processing: Process Intensification 51 32-52 (2012)

1. Energy intensive industries: Manufacturing accounts for approximately one quarter of total U.S. energy consumption.[74] Energy-intensive industry sectors of chemicals, petroleum refining, pulp and paper, and primary metals production, in that order, are the largest manufacturing sector energy consumers – each consuming more than 1 quadrillion BTUs (Quad) of energy per year – and offer large opportunities for potential energy reductions in the manufacturing sector, as identified in DOE's recently published Bandwidth Studies (see Figure 2). [75]

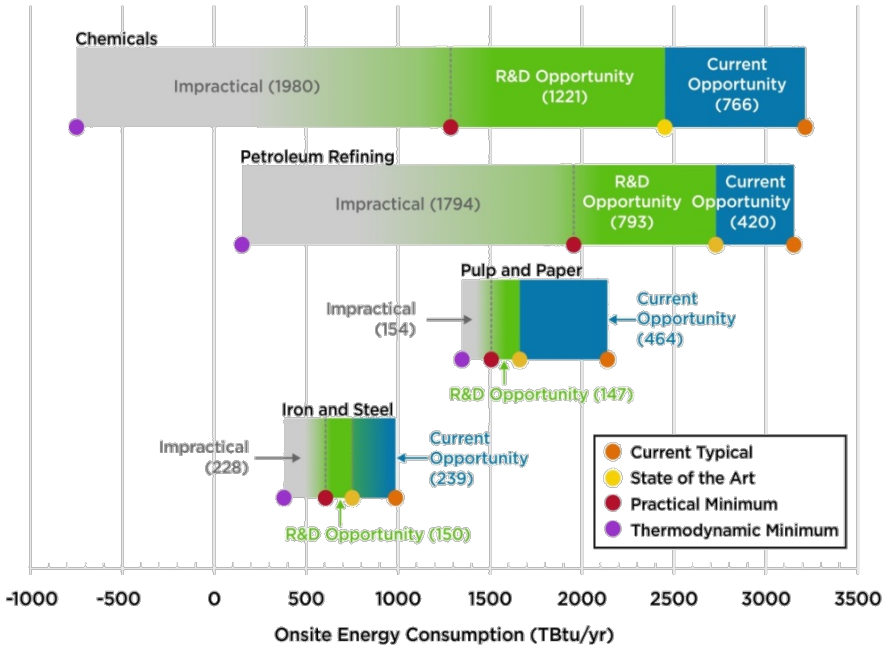

Figure 2. EERE Bandwidth Studies: Energy Savings Potentials for Four Most Energy Intensive Manufacturing Subsectors – Chemicals, Refining, Pulp-Paper and Primary Metals (Iron & Steel).

These Energy Bandwidth studies identify the chemical industry as the top energy consuming manufacturing sub-sector in the U.S., in addition to the sector with the largest energy savings improvement opportunity window through R&D. As a technology which increases chemical reaction efficiency and more closely couples latent heat from reactions to process heating of chemical feedstocks, process intensification has the potential to greatly improve energy efficiency in chemical manufacturing.

[74] http://energy.gov/sites/prod/files/2015/09/f26/QTR2015-06-Manufacturing.pdf

[75] U.S. DOE, Energy Bandwidth Studies can be access here: http://energy.gov/eere/amo/energy-analysis-sector select 'Bandwidth Studies'

One example is the energy intensive cracking of hydrocarbons to ethylene, a process which consumes the most energy of all chemicals (non-electrochemically) manufactured domestically. Process intensification approaches proposed to significantly improve energy efficiency of this process include microwave-enhanced ethylene cracking, with the potential to save 30%–50% as compared to existing approaches.[76,77]

Another intensified approach to ethylene cracking would require the efficient separation of non-condensable gas phase reaction products (C_2H_6, C_2H_4, H_2), eliminating repeated heating/mixing and cooling/separation Other possible process intensification approaches to ethylene cracking could include: membrane reactors and separators, microchannel reactors for the catalytic ethane oxidative dehydrogenation pathway; microchannel reactors for catalytic dehydration of bioethanol to ethylene; and reactive absorption and adsorption with metal organic frameworks (MOFs) for separations.[78]

While ethylene cracking is used as one illustrative example where process intensification can have an impact on energy intensive industries, the opportunity for the use of process intensification technology exists in every energy intensive manufacturing sector, including refining, pulp-paper, food processing, and primary metals. A *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing* would be expected to address multiple of these opportunities.[79]

2. Modular, decentralized manufacturing: Traditional chemical conversion and separation processes rely on plant-level economies of scale to capture increased efficiency, resulting in large scale centralized manufacturing, with fuel and feedstocks brought in to a centralized plant from the point of production (fields for oil/gas, farms for biomass.) Because process intensification technologies combine and reduce processing steps within single modules, process intensification has the potential to revolutionize chemical processing from large-scale, fixed-asset chemical plants to small-scale modular facilities closer to the point of feedstock generation on a decentralized basis. This decentralized manufacturing would be able to flexibly and cost-effectively respond to changing economics.

The development of modular chemical process intensification approaches will also provide a new basis for scaling of chemical related processes. Rather than scaling-up to larger production size for an individual facility (in which economies of scale reduce costs

[76]Ng, S.; Fairbridge, C.; Mutyala, S.; Liu, Y.; Bélanger, J. R.; Paré, J. R. J. "Microwave-Assisted Conversion of Ethane to Ethylene," Applied Petrochemical Research, vol. 3, 2013; pp. 55-61.
[77] Fall, M.; Wagner, E.; Cabe, F.; Eagleson, G.; Carnahan, J.; Lal, R., et al., "Microwave Enhanced Cracking of Ethane for Ethylene Production," presented at the 24th Annual Ethylene Producers Conference, Houston, Texas, 2012.
[78] DOE QTR 2015. Process Intensification Technology Assessment.
[79] D. Reay "The role of process intensification in cutting greenhouse gas emissions" Applied Thermal Engineering 28 (2008) 2011–2019.

at a cube-square scaling relationship), a modular process can be scaled-out through equipment manufacturing economies of scale and the massive parallelization of identical modules. Process intensification provides a new way of achieving cost-reduction, enabled by economies of scale in chemical manufacturing, as the mass-production of the individual modules proceeds down a learning curve.

Use of multiple modules of lower production capacity to meet production volumes of typical large scale manufacturing will require that the cost of building each successive module decreases as well. As previously shown in Figure 1, for the example of a Gas to Liquids process, a plant that costs $1,000K/BPD and produces 10 BPD can be scaled to an observed limit of $100K/BPD for production at 10,000 BPD and larger. As an alternate approach through modularization, an order of magnitude improvement in energy productivity might enable a process module that produces 10 BPD at a capital cost of $250K/BPD. The mass-manufacturing of individual modules themselves would have a learning curve resulting in a cost reduction for individual units (estimated at more than 15% per doubling of cumulative modules produced). Through the economies of scale in the manufacturing of modules, which would then be operated in parallel, the capital cost for production of larger volumes could be less than half the cost of the best available scaled-up process. As a result, the modularization of chemical processes leads to inherently scalable processes providing a new, lower-risk, and capital efficient pathway to adoption of new technologies in manufacturing.

Earlier research has shown the potential for modular, continuous production technology for low to medium scale run-rates for a range of products, from solvent-free polymers, specialty surfactants, and pharmaceutical intermediates to polymers produced from renewable resources.[80] For example, process intensification techniques were demonstrated by a scalable mixer-heat exchange reactor concept in a process that managed heat in the radical polymerization reaction. These types of processes are usually run in batch mode with a long cycle time and semi-continuous addition of reactants to control the exothermic reaction. This new technology was demonstrated at lab scale in continuous operation with intensification factors of 10 to 100 for residual monomer content (a measure of how effective the reactants are converted) at a shared process evaluation facility in Europe.[81] This modular demonstration scale process could be deployed on a distributed basis closer to end-users of the product. While these are specific examples of potential opportunities for distributed process intensification, the Institute would be expected to demonstrate platform capabilities and perform cross-cutting research that could be used in multiple application areas with potential for distributed processing. For example, developing best practices for a common process

[80] F3 Factory Final report 2014.
http://f3factory.com/scripts/pages/en/newsevents/F3_Factory_final_report_to_EC.pdf
[81] F3 Factory Water Soluble Polymer, Solvay, BASF, TU, CNRS, INVITE.

footprint, design rules, operating principles, training, connectivity and interoperability could benefit multiple applications.

3. Other energy-related industries: Process intensification technologies have promising application to many energy-related industries across the DOE portfolio.

Process intensification technologies can be applied in oil and gas (well-head gas separation, distributed gas-to-liquid conversion, fractional distillation), coal (modular gasification), specialty chemicals (distributed feedstocks), food manufacturing (microwave-enhanced heating and wet-mill separation), and biofuels and bio-chemicals (gasification, alcohol separations) among others.[82] In addition to opportunities in EERE applications, there is strong potential for process intensification technologies to improve the energy and environmental performance in the fossil fuel industry, including in carbon capture and sequestration (CCS). [83,84,85] Process intensification can be applied to the management of chemical waste as part of DOE's environmental management mission, including technologies to potentially reduce the out-year liability for processing tank waste.[86] Process intensification can also address RD&D for the national challenge around the separation and capture of helium-4 from natural gas streams, as highlighted in the Helium Stewardship Act of 2013.[87] The cross-cutting nature of process intensification for energy applications will provide breadth and diversity to Institute membership, and sustainable support by the private sector.

One potential opportunity is the use of modular chemical process intensification to unlock distributed feedstocks like natural gas, shale gas, and other stranded energy resources (e.g., methane from wastewater facility off-gas) to manufacture fuels and chemicals. [88,89] In an example relevant to the reduction of GHG aligned with the DOE fossil energy mission, it has been estimated that approximately 0.25 quads of natural gas are flared domestically (5.3 quads globally)[90] emitting at least 13 million tonnes of

[82] W.M.Jack "Scaling Laws and Technology Development Strategies for Biorefineries and Bioenergy Plants" Bioresource Technology 100:24, 6324-6330 (2009)
[83] See References: 49 through 56 for illustrative examples.
[84] D.G.Vlachos, S.Caratzoulas "The Roles of Catalysis and Reaction Engineering in Overcoming the Energy and the Environment Crisis", Chemical Engineering Science 65:1 18-29 (2010)
[85] Wang, M., et.al. "Process intensification for post-combustion CO2 capture with chemical absorption: A critical review" Applied Energy. Volume 158. 15 November 2015. pp 275-291.
[86] J.Flouret, Y.Barré, H.Muhr, E.Plasari "Design of an Intensified Co-precipitation Reactor for the Treatment of Liquid Radioactive Wastes", Chemical Engineering Science, 77 176-183 (2012)
[87] Helium Stewardship Act (2013), https://www.congress.gov/113/plaws/publ40/PLAW-113publ40.pdf
[88] DOE QTR 2015. Process Intensification Technology Assessment.
[89] https://www.americanchemistry.com/Policy/Energy/Shale-Gas/Slides-Shale-Gas-and-New-US-Chemical-Industry-Investment138-Billion-and-Counting.pdf
[90] http://www.eia.gov/dnav/ng/hist/n9040us2a.htm, http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTOGMC/EXTGGFR/0,,contentMDK:21023030~menuPK:2856589~pagePK:64168445~piPK:64168309~theSitePK:578069,00.html

CO_2 annually in the U.S.[91] because this associated gas is uneconomical to collect. Associated gas in non-traditional oil production is estimated to not be economical to capture until an oil-to-gas price ratio of 15:1 or lower is reached.[92] Process intensification could enable distributed conversion of stranded natural gas to higher value fuels and chemical products onsite, with the potential to be economical to gather, instead of flaring.

In electric power generation, areas where process intensification has the potential to lower cost or increase efficiency include: on-site membrane based reactive separations for hydrogen generation, that can subsequently be used either in fuel cells to generate electricity, or as a generator coolant gas, from gasification and microchannel steam reformers.[93,94]

A cross-cutting energy efficiency related technology area for process intensification is thermal processes, as process heating accounts for 7.2 quads of energy in the US.[95] For example, microwave-enhanced processing applied to food manufacturing, where volumetric heating of a flowing liquid (or suspensions) can efficiently heat products while minimizing thermal damage, can be used for microbial inactivation (pasteurization and sterilization).[96] Microwave heating has also been shown on the laboratory scale to reduce the energy intensity of manufacturing of carbon fiber compared to traditional process heating in the oxidation and carbonization furnaces.[97,98] In bio-fuels processing, researchers have demonstrated that base-catalyzed transesterification of bio-oils could reduce reaction time from one hour to 1-2 minutes in the production of biodiesel through the microwave intensification of thermal processes.[99] As a result, manufacturers of intensified thermal processing equipment might partner in an Institute for the design, development, and application of alternative heating equipment (e.g., microwave-based technologies) to reduce risk for equipment development by partnering with users through this consortium.

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[91] EPA Center for Corporate Climate Leadership Emission Factors for Greenhouse Gas Inventories. 19 November 2015.

[92] http://bv.com/Home/news/solutions/energy/us-natural-gas-flaring-is-attracting-increased-attention

[93] Liu, P., et al. "Process intensification in hydrogen production from coal and biomass via the use of membrane-based reactive separations." *Current Opinion in Chemical Engineering. Vol 1, Issue 3, p.342-351 August 2012.*

[94] Bossard, P., et al. "Process Intensification for Hydrogen Generation Using Micro-Channel Steam Reforming" 2012 AICHe Annual Meeting. Conference Presentation.

[95] http://energy.gov/sites/prod/files/2015/10/f27/manufacturing_energy_footprint-2010.pdf

[96] See for example:

- Microwave Sterilization FAQ sheet - http://microwaveheating.wsu.edu/factsheet/index.html
- US FDA - http://www.fda.gov/Food/FoodScienceResearch/SafePracticesforFoodProcesses/ucm100250.htm

[97] DOE sponsored research at ORNL.http://www1.eere.energy.gov/vehiclesandfuels/pdfs/success/microwave_assisted_plasma.pdf

[98] Teijin Toho Tenax Website. http://www.teijin.com/news/2016/ebd160114_48.html

[99]http://etd.lsu.edu/docs/available/etd-04192010-152017/unrestricted/Kanitkarthesis.pdf

To address illustrative examples of possible process intensification applications (and others proposed and justified by an Applicant) in energy industries, an Institute would become a place for innovation in multiple related applications, thereby establishing itself as the globally acknowledged leader in this important emerging technology for energy and manufacturing.

Technical Focus Areas enabling Modular Chemical Process Intensification:
EERE has identified the following high-priority technical focus areas for the *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing*. Applicants are expected to develop their plan of work to address the progress they can make in these technical focus areas as a portfolio of activities within the Institute. Other well justified technical focus areas may be proposed, provided they are justified as being relevant to enabling modular chemical process intensification.

- **Applied research, development and demonstration of methods, tools, technical know-how, and equipment for modular intensified chemical processes with core capabilities to create a sustainable Institute** including, but not limited to:

    - Reaction methods – New approaches to combining reactions with mass and thermal transport operations, membrane reactors, improved modeling and design tools for reactors, and new catalyst materials and structures. This could include the foundational investigation of new materials and approaches, as well as the degradation over time due to corrosion or loss-of performance, as enabling technologies for intensified reactors.

    - Separations – Cost effective and reaction-efficient alternatives to thermal distillation and the applied research, development, and manufacturing of lower cost higher temperature membranes for membrane assisted and membrane distillation and other separation processes. Separations consume about 22% of onsite energy use in many manufacturing industries and is an area for innovation.[100] As a result, technologies to develop low cost, high performance, value-added functional separation membranes are of interest.[101]

    - Mixing - Heat exchangers, mixers, and microchannel reactor designs which can handle extreme thermal gradients, and the development of lower cost materials for high temperature and extreme service environments. Many

[100] DOE QTR. Process Intensification QTR Technology Assessment. 2015.
[101] AMO Workshop on High-Value Roll-to-roll manufacturing (2015): http://energy.gov/eere/amo/downloads/workshop-high-value-roll-roll-hv-r2r-manufacturing-innovation-december-2-3-2015

reactions are mass transfer limited, so addressing mixing and developing hybrid approaches will further enable higher efficiency reactions.

- Heating – New enabling technology approaches to localized heating and cooling through use of alternative thermal technologies such as RF, laser and microwave energy for heating and solid-state refrigeration materials for localized cooling.

- Materials – Corrosion and degradation resistant materials and manufacturing processes for fabricating complex shapes and structure intensified processes (such as additive fabrication of micro-reactors) would provide new capabilities in intensified processes.[102] Additionally, the applied research and development of processes for the fabrication of chemically active multi-materials such as new catalyst materials and catalyst - substrate structures would enable the application and use of new catalyst structures in chemical reaction systems.

- **Development and test-bed demonstration of intensified integrated process modules.** The Institute will also support shared testing facilities and prototype equipment development to demonstrate process intensification processes and equipment at a scale sufficient to demonstrate viability. The Institute could develop a representative test bed (including establishing standards for test-bed requirements) or a facility to baseline new processes and equipment through the applied R&D. The resulting data would be openly shared among Institute members. Additionally, the Institute may create a standard modular prototype system where case studies for more specific vertically integrated teams could be executed for more competitively sensitive activities under common parameters to enable proof of concept and de-risk the deployment of such technologies. Development and test-bed of the physical hardware also provides an opportunity to demonstrate complementary information technology related innovations in sensors, controls, and data algorithms (Digital and/or Smart Manufacturing) developed with NNMI Institute partners as scalable and secure cyber-physical systems.

- **Module manufacturing applied research, development, and demonstration.** The Institute will develop a portfolio of applied research, development and demonstration of manufacturing technologies needed to drive down the cost of producing intensified chemical process modules with cumulative production volumes, including automated and low-cost manufacturing approaches for individual

[102] AMO Workshop on Materials for Harsh Service Conditions (2105): http://energy.gov/eere/amo/downloads/workshop-materials-harsh-service-conditions-november-19-20-2015

reactor modules, enabling cost reduction through economies of mass manufacturing and parallelization of modules.

- **Applied research, development, and knowledge dissemination of cross-cutting process intensification technologies** that include alternative approaches to thermal energy input (electro-magnetic technology, direct energy technologies, rotational buoyancy gradient separation, etc.) for process heating and driving forces; hybrid or multifunctional reactions and separations; enabling technologies to address fouling and degradation of membranes as well as the regeneration of catalysts; development of harsh service environment materials for process intensified hardware; advanced simulation, processing and data management tools to maximize design and implementation productivity of modular systems.

- **Development of open-architecture, open-standard, and open-source (when possible) software and design tools** for design and application of modular chemical process intensification technologies that are applicable across multiple and diverse industries. This includes the application of advanced simulation and modeling of chemical processes and equipment, including the development of codes for multiscale, and the application of high-performance computing (HPC) capabilities in both the design and the operation of modular chemical process intensified systems.

The Institute is expected to establish core technical capabilities, to encourage cross cutting applications, and to address technologies in a precompetitive landscape. The cross cutting, precompetitive facilities and R&D work and the manufacturing demonstration shared facilities are envisioned to support teams addressing shared technical challenges. As technologies mature, the proposed Institute will further partner with industry to demonstrate/de-risk these technologies in specific first-of-kind applications in a realistic manufacturing environment.

Workforce development and education is a key aspect of manufacturing Institutes and evidence from survey data as well as responses from AMO's workshop participants support that most university research and education programs have shifted away from a process engineering focus (unit operations – separations, mixing, etc.) to a product focus (nano- or biomaterials) in chemical engineering departments.[103] Pilot scale facilities will enable hands-on application for operations and earlier stage R&D facilities and work will enable students to develop industry-relevant knowledge and experience in creating new processes, design unit operations, and scale up technologies.

[103] http://www.aiche.org/sites/default/files/docs/conferences/2015che_academicindustry alignmentstudy.compressed.pdf

Funding Opportunity Announcement Goals

The NNMI program has defined overall objectives for each Institute:[104]

- to research, develop and demonstrate high-impact new advanced manufacturing technologies that are adopted into the market at scale for energy efficient manufacturing and clean energy and energy efficient product manufacturing;
- to be financially self-sustaining after 5 years;
- to train an advanced manufacturing workforce; and to enrich the innovation ecosystem and strengthen US manufacturing competitiveness; and
- to establish an industrial consortium as a public-private partnership (including small and medium sized manufacturers).

In meeting these overall objectives for the NNMI program, Applicants for the *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing* must address the following key elements consistent with the design model for all Manufacturing Innovation Institutes:

a) Lead a national effort to research, develop, test, and demonstrate industrially-relevant, high-impact modular chemical process intensification technologies and solutions, primarily in TRL/MRL 4-7 for energy intensive and clean energy and energy efficient product manufacturing with an Institute membership that includes initial partners, as well as a structure for new partners that were not part of the Institute application;

b) Establish and support a modular chemical process intensification-related shared RD&D infrastructure that enables ready and affordable access to cutting-edge physical and virtual tools - as well as expertise - to reduce the cost and risk of commercialization, address technical challenges that may arise from scale-up and production at a manufacturing-relevant scale, and provide data to enable business case development. This infrastructure leverages relevant existing private and public sector resources and facilities such as industry laboratories, university centers, National Laboratories, and other government investments;

c) Provide capabilities for and collaboration in open, pre-competitive work among multiple parties including collaboration around the development of open architecture, open standard, and open source software and design platforms and tools in an Intellectual Property (IP) protected environment, as well as proprietary

[104] From the Revitalize American Manufacturing Innovation Act of 2014, (included as Section 2, Division B, Title VII of the Consolidates and Further Continuing Appropriations Act, 2015) https://www.gpo.gov/fdsys/pkg/BILLS-113hr83enr/pdf/BILLS-113hr83enr.pdf

activities as appropriate, to engage stakeholders as relevant to the modular chemical process intensification technology area;

d) Be a financially self-sustaining, world-leading innovation hub that brings together private and public entities to co-invest in the research, development, commercialization, and deployment of innovative modular chemical process intensification technologies;

e) Establish a technical education and workforce development program to support technical and career education that will leverage relevant existing resources to develop the modular chemical process intensification workforce needed to research, develop, and commercialize new modular chemical process intensification technologies and solutions and to demonstrate and deploy these solutions widely within U.S. industry; and

f) Define, manage and implement clear operating structures and strategies for participation by a wide range of stakeholders in the Institute and, in particular, to engage small and medium-sized enterprises (SMEs), minority-owned businesses, and women-owned businesses through outreach and intermediaries, including programs like the National Institute of Standards and Technology Manufacturing Extension Partnership (NIST MEP) where appropriate, and provide sufficient financial and contractual mechanisms for collaboration with all stakeholders along the supply chain, including end-users, to allow them to benefit from the Institute resources.

In order to quantitatively measure progress towards these goals, the Applicant for the *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing* will need to identify and develop a plan to achieve or exceed the following qualitative and quantitative performance metrics to:

1. Demonstrate Energy Efficiency in Process Intensification Technology: Research, develop and demonstrate intensification in a modular chemical process intensification process[105] at a 20 percent or greater (>20%) improvement in energy efficiency in first-of-kind demonstration in a relevant pilot environment within five years of Institute operation, supporting a goal of at least an order of magnitude improvement in energy productivity for at least one representative process within

[105] Efficiency to be measured and determined using an internationally recognized standard such as ISO 50001, http://www.iso.org/iso/home/standards/management-standards/iso50001.htm

ten years for the *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing*.[106,107, 108]

2. Demonstrate Energy Productivity improvement through Process Intensification Technology: Research, develop, and demonstrate intensification in a modular chemical process through a doubling of energy productivity by a combination of both improvement in capital equipment capacity cost ($/kg per day) and operating cost related to improved feedstock and fuel efficiencies.[109]

3. Demonstrate Intensification in Individual Chemical Process Modules: Research, develop and demonstrate at representative pilot scale with 1,000 hours of operating time, at least one (or more) modular and intensified process that has all of 10x reduced capacity cost ($/(kg per day)), with 20% improved energy efficiency, and 20% lower emissions/environmental waste (kg/kg) relative to commercial state-of-the art at the relevant production rate (kg per day).

4. Demonstrate Approaches to Cost-Effective Manufacturing of Process Intensified Modules: Applied research, development and demonstration of technologies to scale-out manufacturing of intensified process modules, with a modeled cost based on technical advances that reduce by over 20% the cost/unit of intensified process modules with each doubling in cumulative module manufacturing production up to a total capacity equivalent to baseline current typical large-scale process (e.g. model out the production cost of 1000 modules that each produce 1000BPD which has the equivalent production of 1 plant with a capacity of 1,000,000BPD).

5. Demonstrate Potential for Cost Effective Deployment of Modular Chemical Process Intensification: Develop tools and technologies to reduce the cost of deploying modular chemical process intensification in existing processes by fifty percent (50%) relative to the existing state of the art within five years, and be on a pathway to achieve at least installed and operating cost parity for the adoption of modular

[106] http://energy.gov/eere/amo/downloads/superior-energy-performance-measurement-and-verification-protocol-industry

[107] Superior Energy Performance program: http://energy.gov/isosep/

[108] Energy Efficiency is typically defined as relative to the energy requirements to provide a given product or service (ex: % change relative to energy required to provide a product or service). In comparison, Energy Productivity is related to the economics of creating products and services and is measured as economic value resulting from a unit energy expended (ex: $/kwH). Energy productivity improvements can exceed energy efficiency improvements through issues such as improved factory utilization or supply-chain improvements resulting from more energy efficient processes.

[109] "Accelerate Energy Productivity 2030" http://www.energy2030.org/wp-content/uploads/ASE-AEP2030-Executive-Summary-DOE-Print-Version.pdf

chemical process intensification technologies at full scale in one or more application areas.

6. Establish an enabling R&D Portfolio: Establish a portfolio of applied research and development of enabling technologies for the next generation process intensification processes (materials, catalysts, membranes, sorbents, etc.), with quantitative goals.

7. Build Industrial Partnership and Eco-System: Demonstrate potential for significant industry adoption of modular chemical process intensification technology.

8. Build Pathway to Self-Sustainment: Establish a portfolio of external support generating activities for technology RD&D and workforce development that directly replaces the initial Federal funding (i.e., $14 million per year, starting in the sixth year of operation).

9. Train the Trainers in Modular Chemical Process Intensification: Train at least fifty education/training professionals per year in modular chemical process intensification technologies for clean energy including energy management practices, by year 3.

10. Educate Students in Modular Chemical Process Intensification: Train at least 500 students per year in modular chemical process intensification technologies and solutions, including energy management practices, by year 3.

11. Establish an Annual Planning Process: Develop an annual planning process that addresses how the best emerging and new ideas and new participants will be included in Institute activities on an ongoing basis. The management and operations plan and budget must include adequate funding and a plan to ensure there is sufficient funding available to encourage openness and new participants as the Institute goes forward. Plans should also include how changes to the strategic plan will be managed to align with roadmaps and enable partnerships with other Federal government agencies.

12. Establish an Industrial Roadmap: Develop a roadmap for modular chemical process intensification technologies for energy intensive/dependent industries and clean energy and energy efficient product manufacturing that is updated on an annual basis, including engaged contribution from stakeholders from both inside the *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing* and across an emerging modular chemical process intensification industry.

13. Support an Emerging Supply Chain: Document the existence and growth of a domestic supply chain that is the focus of the modular chemical process intensification, document the Institute capabilities supporting the elements of the domestic supply chain, and assess the health of the domestic supply chain annually.

14. Support Increased Diversity of Firms and Individuals in the Eco-System: Demonstrate the participation of underrepresented groups including but not limited to small and medium enterprises, minority-owned businesses, and women-owned businesses in technology development, workforce development, and Institute governance.

The Applicant shall identify clear and quantitative long-term objectives and multiple clear major annual milestones that demonstrate progress towards the objectives for the end of the award period at regular intervals and show a path to achieve the long-term objectives identified for the post-award period. The Applicant is strongly encouraged to have end users and Original Equipment Manufacturers (top-of-the-supply chain OEMs and supply chain customers) from the relevant industries included in the Institute membership, demonstrating market pull and technical relevance for subsequent technology transfer and commercial adoption.

All work under EERE funding agreements must be performed in the United States. See Section IV.K.iii and Appendix C.

Manufacturing Innovation Institute Best Practices

The DOE has identified several best practices for management and operations of Manufacturing Innovation Institutes. The Applicant's plans to address these points must be included in the project narrative section of the application. Deviations from these best practices must be adequately justified by the Applicant with a strong alternative plan.

1. The Institute management is expected to be primarily focused on the operation and management of the proposed Institute. The Institute Director/Executive is expected to be a full time position and key management staff (e.g., Deputy Directors, Chief Technology Officer) give >75% time commitment to the Institute, 100% recommended during the start-up phase.

2. The Institute organization is encouraged to be an independent not-for-profit entity that can support and maintain a neutral and non-biased role during the execution of the Institute effort and during any subsequent period as a self-sustaining Institute.

3. In the case where a new not-for-profit entity will be established for the management and execution of the Institute, a clear plan and timeline for establishing the not-for-profit Institute as a new legal entity should be provided. At a minimum, the not-for-profit entity must be legally established and able to fulfill the requirements as the Prime Recipient by the completion of award negotiations so the DOE award can be issued to the not-for-profit entity. DOE prefers for the new not-for-profit to obtain a DUNS number prior to submitting a Concept Paper so the entity can register in Exchange and apply as the Prime Applicant.

4. As a public-private partnership, the Institute should expect that DOE (and other Federal government participants identified by DOE) will participate in decision-making bodies (boards/committees) at both a strategic and technical level within the Institute.

5. Applicants are encouraged to review the Intellectual Property Rights guidance established by the Advanced National Program Office (AMNPO) for Manufacturing Innovation Institutes[110] and to develop IP policies that support sharing of IP and information to the broadest extent possible, including availability of open-source information where appropriate. Approaches for fully funded RD&D work (work-for-others or fee-for-service type arrangements) need to be clearly defined and delineated from precompetitive RD&D where IP is anticipated to more broadly benefit the Institute community.

In addition, the Advanced Manufacturing National Program Office (AMNPO) has issued a second guidance document regarding Performance Metrics.[111] Applicants to this FOA are not required to follow the guidance in these documents released by the AMNPO but are encouraged to review them and consider what guidance may be appropriate to incorporate.

When public funding supports research and development efforts as a result of this FOA, it is expected that some portion of or all of the results are to be shared with the greater manufacturing community and the public as appropriate. An additional objective with regard to public funding is to ensure that the underlying data for such projects be made available in an open and digitally accessible manner that also protects confidentiality (see the open data initiatives summarized in the Administration's Digital Government strategy).[112] Applicants who are selected for award negotiations will be required to submit a complete Data Management Plan (See Section VI.B.xi) and Applicants are to describe high level approaches for data sharing in the Full Application.

[110] Guidance on Intellectual Property NNMI (2015) https://www.manufacturing.gov/news/reports/
[111] Guidance on Institute Performance Metrics: National Network for Manufacturing Innovation https://www.manufacturing.gov/news/reports/
[112] https://www.whitehouse.gov/sites/default/files/omb/egov/digital-government/digital-government.html

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.D of the FOA):

1. Applications that fall outside the technical parameters specified in Section I.C of the FOA, including but not limited to modular chemical process intensification technology development and demonstration that is primarily ***not*** focused on energy efficient or lifecycle energy manufacturing or is solely focused on technology development with no relevant application to energy intensive or energy related industries or clean energy/energy efficient product manufacturing.
2. Applications that focus primarily on modular chemical process intensification demonstrations at industrial facilities without the research, development and demonstration of technology or sharing of pre-competitive knowledge as a resource in a public-private partnership.
3. Applications for proposed technologies that are not based on sound scientific principles (e.g., violates the law of thermodynamics).
4. Applications that do not propose the establishment of a pre-competitive public-private consortium with partners from industry (including small and medium-sized firms).

E. Authorizing Statutes

The programmatic authorizing statute is Section 911 (a)(2)(C) of the Energy Policy Act of 2005, codified at 42 USC § 16191(a)(2)(C).

Awards made under this announcement will fall under the purview of 2 CFR Part 200 as amended by 2 CFR Part 910.

II. Award Information

A. Award Overview

i. Estimated Funding

EERE expects to make approximately $70,000,000 of Federal funding available for new awards under this FOA, subject to the availability of appropriated funds and congressional direction. EERE anticipates making one award under this FOA. However, EERE may issue one, multiple, or no awards. Individual awards may vary between $35,000,000 and $70,000,000.

EERE will establish budget periods for the award and initially fund only the first budget period. To provide an official startup phase for the Institute, the Institute is expected to have an initial Budget Period 1 for approximately 6 months, which will be part of the overall 5 year award period. The purpose of this first budget period is to provide resources for the startup phase consisting of formalization of industrial partnerships as well as finalizing technical development plans. The following activities shall not be included in the Statement of Project Objectives (SOPO) or budget for Budget Period 1: Any costs associated with the formation of an entity to become the Prime Recipient or costs associated with the development of Operational Plans, By-Laws, the entity's policies and procedures or with the formation of an accounting system. These activities must be completed before or during negotiations and must be in place prior to the Contracting Officer approving the award. Applicants should propose an initial budget and SOPO to accomplish Budget Period 1 activities as well as the following 12 month (approximate) budget period for initial technical work (Budget Period 2) and outline of the SOPO for the remaining budget periods. Subsequent budget periods will be 12 months (approximate) in length, with the final budget period being 18 months; additional detail will be required in the SOPO submitted as part of the continuation application before the end of each budget period. Up to $14,000,000 is anticipated to be available for each full year budget period, with the initial 6 month Budget Period 1 funding being approximately $4,000,000 to $6,000,000. Funding for all budget periods, including the first budget period, is not guaranteed. Before the expiration of each budget period, EERE will perform a Go/No-Go decision review (See Section VI.B.xix). Continued Federal funding will be contingent upon availability of funds appropriated by Congress for the purpose of this program, the availability of future-year budget authority, satisfactory performance, and the Go/No-Go decision review process.

ii. Period of Performance

EERE anticipates making awards that will run up to 60 months in length. Project continuation will be contingent upon satisfactory performance and Go/No-Go decision review. At the Go/No-Go decision points, EERE 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, EERE will make a determination to: (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.

iii. New Applications Only

EERE will accept only new applications under this FOA. EERE will not consider applications for renewals of existing EERE-funded awards through this FOA.

B. EERE Funding Agreements

Through Cooperative Agreements and other similar agreements, EERE provides financial and other support to projects that have the potential to realize the FOA objectives. EERE does not use such agreements to acquire property or services for the direct benefit or use of the United States Government.

i. Cooperative Agreements

EERE generally uses Cooperative Agreements to provide financial and other support to Prime Recipients.

Through Cooperative Agreements, EERE provides financial or other support to accomplish a public purpose of support or stimulation authorized by Federal statute. Under Cooperative Agreements, the Government and Prime Recipients share responsibility for the direction of projects.

EERE has substantial involvement in all projects funded via Cooperative Agreement. See Section VI.B.ix of the FOA for more information on what substantial involvement may involve.

ii. Funding Agreements with FFRDCs

In most cases, Federally Funded Research and Development Centers (FFRDC) are funded independently of the remainder of the Project Team. The FFRDC then executes an agreement with any non-FFRDC Project Team members to arrange work structure, project execution, and any other matters. Regardless of these arrangements, the entity that applied as the Prime Recipient for the project will remain the Prime Recipient for the project.

III. Eligibility Information

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.

A. 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 incorporated (or otherwise formed) under the laws of a particular State or territory of the United States with majority domestic ownership or control 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.

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

DOE/NNSA Federally Funded Research and Development Centers (FFRDCs) are eligible to apply for funding as a Prime Recipient or Subrecipient.

Non-DOE/NNSA FFRDCs are eligible to apply for funding as a Subrecipient, but are not eligible to apply as a Prime Recipient.

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.

iii. Foreign Entities

Foreign entities, [113] whether for-profit or otherwise, are eligible to apply for funding 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 with majority domestic ownership

[113] Any entity that is substantially (50% or greater) owned or controlled by non-U.S. individuals, organizations or affiliates, or whose ultimate parent, if any, is incorporated outside of the United States (including U.S. territories), is considered a foreign entity under this FOA.

or control. 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 with majority domestic ownership or control 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. Appendix C lists the necessary information that must be included in a request to waive this requirement. The Applicant does not have the right to appeal EERE's decision concerning a waiver request.

In the waiver request, the Applicant must demonstrate to the satisfaction of EERE 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. EERE may require additional information before considering the waiver request.

Please refer to Section VI.B.xv regarding involvement by foreign entities, including members of a consortium.

iv. Incorporated Consortia

Incorporated consortia are eligible to apply for funding as a Prime Recipient or Subrecipient. For consortia incorporated (or otherwise formed) under the laws of a State or territory of the United States with majority domestic ownership or control, please refer to "Domestic Entities" above. For a consortium incorporated in a foreign country or that has a majority foreign ownership or control, please refer to the requirements in "Foreign Entities" above.

Each incorporated consortium must have an internal governance structure and a written set of internal rules. Upon request, the consortium must provide a written description of its internal governance structure and its internal rules to the EERE Contracting Officer.

Please refer to Section VI.B.xv regarding involvement by foreign entities, including members of a consortium.

v. Unincorporated Consortia

Unincorporated Consortia must designate one member of the consortium to serve as the Prime Recipient/consortium representative. The Prime Recipient/consortium representative must be incorporated (or otherwise formed) under the laws of a State or territory of the United States with majority domestic ownership or control. The eligibility of the consortium will be determined by the eligibility of the Prime Recipient/consortium representative under Section III.A of the FOA.

Upon request, unincorporated consortia must provide the EERE Contracting Officer with a collaboration agreement, commonly referred to as the articles of collaboration, which sets out the rights and responsibilities of each consortium member. This agreement binds the individual consortium members together and should discuss, among other things, the consortium's:

- Management structure;
- Method of making payments to consortium members;
- Means of ensuring and overseeing members' efforts on the project;
- Provisions for members' cost sharing contributions; and
- Provisions for ownership and rights in intellectual property developed previously or under the agreement.

Please refer to Section VI.B.xv regarding involvement by foreign entities, including members of a consortium.

B. Cost Sharing

Cost Share 50%

The cost share must be at least 50% of the total allowable costs under the award (i.e., the sum of the Government share, including FFRDC 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 200.306 and 2 CFR 910.130 for the applicable cost sharing requirements.)

To assist Applicants in calculating proper cost share amounts, EERE has included a cost share information sheet and sample cost share calculation as Appendix A to this FOA.

Further, Applicants are encouraged to review the regulations regarding Program Income and be aware of the ways in which Program Income can be treated during the award. For awards made under this FOA, the default use of program income is Addition.[114] Any other treatment of Program Income must be negotiated and approved by the Contracting Officer. Program Income should not be included as cost share in the Applicant's budget.

i. Legal Responsibility

Although 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.

ii. 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.

iii. Cost Share Types and Allowability

Every cost share contribution must be allowable under the applicable Federal cost principles, as described in Section IV.K.i of the FOA. In addition, cost share must be verifiable upon submission of the Full Application.

Project Teams may provide cost share in the form of cash or in-kind contributions. Cash contributions may be provided by the Prime Recipient or Subrecipients. Allowable in-kind contributions include, but are not limited to: rental value of buildings or equipment, the value of a donated service or resource, or third party in-kind contribution.

[114] See 2 CFR 200.307(e)(2).

Project teams may use funding or property received from state or local governments to meet the cost share requirement, so long as the funding was not provided to the state or local government by the Federal Government.

The Prime 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 guidance on cost sharing.

iv. Cost Share Contributions by FFRDCs

Because FFRDCs are funded by the Federal Government, costs incurred by FFRDCs generally may not be used to meet the cost share requirement. FFRDCs may contribute cost share only if the contributions are paid directly from the contractor's Management Fee or another non-Federal source.

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 Appendix A of the FOA.

vi. Cost Share Payment

EERE requires Prime Recipients to contribute the cost share amount incrementally over the life of the award. Specifically, the Prime Recipient's cost share for each billing period must always reflect the overall cost share ratio negotiated by the parties (i.e., the total amount of cost sharing on each invoice when considered cumulatively with previous invoices must reflect, at a minimum, the cost sharing percentage negotiated).

In limited circumstances, and where it is in the government's interest, the EERE Contracting Officer may approve a request by the Prime Recipient to meet its cost share requirements on a less frequent basis, such as monthly or quarterly. Regardless of the interval requested, the Prime Recipient must be up-to-date on cost share at each interval. Such requests must be sent to the Contracting Officer during award negotiations and include the following information: (1) a detailed justification for the request; (2) a proposed schedule of payments, including amounts and dates; (3) a written commitment to meet that schedule; and (4) such evidence as necessary to demonstrate that the Prime Recipient has complied with its cost share obligations to date. The Contracting Officer must approve all such requests before they go into effect.

C. Compliance Criteria

Concept Papers and Full Applications must meet all Compliance criteria listed below or they will be considered noncompliant. EERE will not review or consider noncompliant submissions, including Concept Papers, Full Applications, and Replies to Reviewer Comments that were: submitted through means other than EERE Exchange; submitted after the applicable deadline; and/or submitted incomplete. EERE will not extend the submission deadline for Applicants that fail to submit required information due to server/connection congestion.

i. Compliance Criteria

1. Concept Papers

Concept Papers are deemed compliant if:

- The Concept Paper complies with the content and form requirements in Section IV.C of the FOA; and

- The Applicant successfully uploaded all required documents and clicked the "Submit" button in EERE Exchange by the deadline stated in this FOA.

2. Full Applications

Full Applications are deemed compliant if:

- The Applicant submitted a compliant Concept Paper;
- The Full Application complies with the content and form requirements in Section IV.D of the FOA; and
- The Applicant successfully uploaded all required documents and clicked the "Submit" button in EERE Exchange by the deadline stated in the FOA.

3. Replies to Reviewer Comments

Replies to Reviewer Comments are deemed compliant if:

- The Reply to Reviewer Comments complies with the content and form requirements in Section IV.E of the FOA; and
- The Applicant successfully uploaded all required documents to EERE Exchange by the deadline stated in the FOA.

D. Responsiveness Criteria

All "Applications Specifically Not of Interest," as described in Section I.D. of the FOA, are deemed nonresponsive and are not reviewed or considered.

E. Other Eligibility Requirements

i. Requirements for DOE/NNSA Federally Funded Research and Development Centers (FFRDC) Listed as the Applicant

A DOE/NNSA FFRDC is eligible to apply for funding under this FOA if its cognizant Contracting Officer provides written authorization and this authorization is submitted with the application. If a DOE/NNSA FFRDC is selected for award negotiation, the proposed work will be authorized under the DOE work authorization process and performed under the laboratory's Management and Operating (M&O) contract.

The following wording is acceptable for the authorization:

Authorization is granted for the [Enter Laboratory Name] Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complementary to the missions of the laboratory, and will not adversely impact execution of the DOE assigned programs at the laboratory.

ii. Requirements for DOE/NNSA and non-DOE/NNSA Federally Funded Research and Development Centers Included as a Subrecipient

DOE/NNSA and non-DOE/NNSA FFRDCs may be proposed as a Subrecipient on another entity's application subject to the following guidelines:

1. **Authorization for non-DOE/NNSA FFRDCs**
   The Federal agency sponsoring the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The use of a FFRDC must be consistent with its authority under its award.

2. **Authorization for DOE/NNSA FFRDCs**
   The cognizant Contracting Officer for the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The following wording is acceptable for this authorization:

   Authorization is granted for the [Enter Laboratory Name] Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complementary to the missions of the laboratory, and will not adversely impact execution of the DOE assigned programs at the laboratory.

3. **Value/Funding**
   The value of and funding for the FFRDC portion of the work will not normally be included in the award to a successful Applicant. Usually, DOE will fund a DOE/NNSA FFRDC contractor through the DOE field work proposal system and non-DOE/NNSA FFRDC through an interagency agreement with the sponsoring agency.

4. **Cost Share**
   Although the FFRDC portion of the work is usually excluded from the award to a successful Applicant, the Applicant's cost share requirement

will be based on the total cost of the project, including the Applicant's and the FFRDC's portions of the project.

5. **Responsibility**
   The Prime Recipient 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 Prime Recipient and the FFRDC contractor.

6. **Limit on FFRDC Effort**
   The scope of work to be performed by the FFRDC may not be more significant than the scope of work to be performed by the Applicant.

F. Limitation on Number of Concept Papers and Full Applications Eligible for Review

An entity may only submit one Concept Paper and one Full Application for consideration under this FOA. For example, EERE will only consider one Concept Paper and one Full Application per university for this FOA (not one submission per each college or school under the university). This limitation does not prohibit an Applicant from collaborating on other applications (e.g., as a potential Subrecipient or partner) so long as the entity is only listed as the prime Applicant on one Concept Paper and Full Application submitted under this FOA.

G. Questions Regarding Eligibility

EERE 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. Application Process

The application process will include two phases: a Concept Paper phase and a Full Application phase. **Only Applicants who have submitted an eligible Concept Paper will be eligible to submit a Full Application**. At each phase, EERE performs an initial eligibility review of the Applicant submissions to determine whether they meet the eligibility requirements of Section III of the FOA. EERE will not review or consider submissions that do not meet the eligibility requirements of Section III. All submissions must conform to the following form and content requirements,

including maximum page lengths (described below) and must be submitted via EERE Exchange at https://eere-exchange.energy.gov/, unless specifically stated otherwise. **EERE will not review or consider submissions submitted through means other than EERE Exchange, submissions submitted after the applicable deadline, and incomplete submissions**. EERE will not extend deadlines for Applicants who fail to submit required information and documents due to server/connection congestion. A control number will be issued when an Applicant begins the Exchange application process. This control number must be included with all Application documents, as described below.

The Concept Paper, Full Application, and Reply to Reviewer Comments must conform to the following requirements:

- 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 12 point or larger (except in figures or tables, which may be 10 point font). 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.
- The Control Number must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.
- Each submission must not exceed the specified maximum page limit, including cover page, charts, graphs, maps, and photographs when printed using the formatting requirements set forth above and single spaced. If Applicants exceed the maximum page lengths indicated below, EERE will review only the authorized number of pages and disregard any additional pages.

Applicants are responsible for meeting each submission deadline. **Applicants are strongly encouraged to submit their Concept Papers and 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 Concept Paper, Full Application, or Reply to Reviewer Comments. Once the Concept Paper, Full Application, or Reply to Reviewer Comments is submitted in EERE Exchange, Applicants may revise or update that submission until the expiration of the applicable deadline. If changes

are made, the Applicant must resubmit the Concept Paper, Full Application, or Reply to Reviewer Comments before the applicable deadline.

EERE urges Applicants to carefully review their Concept Papers, and 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.A.ii of the FOA.

i. Additional Information on EERE Exchange

EERE Exchange is designed to enforce the deadlines specified in this FOA. The "Apply" and "Submit" buttons will automatically disable at the defined submission deadlines. Should Applicants experience problems with Exchange, the following information may be helpful.

Applicants that experience issues with submission PRIOR to the FOA deadline: In the event that an Applicant experiences technical difficulties with a submission, the Application should contact the Exchange helpdesk for assistance (EERE-ExchangeSupport@hq.doe.gov). The Exchange helpdesk and/or the EERE Exchange system administrators will assist Applicants in resolving issues.

Applicants that experience issue with submissions that result in late submissions: In the event that an Applicant experiences technical difficulties so severe that they are unable to submit their application by the deadline, the Applicant should contact the Exchange helpdesk for assistance (EERE-ExchangeSupport@hq.doe.gov). The Exchange helpdesk and/or the EERE Exchange system administrators will assist the Applicant in resolving all issues (including finalizing submission on behalf of and with the applicant's concurrence). PLEASE NOTE, however, those Applicants who are unable to submit their application on time due to their waiting until the last minute when network traffic is at its heaviest to submit their materials will not be able to use this process.

B. Application Forms

The application forms and instructions are available on EERE Exchange. To access these materials, go to https://eere-Exchange.energy.gov and select the appropriate funding opportunity number.

Note: The maximum file size that can be uploaded to the EERE Exchange 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:
ControlNumber_LeadOrganization_Project_Part_1
ControlNumber_LeadOrganization_Project_Part_2, etc.

C. Content and Form of the Concept Paper

To be eligible to submit a Full Application, Applicants must submit a Concept Paper by the specified due date and time.

i. Concept Paper Content Requirements

EERE will not review or consider ineligible Concept Papers (see Section III of the FOA).

The ideas and technologies proposed in a Concept Paper must all be relevant to the objectives of the FOA for Modular Chemical Process Intensification as described in Section I of the FOA. A single Concept Paper should not include concepts for more than one Institute or include technologies unrelated to the overall objectives of the FOA.

The Concept Paper must conform to the following content requirements:

Section	Page Limit	Description
Cover Page	1 page maximum	The cover page should include the proposed Institute title, both the technical (Institute Director/Executive) and business points of contact, names of all team member organizations, proposed budget, and any statements regarding confidentiality.
Technical Description Innovation and Impact	6 pages maximum	Applicants are required to describe succinctly: • The proposed integrated technology approach for the Institute, including technical focus areas and core competencies; • The proposed technologies target levels of performance (Applicants should provide technical data or other support to show how the proposed target could be met); • A summary of the current state-of-the-art in the relevant field and applications, including key shortcomings, limitations, and challenges;

		• How the proposed key technology developments will overcome the shortcomings, limitations, and challenges in the relevant field and application; • The estimated impact on energy and competitiveness that the proposed Institute would have an on clean energy and energy efficient product manufacturing; • The technical education and workforce development plan summary highlighting key aspects; • Strategy to meet the goal of strengthening U.S. manufacturing competitiveness while engaging a wide range of stakeholders with both horizontal and vertical reach across and within supply chains.
Qualifications and Resources Description	2 pages maximum	Applicants are required to describe succinctly: • The key leadership and technical roles and responsibilities and identify any individuals known for these roles. • The skills, expertise and prior relevant experience the Principal Investigator (Institute Director/Executive) and Project Team that demonstrates capability to successfully execute the Institute; • The proposed Institute's access to equipment and facilities necessary to accomplish the effort and/or clearly explain how the Institute intends to obtain access to the necessary equipment and facilities.
Operations and Management Approach Description	2 pages maximum	Applicants are required to describe succinctly: • The proposed management and operations structure and approach, including the role of the U.S. government in the management of the proposed Institute.
Addendum	4 pages maximum	Applicants may provide graphs, charts, or other data to supplement their Concept Paper.

EERE makes an independent assessment of each Concept Paper based on the criteria in Section V.A.i of the FOA. EERE will encourage a subset of Applicants to submit Full Applications. Other Applicants will be discouraged from submitting a Full Application. An Applicant who receives a "discouraged" notification may still submit a Full Application. EERE will review all eligible Full Applications. However, by discouraging the submission of a Full Application, EERE intends to convey its lack of programmatic interest in the proposed project in an effort to save the Applicant the time and expense of preparing an application that is unlikely to be selected for award negotiations.

EERE may include general comments provided from reviewers on an Applicant's Concept Paper in the encourage/discourage notification sent to Applicants at the close of that phase.

D. Content and Form of the Full Application

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 following application forms found on the EERE Exchange website at https://eere-Exchange.energy.gov/, in accordance with the instructions.

Applicants will have approximately 50 days from receipt of the Concept Paper Encourage/Discourage notification to prepare and submit a Full Application. Regardless of the date the Applicant receives the Encourage/Discourage notification, the submission deadline for the Full Application remains the date and time stated on the FOA cover page.

All Full Application documents must be marked with the Control Number issued to the Applicant. Applicants will receive a control number upon submission of their Concept Paper, and should include that control number in the file name of their Full Application submission (i.e., Control number_Applicant Name_Full Application)."

i. Full Application Content Requirements

EERE will not review or consider ineligible Full Applications (see Section III of the FOA).

The ideas and technologies proposed in a Full Application must all be relevant to the objectives of the FOA for Modular Chemical Process Intensification as described in Section I of the FOA. A single Full Application should not include concepts for more than one Institute or include technologies unrelated to the overall objectives of the FOA.

Full Applications must conform to the following requirements:

Submission	Components	File Name
Full Application	Technical Volume (See Chart in Section IV.D.ii)	ControlNumber_LeadOrganization_TechnicalVolume

(PDF, unless stated otherwise)	Statement of Project Objectives (Microsoft Word format) (100 page limit)	ControlNumber_LeadOrganization_SOPO
	SF-424	ControlNumber_LeadOrganization_App424
	Budget Justification (EERE 335) (Microsoft Excel format. Applicants must use the template available in EERE Exchange)	ControlNumber_LeadOrganization_Budget_Justification
	Summary for Public Release (1 page limit)	ControlNumber_LeadOrganization_Summary
	Summary Slide (1 page limit, Microsoft PowerPoint format)	ControlNumber_LeadOrganization_Slide
	Subaward Budget Justification (EERE 335) (Microsoft Excel format. Applicants must use the template available in EERE Exchange)	ControlNumber_LeadOrganization_Subawardee_Budget_Justification
	Budget for FFRDC, if applicable	ControlNumber_LeadOrganization_FWP
	Authorization from cognizant Contracting Officer for FFRDC, if applicable	ControlNumber_LeadOrganization_FFRDCAuth
	SF-LLL Disclosure of Lobbying Activities	ControlNumber_LeadOrganization_SF-LLL
	Foreign Entity and Performance of Work in the United States waiver requests, if applicable	ControlNumber_LeadOrganization_Waiver
	U.S. Manufacturing Plans	ControlNumber_LeadOrganization_USMP
	Draft IP Management Plan	ControlNumber_LeadOrganization_IPP
	Conflict of Interest Statement	ControlNumber_LeadOrganization_COI
	Compliance Matrix	ControlNumber_LeadOrganization_Matrix

Note: The maximum file size that can be uploaded to the EERE Exchange 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:

ControlNumber_LeadOrganization_TechnicalVolume_Part_1
ControlNumber_LeadOrganization_TechnicalVolume_Part_2, etc.

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

EERE provides detailed guidance on the content and form of each component below.

ii. Technical Volume

The Technical Volume must be submitted in Adobe PDF format. The Technical Volume must conform to the following content and form requirements, including maximum page lengths. If Applicants exceed the maximum page lengths indicated below, EERE will review only the authorized number of pages and disregard any additional pages. This volume must address the Merit Review Criteria as discussed in Section V.A.ii of the FOA. Save the Technical Volume in a single PDF file using the following convention for the title: "ControlNumber_LeadOrganization_TechnicalVolume".

Applicants must provide sufficient citations and references to the primary research literature to justify the claims and approaches made in the Technical Volume. However, EERE and reviewers are under no obligation to review cited sources.

The Technical Volume to the Full Application may not be more than 50 pages, including the cover page, table of contents, and all citations, charts, graphs, maps, photos, or other graphics, and must include all of the information in the table below. The Applicant should consider the weighting of each of the evaluation criteria (see Section V.A.ii of the FOA) when preparing the Technical Volume.

The Technical Volume should clearly describe and expand upon information provided in the Concept Paper.

SECTION/PAGE LIMIT	DESCRIPTION
	The cover page should include the Institute title, both the technical (Institute Director/Executive) and business points of contact, names of all team member organizations, and any statements regarding confidentiality.

Institute Overview (This section should be no more than 2 pages)	The Project Overview should contain the following information: • Institute Goals: The Applicant should explicitly identify the targeted improvements to the baseline technology and the critical success factors in achieving that goal. • Institute technical structure or "architecture" with a graphical representation. • Summary of the key technical work or approaches in bulleted format • Total funding requested including Federal and cost share
Technical Description, Innovation, and Impact (This section should constitute approximately 50% of the Technical Volume)	The Technical Description should contain the following information: The Technical Description should describe the overall structure or "architecture" of the Institute, including technical focus areas and core competencies, the technical challenges specific to those focus areas and proposed innovative solutions to those challenges that will be explored in the specific projects and work that is defined in greater detail in the Statement of Project Objectives (SOPO). This section should emphasize how the proposed RD&D activities, innovations, and approach will enable achievement of the overall Institute goals and describe the impact of the Institute. Specifically describe: • Technology Development: The integrated technical approach, the overall structure or "architecture" and the core competencies of the proposed Institute as they align with and build upon the technical topic areas identified in the FOA; • Relevance: The key barriers and opportunities in the technical topic areas proposed to advance the field of modular chemical process intensification; • Targets: The proposed performance metrics for the Institute as a whole and quantitative technical goals for the *Modular Chemical Process Intensification Institute for Clean Energy Manufacturing*; • Innovations: For the identified technical topic areas, the specific technical innovations that the Institute will pursue and demonstration of scientific merit and feasibility of these proposed ideas to achieve the goals identified; • Technical Education and Workforce Development: The technical education and workforce development plan, how technical data and information will be shared among members and the broader manufacturing community, and how the educational/workforce activities are integrated into the other aspects of the Institute; • Impacts: The estimated impact that the proposed Institute would have an on clean energy and energy efficient product manufacturing and supply chains. Applicants must provide realistic estimates for the projected Institute impact on aggregate

	energy savings (TBTUs), reduction in GHG (tons of CO2 equivalents) over ten years relative to existing available technologies. Applicants must provide justification for all estimates and assumptions. • U.S. Manufacturing Plan: Strategy to meet the goal of strengthening U.S. manufacturing competitiveness while engaging a wide range of stakeholders that may include foreign participants. Summarize the U.S. Manufacturing Plan (to be submitted as a separate document) describing the level of commitment to support U.S. manufacturing competiveness. • Market Transformation Plan: The Applicant should provide a market transformation plan, including the following: o Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including a mitigation plan o Identification of a product development and/or service plan, commercialization timeline, financing, product marketing, legal/regulatory considerations including intellectual property, infrastructure requirements, data dissemination, U.S. manufacturing plan etc., and product distribution. Project Schedule (Gantt Chart or similar): The Applicant should provide a schedule for the entire project, including task and subtask durations, milestones, and Go/No-Go decision points. A detailed Statement of Project Objectives (SOPO) for the first two budget periods (6 month Budget Period 1 and a subsequent 12 month budget period (Budget Period 2)) as well as an outline for subsequent budget periods is required. The SOPO is to be submitted with the application and will not count as part of the technical volume page count.
Qualifications and Resources (Approximately 20% of the Technical Volume)	The Qualifications and Resources section should contain the following information: • Qualifications: The Institute Team's unique qualifications and expertise of the lead organization including those of key Subrecipients to execute the proposed Institute. • Leadership: The key leadership and technical roles and responsibilities, the skills, expertise and prior relevant experience of the individuals identified for these roles and the level of time commitment of each individual to the Institute.

	Note: Attach one-page resumes for key participating team members as an appendix. Resumes do not count towards the page limit. Multi-page resumes are not allowed. • Facilities: The Institute Team's equipment and facilities necessary accomplish the scope of work; include a justification of updates to or any new equipment or facilities requested as part of the initial work of the Institute or how the Institute will access necessary equipment and facilities. • Leveraged Resources: Illustrate the specific ways in which DOE funding will enable acceleration of RD&D (e.g., complement existing physical infrastructure, human capital, intellectual property, or other resources) and thereby lead to outcomes that are more impactful than these resources would be in isolation. Describe how the Institute will utilize and leverage technical services to be provided by DOE/NNSA FFRDCs, National Institute of Standards and Technology's Manufacturing Extension Partnership (MEP), National Science Foundation's Advanced Technological Education (ATE) Centers, national laboratories, and other government investments, if applicable. • Support: Attach any letters of support and all cost share commitment letters from partners/end users as an appendix (1 page maximum per letter). Letters of support and cost share commitment letters do not count towards the page limit. • Cost Share Summary: The Applicant must summarize the cost share commitment letters in a table in the Technical Volume, clearly defining cost share contributions based on cash, in-kind and other contributions to the Institute with a total calculation for each type of cost share. The cost share summary must also include a breakdown of the source of the funding showing total percent contribution by industry, academia, states and others to the cost share total. • Budget Summary: Provide an overall budget summary that supports the proposed project and objectives, and can accommodate changes in strategic direction that may occur once the Institute is formalized and aligned with strategic roadmaps. Additionally any funds anticipated from other non-cost share sources such as fee-for-service work at full cost burden, IP licenses, membership dues, etc. should be identified and included in the budget under program income.
Operations and Management Plan (Approximately 30% of the Technical Volume)	The Operations and Management Plan should contain a description of the following and expand on the content from the Concept Paper and describe succinctly: Operations and Management

	• The overall management approach including the roles and the work to be performed by the Applicant, each PI and Key Participants. • Provide a proposed organizational chart to including management structure, Institute Director/Executive, key management staff as well as technical advisory and strategic governance boards. • The proposed governance structure and explain how decisions will be made and how any governing entities/advisory boards will function and what authority they will have and how the Federal government (DOE and others as identified by DOE) will be included in strategic and technical decision making. • How the proposed Institute will operate as an independent, neutral and non-biased entity to coordinate and convene a broad range of stakeholders (best practice indicates this should be an independent not-for-profit organization). • The proposed participation structure (e.g., tiered membership structure, pay-for-use arrangements, etc.) and the benefits and restrictions for each level of participation including IP rights. • Summarize the business agreements that will be utilized between the Applicant and different participants, including non-disclosure agreements. • The plan for coordination and communication with other Institutes as they are established and external stakeholder dissemination of knowledge. The proposed Institute that is the goal of this FOA will be expected to coordinate with, share and establish best practices, and participate in meetings with other Institutes for manufacturing innovation established by DOE and other Federal Agencies and support the creation of a national network for manufacturing innovation. • The industry road-mapping process and mechanism for identification of technical and non-technical challenges appropriate to be addressed by the Institute, including quantified targets associated with roadmap goals as well as the plan to update the roadmap periodically (annual or bi-annual). • The annual strategic planning and project review/assessment process for the Institute. The process by which the industry roadmap will inform and establish priorities for the Institute strategic plan. How the annual planning process will encourage new ideas and participants in the Institute activities. • The process for making decisions on scientific/technical direction including how RD&D projects and technical work in the proposed

	RD&D facilities will be selected, prioritized, relate to road-mapping efforts, and how conflicts will be resolved. • The plan to encourage openness and new participants as the Institute goes forward including plans to fund expansion of RD&D activities as the Institute evolves and the plan to keep the Institute relevant and accommodate the strategic changes that may occur to align with the industry roadmap and enable partnerships with other Federal government agencies. • How the Institute will encourage participation by small and medium-sized enterprises (SMEs) (examples include providing free or low-cost access to the shared infrastructure, low barrier or no entry fees to membership, job swapping arrangements between Institute and SME staff, engagement of the MEP Centers, etc.). • Integration: How the Institute will operate as an integrated organization - how individual Institute elements (shared RD&D facilities, initial RD&D projects, stakeholder engagement and road-mapping efforts, technical education and workforce development and commercialization activities, etc.) will be connected to provide value that is greater than the sum of the individual activities (i.e., how will the shared facilities support the technical education and workforce development plans and project activities). • Performance Management: Describe how Institute performance will be tracked and evaluated; describe plans for program reviews, etc. frequency and methodology for how they will be conducted. • Project Management: The Applicant should discuss the team's proposed management plan for any initial proposed RD&D projects or technical work in the RD&D facilities described in the SOPO, including the following: o The overall approach to and organization for managing the individual work activities o The technical and management aspects of the management plan, including systems and practices, such as financial and project management practices o The approach to project risk management o A description of how project changes will be handled o If applicable, the approach to Quality Assurance/Control o How communications will be maintained among Project Team members • Foreign Entities: If the Applicant anticipates involvement of foreign entities, describe how the Institute will handle participation of foreign entities as users, members or otherwise engage in activities at the Institute or in connection with the Institute while ensuring the goal to strengthen U.S. manufacturing competitiveness is met.

	• Export Control: How the Institute will manage export control compliance for activities at the Institute or in connection with the Institute. • Risk Mitigation: A risk assessment and risk mitigation plan for the technical, economic and operational aspects of the proposed Institute including Intellectual Property management and strengthening U.S. manufacturing competitiveness. • IP Management: A detailed summary of the major points in the draft IP Management Plan submitted as an Appendix. The summary should include, as appropriate for any different plans for how IP is to be handled: o Ownership o Dissemination pathways for IP, eligibility for licensing o IP sharing for research purposes o IP sharing for educational purposes o How the IP management plan will support domestic manufacturing and encourage participation by domestic industry in the Institute; and o How IP issues inherent with collaborations and/or multi-user facilities will be addressed. Financial Sustainability • Describe the sustainability plan for the proposed Institute past the award period, including realistic strategies to increase revenue in later years of the award period in order to achieve financial self-sufficiency within five years from dedicated Institute funding. • Describe the proposed sources of funding/revenue and the model which will support the Institute operations beyond the award period. • Provide an estimate of profit and loss for three years after the initial five year award period demonstrating how the Institute will maintain financial self-sufficiency. • Explain the strategy to keep the Institute relevant to industry, what resources will support Institute operations beyond the award period and how will manufacturing professionals will be recruited and trained over time to support the Institute.

iii. Statement of Project Objectives

Applicants are required to complete a Statement of Project Objectives (SOPO). A SOPO template is available on EERE Exchange at https://eere-Exchange.energy.gov/. The SOPO, including the Milestone Table, must not exceed 100 pages when printed using standard 8.5 x 11 paper with 1" margins (top, bottom, left, and right) with font not smaller than 12 point. The SOPO should detail all work for the first two budget periods (6 month Budget Period 1 and a subsequent 12 month budget period (Budget Period 2)) as well as an outline for subsequent budget periods. Save the SOPO in a single Microsoft Word file using the following convention for the title "ControlNumber_LeadOrganization_SOPO".

iv. SF-424: Application for Federal Assistance

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 http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms, under Certifications and Assurances. Note: The dates and dollar amounts on the SF-424 are for the complete project period and not just the first project year, first phase or other subset of the project period. Save the SF-424 in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_App424".

v. Budget Justification Workbook (EERE 335)

Applicants are required to complete the Budget Justification Workbook. This form is available on EERE Exchange at https://eere-Exchange.energy.gov/. Prime Recipients must complete each tab of the Budget Justification Workbook for the project as a whole, including all work to be performed by the Prime Recipient and its Subrecipients and Contractors, and provide all requested documentation (e.g., a Federally-approved rate agreement, vendor quotes). Applicants should include costs associated with required annual audits and incurred cost proposals in their proposed budget documents. 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. Save the Budget Justification Workbook in a single Microsoft Excel file using the following convention for the title "ControlNumber_LeadOrganization_Budget_Justification".

vi. Summary/Abstract for Public Release

Applicants are required to submit a one-page summary/abstract of their project. The project summary/abstract must contain a 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 (e.g., benefits, outcomes), and major participants (for collaborative projects). This document must not include any proprietary or sensitive business information as DOE may make it available to the public after selections are made. The project summary must not exceed 1 page when printed using standard 8.5 x 11 paper with 1" margins (top, bottom, left, and right) with font not smaller than 12 point. Save the Summary for Public Release in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Summary".

vii. Summary Slide

Applicants are required to provide a single PowerPoint slide summarizing the proposed project. The slide must be submitted in Microsoft PowerPoint format. This slide is used during the evaluation process. Save the Summary Slide in a single file using the following convention for the title "ControlNumber_LeadOrganization_Slide".

The Summary Slide template requires the following information:

- A technology Summary;
- A description of the technology's impact;
- Proposed project goals;
- Any key graphics (illustrations, charts and/or tables);
- The project's key idea/takeaway;
- Project title, Prime Recipient, Principal Investigator, and Key Participant information; and
- Requested EERE funds and proposed Applicant cost share.

viii. Subaward Budget Justification (EERE 335) (if applicable)

Applicants must provide a separate budget justification, EERE 335 (i.e., budget justification for each budget year and a cumulative budget) for each subawardee that is expected to perform work estimated to be more than $250,000 or 25 percent of the total work effort (whichever is less). The budget justification must include the same justification information described in the "Budget Justification" section above. Save each subaward budget justification in a Microsoft Excel file using the following convention for the title "ControlNumber_LeadOrganization_Subawardee_Budget_Justification".

ix. Budget for DOE/NNSA FFRDC (if applicable)

If a DOE/NNSA FFRDC contractor is to perform a portion of the work, the Applicant must provide a DOE Field Work Proposal (FWP) in accordance with the requirements in DOE Order 412.1, Work Authorization System. DOE Order 412.1 and DOE O 412.1 (Field Work Proposal form) area available at the following link, under "DOE Budget Forms": https://www.directives.doe.gov/directives/0412.1-BOrder-a/view. Save the FWP in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_FWP".

x. Authorization for non-DOE/NNSA or DOE/NNSA FFRDCs (if applicable)

The Federal agency sponsoring the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The use of a FFRDC must be consistent with the contractor's authority under its award. Save the Authorization in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_FFRDCAuth".

xi. SF-LLL: Disclosure of Lobbying Activities

Prime 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.

Prime Recipients and Subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf) if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence any of the following in connection with your application:

- An officer or employee of any Federal agency;
- A Member of Congress;
- An officer or employee of Congress; or
- An employee of a Member of Congress.

Save the SF-LLL in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_SF-LLL".

xii. Waiver Requests: Foreign Entities and Performance of Work in the United States (if applicable)

1. **Foreign Entity Participation***:*
   As set forth in Section III.A.iii, 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 with majority domestic ownership or control. To request a waiver of this requirement, the Applicant must submit an explicit waiver request in the Full Application. Appendix C lists the necessary information that must be included in a request to waive this requirement.

2. **Performance of Work in the United States**
   As set forth in Section IV.K.iii, all work under EERE 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. Appendix C lists the necessary information that must be

included in a request to waive the Performance of Work in the United States requirement.

Save the waiver request(s) in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Waiver".

xiii. U.S. Manufacturing Plan

As part of the application, Applicants are required to submit a U.S. Manufacturing Plan. The U.S. Manufacturing Plan represents the Applicant's measurable commitment to support U.S. manufacturing as a result of its award.

The weight given to the U.S. Manufacturing Plans during the review and selection process varies based on the particular FOA. Applicants should review Section V.A.ii of this FOA to determine the weight given to the U.S. Manufacturing Plans under this FOA.

A U.S. Manufacturing Plan should contain the following or similar preamble: "If selected for funding, the Applicant agrees to the following commitments as a condition of that funding:" and, after the preamble, the plan should include one or more specific and measureable commitments. For example, an Applicant may commit particular types of products to be manufactured in the U.S. In addition to or instead of making a commitment tied to a particular product, the Applicant may make other types of commitments still beneficial to U.S. manufacturing. An Applicant may commit to a particular investment in a new or existing U.S. manufacturing facility, keep certain activities based in the U.S. (e.g., final assembly) or support a certain number of jobs in the U.S. related to the technology and manufacturing. For an Applicant which is likely to license the technology to others, especially universities for which licensing may be the exclusive means of commercialization the technology, the U.S. manufacturing plan may indicate the Applicant's plan and commitment to use a licensing strategy that would likely support U.S. manufacturing.

For this FOA, the U.S. Manufacturing Plan should set forth the commitments in the context of the proposed Institute, including how the commitments relate to the members and how the commitments will be monitored and enforced. As an example, the proposed Institute could require all members of the Institute to agree to the following standard U.S. Competitiveness Provision that is used in DOE cooperative research and development agreements:

The Members agree that a purpose of the Institute is to provide substantial benefit to the U.S. economy. In exchange for the benefits received through the Institute, the Member therefore agrees to the following:
(1) Products embodying Intellectual Property developed under the Institute shall be substantially manufactured in the United States, and
(2) Process, services, and improvements thereof which are covered by Intellectual Property developed under the Institute shall be incorporated into the Member's manufacturing facilities in the United States either prior to or simultaneously with implementation outside the United States. Such processes, services, and improvements, when implemented outside the United States, shall not result in reduction of the use of the same processes, services, or improvements in the United States.

When an Applicant that is a domestic small business, domestic educational institution, or nonprofit organization is selected for an award, the U.S. Manufacturing Plan submitted by the Applicant becomes part of the terms and conditions of the award. The Applicant/awardee may request a waiver or modification of the U.S. Manufacturing Plan from DOE upon a showing that the original U.S. Manufacturing Plan is no longer economically feasible.

When an Applicant that is a domestic large business is selected for an award, a class patent waiver applies as set forth in Section VIII. L. Under this class patent waiver, domestic large businesses may elect title to their subject inventions similar to the right provided to the domestic small businesses, educational institutions, and nonprofits by law. In order to avail itself of the class patent waiver, a domestic large business must agree that any products embodying or produced through the use of an invention conceived or first actually reduced to practice under the award will be substantially manufactured in the United States, unless DOE agrees that the commitments proposed in the U.S. Manufacturing Plan are sufficient.

For other entity types that are selected for award, please see Section VIII.L regarding U.S. manufacturing commitments.

xiv. Draft IP Management Plan

As part of the application, Applicants are required to submit a draft IP Management Plan that will form the basis of the final and executed IP Management Plan as described in Section VI.B.x of this FOA. The draft is expected to cover the major points as described in Section VI.B.x of this FOA. The Prime Recipient must submit a completed and signed Intellectual

Property Management plan to DOE within 30 days of the notification of selection. All Intellectual Property Management Plans are subject to the terms and conditions of the funding agreement and its intellectual property provisions, and applicable Federal laws, regulations, and policies, all of which take precedence over the terms of Intellectual Property Management Plans.

Save the IP Management Plan in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_IPP".

xv. Conflict of Interest Statement

Due to the high profile nature of this Institute and its impact on U.S. manufacturing, it is important that any conflicts of interest (COI), whether actual or perceived, affecting the proposed senior leadership team for the Institute be identified and a mitigation plan be developed. Examples of conflicts of interest include, but are not limited to: financial holdings, business relationships, professional affiliations, and personal relationships and/or affiliations that currently exist or may arise during the operation of the Institute involving foreign or domestic institutions or individuals.

The Applicant must provide a COI Statement for all key Institute management and technical personnel. Identify potential, apparent, or actual organizational and individual conflicts of interest. This shall include Applicants, their team members, and senior/key personnel named in the application. Negative responses are also required.

Save the Conflict of Interest Statement in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_COI".

If an Applicant is selected for award negotiations, the Applicant will be required to submit a Conflict of Interest Management Plan during the award negotiations phase. The Conflict of Interest Management Plan should address how the Institute will manage conflicts across the Institute, and is separate and distinct from the COI Statement referenced above. See Section VI.B.xii.

xvi. Compliance Matrix

Applicants shall provide a "Compliance Matrix" in table format (separate and exempt from total page count) that explains how and where each merit review criteria are addressed in the Project Narrative and Application documentation. The table's format is at the discretion of the Applicant.

Save the Compliance Matrix in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Matrix".

E. Content and Form of Replies to Reviewer Comments

EERE will provide Applicants with reviewer comments following evaluation of all eligible Full Applications. Applicants will have a brief opportunity to review the comments and to prepare a short Reply to Reviewer Comments responding to comments however they desire or supplementing their Full Application. The Reply to Reviewer Comments is an optional submission; Applicants are not required to submit a Reply to Reviewer Comments. EERE will notify Applicants via email when the Reviewer Comments are available for reply. The expected submission deadline is on the cover page of the FOA; however, it is the Applicant's responsibility to monitor email in the event that the expected date changes. The deadline will not be extended for Applicants who are unable to timely submit their reply due to failure to check email or relying on the expected date alone. Applicants should anticipate having approximately three (3) business days to submit Replies to Reviewer Comments.

EERE will not review or consider ineligible Replies to Reviewer Comments (see Section III of the FOA). EERE will review and consider each eligible Full Application, even if no Reply is submitted or if the Reply is found to be ineligible.

Replies to Reviewer Comments must conform to the following content and form requirements, including maximum page lengths, described below. If a Reply to Reviewer Comments is more than six pages in length, EERE will review only the first six (6) pages and disregard any additional pages.

SECTION	PAGE LIMIT	DESCRIPTION
Text	5 pages max	Applicants may respond to one or more reviewer comments or supplement their Full Application.
Optional	1 page max	Applicants may use this page however they wish; text, graphs, charts, or other data to respond to reviewer comments or supplement their Full Application are acceptable.

F. Post-Award Information Requests

If selected for award, EERE reserves the right to request additional or clarifying information for any reason deemed necessary, including but not limited to:

- Indirect cost information
- Other budget information
- Commitment Letters from Third Parties Contributing to Cost Share, if applicable
- Name and phone number of the Designated Responsible Employee for complying with national policies prohibiting discrimination (See 10 CFR 1040.5)
- Representation of Limited Rights Data and Restricted Software, if applicable
- Environmental Questionnaire
- Operational Plan and By-Laws
- Data Management Plan
- Accounting System Survey
- Export Control Plan
- Conflict of Interest

G. Dun and Bradstreet Universal Numbering System Number and System for Award Management

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 System for Award Management (SAM) at https://www.sam.gov before submitting its application; (2) provide a valid Dun and Bradstreet Universal Numbering System (DUNS) 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 DUNS 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 may 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.

H. Submission Dates and Times

Concept Papers, Full Applications, and Replies to Reviewer Comments must be submitted in EERE Exchange no later than 5 p.m. Eastern on the dates provided on the cover page of this FOA.

I. Reserved

J. Intergovernmental Review

This FOA is not subject to Executive Order 12372 – Intergovernmental Review of Federal Programs.

K. Funding Restrictions

i. Allowable Costs

All expenditures must be allowable, allocable, and reasonable in accordance with the applicable Federal cost principles.

Refer to the following applicable Federal cost principles for more information:

- FAR Part 31 for For-Profit entities; and
- 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

ii. Pre-Award Costs

Selectees must request prior written approval to charge pre-award costs. Pre-award costs are those incurred prior to the effective date of the Federal award directly pursuant to the negotiation and in anticipation of the Federal award where such costs are necessary for efficient and timely performance of the scope of work. Such costs are allowable only to the extent that they would have been allowable if incurred after the date of the Federal award and **only** with the written approval of the Federal awarding agency, through the Contracting Officer assigned to the award.

Pre-award costs cannot be incurred prior to the Selection Official signing the Selection Statement and Analysis. Pre-award costs can only be incurred if such costs would be reimbursable under the agreement if incurred after award.

Pre-Award expenditures are made at the Selectee's risk; EERE is not obligated to reimburse costs: (1) in the absence of appropriations; (2) if an award is not made; or (3) if an award is made for a lesser amount than the Selectee anticipated.

1. **Pre-Award Costs Related to National Environmental Policy Act (NEPA) Requirements**
   EERE'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 EERE completing the NEPA review process.

   EERE does not guarantee or assume any obligation to reimburse costs where the Prime Recipient incurred the costs prior to receiving written authorization from the Contracting Officer. If the Applicant elects to undertake activities that 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 and such costs may not be recognized as allowable cost share. 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 EERE 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. 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.

iii. Performance of Work in the United States

1. **Requirement**
   All work performed under EERE Awards must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment; however, the Prime Recipient should make every effort to purchase supplies and equipment within the United States. The Prime Recipient must flow down this requirement to its Subrecipients.

2. **Failure to Comply**
   If the Prime Recipient fails to comply with the Performance of Work in the United States requirement, EERE 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 if the work is performed by the Prime Recipient, Subrecipients, contractors or other project partners.

3. **Waiver**
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 a written waiver request to EERE. Appendix C lists the necessary information that must be included in a request to waive the Performance of Work in the United States requirement.

The Applicant must demonstrate to the satisfaction of EERE that a waiver would further the purposes of the FOA and is in the economic interests of the United States. EERE may require additional information before considering a waiver request. Save the waiver request(s) in a single PDF file titled "ControlNumber_LeadOrganization_Waiver". The Applicant does not have the right to appeal EERE's decision concerning a waiver request.

iv. Construction

Recipients are required to obtain written authorization from the Contracting Officer before incurring any major construction costs.

v. 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. Foreign travel costs are allowable only with the written prior approval of the Contracting Officer assigned to the award.

vi. Equipment and Supplies

To the greatest extent practicable, all equipment and products purchased with funds made available under this FOA should be American-made. This requirement does not apply to used or leased equipment.

Property disposition will be required at the end of a project if the current fair market value of property exceeds $5,000. The rules for property disposition are set forth in 2 CFR 200.310 – 200.316 as amended by 2 CFR 910.360.

vii. Lobbying

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.

Recipients and Subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf) if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence any of the following in connection with your application:

- An officer or employee of any Federal agency;
- A Member of Congress;
- An officer or employee of Congress; or
- An employee of a Member of Congress.

viii. Risk Assessment

Prior to making a Federal award, the DOE is required by 31 U.S.C. 3321 and 41 U.S.C. 2313 to review information available through any OMB-designated repositories of government-wide eligibility qualification or financial integrity information, such as SAM Exclusions and "Do Not Pay."

In addition, DOE evaluates the risk(s) posed by Applicants before they receive Federal awards. This evaluation may consider: results of the evaluation of the Applicant's eligibility; the quality of the application; financial stability; quality of management systems and ability to meet the management standards prescribed in this part; history of performance; reports and findings from audits; and the Applicant's ability to effectively implement statutory, regulatory, or other requirements imposed on non-Federal entities.

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.

V. Application Review Information

A. Technical Review Criteria

i. Concept Papers

Concept Papers are evaluated based on consideration the following factors. All sub-criteria are of equal weight.

Criterion 1: Technical Description, Innovation and Impact (40%)
This criterion involves consideration of the following factors:

- Quality of the proposed integrated modular chemical process intensification technical approach;
- The proposed technical focus areas are well-defined and have well-defined, aggressive quantitative technical objectives;
- The Applicant's understanding of the current state-of-the-art in the field of modular chemical process intensification, including key opportunities and challenges;
- Extent to which the Applicant has described how the proposed technical work will overcome the challenges identified;
- The estimated energy and competitiveness impact that the proposed Institute would have on clean energy and energy efficient manufacturing;
- Quality of the approach presented in the technical education and workforce development plan summary;
- Quality of the approach to strengthen U.S. manufacturing competitiveness while engaging a broad range of stakeholders with both horizontal and vertical reach across and within supply chains.

Criterion 2: Team and Resources (30%)
This criterion involves consideration of the following factors:

- Extent to which the roles and responsibilities of the leadership team are well-defined;

- Whether the Principal Investigator (Institute Director/Executive) and Project Team have the skill, expertise and prior experience needed to successfully execute the Institute;
- Whether the Applicant has adequate access to equipment and facilities necessary to accomplish the effort and/or clearly explains how the proposed Institute intends to obtain access to the necessary equipment and facilities.

Criterion 3: Operations and Management Approach Description (30%)
This criterion involves consideration of the following factors:

- The proposed management and operations structure and approach, including the role of the U.S. government in the management of the proposed Institute.

ii. Full Applications

Applications will be evaluated against the merit review criteria shown below. All sub-criteria are of equal weight.

Criterion 1: Technical Merit, Innovation and Impact (40%)

Technical Merit and Innovation

- Quality of the integrated technical approach, including core competencies identified for the proposed Institute to research, develop and demonstrate innovative modular chemical process intensification technologies that meet the goals and the objectives of the Institute in Section I.C. and those proposed by the Applicant;
- Degree to which the Applicant has defined and justified the proposed Technical Focus Areas building upon those identified in Section I.C. of this FOA, and has clearly defined Institute objectives, goals, performance metrics including aggressive technical targets to achieve the goals of the FOA;
- Extent to which the Applicant demonstrates a strong understanding of the state of the art;
- Scientific merit, feasibility and innovativeness of the technical work as described in the Technical Volume and the SOPO;
- Quality of the technical education and workforce development plan to integrate and support technical education and career training into the Institute ecosystem, and leverage existing resources;
- Strength of the quantifiable metrics, milestones and Go/No-Go decision point and mid-point deliverables defined in the application; and

- Adequacy of the plan for the initial startup phase and initial technical activities, as well as the overall plan for the award period as described in the Technical Volume and the SOPO to accomplish the technical objectives of the Institute.

Impact

- The quality of the Market Transformation plan for the initial proposed projects and technical work and the extent to which the Applicant demonstrates the likelihood of successful technology adoption by industry and supports precompetitive technology development;
- Extent to which the Applicant demonstrates a high and credible impact of the Institute for aggregate cumulative energy savings (TBTU) and reduction in GHG (tons of CO2 equivalent) over ten years relative to existing available technologies;
- Extent to which the Applicant demonstrates the potential impact of the Institute to support U.S manufacturing competitiveness for clean energy and energy efficient manufacturing and supply chains, such as increased domestic production capacity, growth of domestic supply chains, impact on domestic job creation, as well as regional economic development, etc. as a result of successful technology deployment and commercialization from Institute related activities over ten years;
- Degree of commitment to support U.S. manufacturing as demonstrated in the U.S. Manufacturing Plan; and
- Degree to which the Applicant illustrates how DOE funding will enable acceleration of RD&D.

Criterion 2: Qualifications and Resources (30%)

- Quality of the Institute key technical personnel and their level of technical capabilities and relevance to achieving the goals and objectives of the Institute and the FOA;
- Qualifications, relevant expertise, experience and time commitment of the proposed Institute Director/Executive and key management staff, e.g., Deputy Director(s), Chief Technology Officer, Chief Operating Officer, in successfully managing a national effort to develop and deploy modular chemical process intensification technologies;
- The sufficiency of the existing and proposed equipment, facilities and capabilities to support the proposed work as well as enhance horizontal (cross-cutting capabilities across multiple applications/sectors) and vertical supply chain (within a single industry sector or for a particular application) activities;

- Adequacy of budget and spend plan for the proposed project to achieve the defined objectives;
- The degree that cost share demonstrates strong industry commitment and the clarity of the representation of cost share contributions (cash, in-kind) including the source of cost share;
- Degree to which the Application defines the approaches to generate Program Income, if applicable, and how well it will be utilized to support Institute activities and sustainability; and
- Adequacy of funding availability to encourage openness and new participants as the Institute goes forward, and to accommodate changes in strategic direction that may occur once the Institute is formalized and aligned with strategic roadmaps.
- Degree to which the Institute will appropriately leverage existing resources that will result in more impactful outcomes including but not limited to DOE/NNSA FFRDCs, National Institute of Standards and Technology's Manufacturing Extension Partnership (MEP) Centers, National Science Foundation's Advanced Technological Education (ATE) Centers, national laboratories, and other government investments.

Criterion 3: Operations and Management (30%)

Management and Governance Approach

- Effectiveness of management approach and governance structure to enable strategic and technical decision-making;
- Degree to which the Institute can operate as an independent, neutral, non-biased coordinating and convening body for a diverse set of stakeholders;
- Adequacy of the inclusion of Federal government (DOE and other Federal government participants identified by DOE) on decision making bodies (boards/committees) at both a strategic and technical level within the Institute;
- The adequacy and quality of the proposed participation structure (e.g., tiered membership structure, pay-for-use arrangements, etc.) including the benefits and restrictions for each level of participation (such as IP rights) to incentivize broad private sector participation (SMEs, minority-owned businesses, and women-owned businesses);
- Adequacy of the planned business agreements, including how non-disclosure agreements will be used to support the Institute objectives;

Operations and Project Management

- Quality of the operational plans for annual strategic planning, industry roadmap activities; RD&D project selection and prioritization, project

management, performance tracking, export control policies, foreign entity participation and annual performance reviews;

- Quality of the stakeholder engagement plan, and how it demonstrates openness to new participants, in particular with SMEs, minority-owned businesses, and women-owned businesses, and ability to engage stakeholders along the supply chain including end-users;
- Adequacy of the discussion of the economic and operational key risk areas involved in the operations and management plan, and the quality of the mitigation strategies to address them, specifically with respect to Intellectual Property management and strengthening U.S. manufacturing competitiveness;
- Extent to which the Applicant demonstrates a strong level of integration across the Institute elements to provide value that is greater than the sum of the individual activities (i.e., how will the shared facilities support the technical education and workforce development plans and project activities);

Intellectual Property Management Plan

- Adequacy of the IP management plan for supporting the needs of the Institute and its participants, which addresses the precompetitive landscape and the broader U.S. manufacturing sector;
- Quality of the IP Management plan and any other IP agreements (attached as an Appendix to the Narrative) demonstrating that the IP issues inherent with collaborations and/or multi-user facilities are addressed, including those outlined in Section VI.B.x of the FOA;

Transition Plan

- Likelihood that the Institute can achieve financial self-sufficiency from dedicated Federal funding within five years; and
- Reasonableness of the extended profit and loss estimates for an additional three years beyond the award period.

iii. Criteria for Replies to Reviewer Comments

EERE has not established separate criteria to evaluate Replies to Reviewer Comments. Instead, Replies to Reviewer Comments are attached to the original applications and evaluated as an extension of the Full Application.

B. Standards for Application Evaluation

Applications that are determined to be eligible will be evaluated in accordance with this FOA, by the standards set forth in EERE's Notice of Objective Merit

Review Procedure (76 Fed. Reg. 17846, March 31, 2011) and the guidance provided in the "Department of Energy Merit Review Guide for Financial Assistance," which is available at: http://energy.gov/sites/prod/files/meritrev.pdf.

C. 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:

- The degree to which the proposed project optimizes the use of available EERE funding to achieve programmatic objectives;
- The level of industry involvement and demonstrated ability to accelerate commercialization and overcome key market barriers; and
- The degree to which the proposed project will accelerate transformational technological advances in areas that industry, by itself, is not likely to undertake because of technical and financial uncertainty.

Note: Cost sharing above the minimum required will not be considered in the evaluation.

D. Evaluation and Selection Process

i. Overview

The evaluation process consists of multiple phases; each includes an initial eligibility review and a thorough technical review. Rigorous technical reviews of eligible submissions are conducted by reviewers that are experts in the subject matter of the FOA. Ultimately, the Selection Official considers the recommendations of the reviewers, along with other considerations such as program policy factors, in determining which applications to select.

ii. Pre-Selection Interviews

As part of the evaluation and selection process, EERE may invite one or more Applicants to participate in Pre-Selection Interviews. Pre-Selection Interviews are distinct from and more formal than pre-selection clarifications (See Section V.D.iii of the FOA). The invited Applicant(s) will meet with EERE representatives to provide clarification on the contents of the Full Applications and to provide EERE an opportunity to ask questions regarding the proposed project. The information provided by Applicants to EERE through Pre-Selection Interviews contributes to EERE's selection decisions.

EERE will arrange to meet with the invited Applicants in person at EERE's offices or a mutually agreed upon location. EERE may also arrange site visits at certain Applicants' facilities. In the alternative, EERE may invite certain Applicants to participate in a one-on-one conference with EERE via webinar, videoconference, or conference call.

EERE will not reimburse Applicants for travel and other expenses relating to the Pre-Selection Interviews, nor will these costs be eligible for reimbursement as pre-award costs.

EERE may obtain additional information through Pre-Selection Interviews that will be used to make a final selection determination. EERE may select applications for funding and make awards without Pre-Selection Interviews. Participation in Pre-Selection Interviews with EERE does not signify that Applicants have been selected for award negotiations.

iii. Pre-Selection Clarification

EERE may determine that pre-selection clarifications are necessary from one or more Applicants. Pre-selection clarifications are distinct from and less formal than pre-selection interviews. These pre-selection clarifications will solely be for the purposes of clarifying the application, and will be limited to information already provided in the application documentation. The pre-

selection clarifications may occur before, during or after the merit review evaluation process. Information provided by an Applicant that is not necessary to address the pre-selection clarification question will not be reviewed or considered. Typically, a pre-selection clarification will be carried out through either written responses to EERE's written clarification questions or video or conference calls with EERE representatives.

The information provided by Applicants to EERE through pre-selection clarifications is incorporated in their applications and contributes to the merit review evaluation and EERE's selection decisions. If EERE contacts an Applicant for pre-selection clarification purposes, it does not signify that the Applicant has been selected for negotiation of award or that the Applicant is among the top ranked applications.

EERE will not reimburse Applicants for expenses relating to the pre-selection clarifications, nor will these costs be eligible for reimbursement as pre-award costs.

iv. Recipient Integrity and Performance Matters

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 information about the Applicant that is in the designated integrity and performance system accessible through SAM (currently FAPIIS) (see 41 U.S.C. 2313).

The Applicant, at its option, may review information in the designated integrity and performance systems accessible through SAM and comment on any information about itself that a Federal awarding agency previously entered and is currently in the designated integrity and performance system accessible through SAM.

DOE will consider any written comments by the Applicant, in addition to the other information in the designated integrity and performance system, 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 C.F.R. § 200.205.

v. Selection

The Selection Official may consider the technical merit, the Federal Consensus Board's recommendations, program policy factors, and the amount of funds available in arriving at selections for this FOA.

E. Anticipated Notice of Selection and Award Dates

EERE anticipates notifying Applicants selected for negotiation of award by Fall 2016 and making awards by Spring 2017.

VI. Award Administration Information

A. Award Notices

i. Ineligible Submissions

Ineligible Concept Papers and 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 EERE Exchange. The notification letter will state the basis upon which the Concept Paper or the Full Application is ineligible and not considered for further review.

ii. Concept Paper Notifications

EERE will notify Applicants of its determination to encourage or discourage the submission of a Full Application. EERE will send a notification letter by email to the technical and administrative points of contact designated by the Applicant in EERE Exchange.

Applicants may submit a Full Application even if they receive a notification discouraging them from doing so. By discouraging the submission of a Full Application, EERE intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. The purpose of the Concept Paper phase is to save Applicants the considerable time and expense of preparing a Full Application that is unlikely to be selected for award negotiations.

A notification letter encouraging the submission of a Full Application does not authorize the Applicant to commence performance of the project. Please refer to Section IV.K.ii of the FOA for guidance on pre-award costs.

iii. Full Application Notifications

EERE 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 EERE Exchange. The notification letter will inform the Applicant whether or not its Full Application was selected for award negotiations.

Alternatively, EERE 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.

iv. 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 EERE 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 will take approximately 120 days. Applicants must designate a primary and a backup point-of-contact in EERE Exchange with whom EERE 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, EERE will cancel the award negotiations and rescind the Selection. EERE reserves the right to terminate award negotiations at any time for any reason.

Please refer to Section IV.K.ii of the FOA for guidance on pre-award costs.

v. Alternate Selection Determinations

In some instances, an Applicant may receive a notification that its application was not selected for award and EERE designated the application to be an alternate. As an alternate, EERE 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. EERE may ultimately determine to select or not select the Full Application for award negotiations.

vi. Unsuccessful Applicants

EERE shall promptly notify in writing each Applicant whose application has not been selected for award or whose application cannot be funded because of the unavailability of appropriated funds.

B. Administrative and National Policy Requirements

i. Registration Requirements

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 as follows:

1. **EERE Exchange**
   Register and create an account on EERE Exchange at https://eere-Exchange.energy.gov.
   This account will then allow the user to register for any open EERE FOAs that are currently in EERE Exchange. It is recommended that each organization or business unit, whether acting as a team or a single entity, use only one account as the contact point for each submission. Applicants should also designate backup points of contact so they may be easily contacted if deemed necessary. **This step is required to apply to this FOA.**

   The EERE Exchange registration does not have a delay; however, **the remaining registration requirements below could take several weeks to process and are necessary for a potential Applicant to receive an award under this FOA**.

2. **DUNS Number**
   Obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number (including the plus 4 extension, if applicable) at http://fedgov.dnb.com/webform.

3. **System for Award Management**
   Register with the System for Award Management (SAM) at https://www.sam.gov. Designating an Electronic Business Point of Contact (EBiz POC) and obtaining a special password called an MPIN are important steps in SAM registration. Please update your SAM registration annually.

4. **FedConnect**
   Register in FedConnect at https://www.fedconnect.net. To create an organization account, your organization's SAM MPIN is required. For

more information about the SAM MPIN or other registration requirements, review the FedConnect Ready, Set, Go! Guide at http://www.fedconnect.net/FedConnect/Marketing/Documents/FedConnect_Ready_Set_Go.pdf.

5. **Grants.gov**
   Register in Grants.gov (http://www.grants.gov) to receive automatic updates when Amendments to this FOA are posted. However, please note that Concept Papers, and Full Applications will not be accepted through Grants.gov.

6. **Electronic Authorization of Applications and Award Documents**
   Submission of an application and supplemental information under this FOA through electronic systems used by the Department of Energy, including EERE Exchange and FedConnect.net, constitutes the authorized representative's approval and electronic signature.

ii. 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.

iii. Foreign National Access to DOE Sites

All Applicants that ultimately enter into an award resulting from this FOA will be subject to the following requirement concerning foreign national involvement. Upon DOE's request, Prime Recipients must provide information to facilitate DOE's responsibilities associated with foreign national access to DOE sites, information, technologies, and equipment. A foreign national is defined as any person who was born outside the jurisdiction of the United States, is a citizen of a foreign government, and has not been naturalized under U.S. law. If the Prime Recipient or Subrecipients, contractors or vendors under the award, anticipate utilizing a foreign national person in the performance of an award, the Prime Recipient is responsible for providing to the Contracting Officer specific information of the foreign national(s) to satisfy compliance with all of the requirements for access approval.

iv. Subaward and Executive Reporting

Additional administrative requirements necessary for DOE grants and cooperative agreements to comply with the Federal Funding and Transparency Act of 2006 (FFATA) are contained in 2 CFR Part 170. Prime Recipients must register with the new FFATA Subaward Reporting System

database and report the required data on their first tier Subrecipients. Prime Recipients must report the executive compensation for their own executives as part of their registration profile in SAM.

v. National Policy Requirements

The National Policy Assurances that are incorporated as a term and condition of award are located at: http://www.nsf.gov/awards/managing/rtc.jsp.

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

EERE'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 costs to prepare the necessary records may be included as part of the project costs.

vii. Applicant Representations and Certifications

1. **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.

2. **Corporate Felony Conviction and Federal Tax Liability Representations**
   In submitting an application in response to this FOA, the Applicant represents that:

a. It is **not** a corporation that has been convicted of a felony criminal violation under any Federal law within the preceding 24 months, and
b. 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 definitions apply:

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.

3. Nondisclosure and Confidentiality Agreements Representations
In submitting an application in response to this FOA the Applicant represents that:

a. 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.

b. 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.''

(2) 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.

(3) 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.

viii. Statement of Federal Stewardship

EERE will exercise normal Federal stewardship in overseeing the project activities performed under EERE 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.

ix. Statement of Substantial Involvement

EERE has substantial involvement in work performed under Awards made as a result of this FOA. EERE does not limit its involvement to the administrative requirements of the Award. Instead, EERE has substantial involvement in the direction and redirection of the technical aspects of the project as a whole. Substantial involvement includes, but is not limited to, the following:

1. EERE shares responsibility with the Recipient for the management, control, direction, and performance of the Project.
2. EERE may intervene in the conduct or performance of work under this Award for programmatic reasons. Intervention includes the interruption or modification of the conduct or performance of project activities.
3. EERE may redirect or discontinue funding the Project based on the outcome of EERE's evaluation of the Project at a Go/No-Go decision point.
4. EERE may redirect or discontinue funding for individual Institute Activities based on the outcome of EERE's evaluation of those activities at the Go/No-Go decision points.
5. EERE participates in major project decision-making processes.
6. EERE participates in any governance or management boards that may be established and may invite other U.S. Government officials for participation in advisory capacity.
7. To adequately monitor project progress and provide direction to the Institute, the Prime Recipient must provide EERE with an adequate level of insight into various Institute activities. Government Insight activities by EERE include attendance at Institute meetings, reviews and tests, and project management and monitoring activities which may result in co-location and physical accommodation of a Federal employee or Federal contractor onsite. The Prime Recipient must notify EERE of meetings, reviews, and tests in sufficient time to permit EERE participation and provide all appropriate documentation for EERE review. The Prime Recipient may be asked to provide a suitable physical location for a Federal employee or contractor for a specific time or as part of ongoing project management and monitoring by EERE.
8. EERE may choose to engage a private, independent engineering (IE) firm to assist in assessing the progress of the project and provide timely and accurate reports to EERE. The Prime Recipient will ensure that the IE has access to any and all relevant documentation sufficient to allow the IE to provide independent evaluations to EERE on the progress of the project. The Prime Recipient may require the IE to sign a nondisclosure agreement, and will negotiate the agreement in good faith and in a timely manner. EERE will evaluate the quality and completeness of

information and documentation provided by the Prime Recipient to EERE and its consultants (i.e., IE) in order to allow EERE to provide technical direction to the Prime Recipient about how best to achieve the objectives of the Institute. Consultants to EERE may not provide technical direction to the Prime Recipient.

x. Intellectual Property Management Plan

Each Applicant selected for award negotiations will be required to submit a final IP Management Plan during the award negotiations phase. The final IP Management Plan must be based on the draft IP Management Plan submitted with the application and agreed upon by the members of the Institute.

The award will set forth the treatment of and obligations related to intellectual property rights between EERE and the individual members. The IP Management Plan should describe how the members will handle intellectual property rights and issues between themselves while ensuring compliance with Federal IP laws, regulations, and policies (see Sections VIII.L-VIII.O of this FOA for more details on applicable Federal IP laws and regulations). Guidance regarding the contents of IP Management Plans is available from EERE upon request.

The following is a non-exhaustive list of examples of items that the IP Management Plan may cover:

- The treatment of confidential information between members (e.g., the use of non-disclosure agreements);
- The treatment of background IP (e.g., any requirements for identifying it or making it available);
- The treatment of inventions made under the project (e.g., any requirements for disclosing to the other members, filing patent applications, paying for patent prosecution, and cross-licensing or other licensing arrangements between the members);
- The treatment of data produced, including software, under the project (e.g., any publication process or other dissemination strategies, copyrighting strategy or arrangement between members);
- Any technology transfer and commercialization requirements or arrangements between the members;
- The treatment of any intellectual property issues that may arise due to a change in membership of the consortia or team; and

- The handling of disputes related to intellectual property between the members.

xi. Data Management Plan

Applicants whose Full Applications are selected for award negotiations will be required to submit a Data Management Plan during the award negotiations phase. The Data Management Plan is a document that outlines the proposed plan for data sharing or preservation. Submission of this plan is required, and failure to submit the plan may result in the termination of award negotiations.

At a minimum, the Data Management Plan 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 Data Management Plan must provide a plan for making all research data displayed in publications resulting from the proposed work digitally accessible at the time of publication. The Data Management Plan should also address how the results from the Institute are to be shared with the greater manufacturing community and the public as appropriate.

As a courtesy, guidance for preparing a Data Management Plan is provided in Appendix D of the FOA.

xii. Conflict of Interest Identification and Mitigation

Due to the high profile nature of this Institute and its impact on U.S. manufacturing, it is important that any conflicts of interest (COI), whether actual or perceived, affecting the proposed senior leadership team for the Institute be identified and a mitigation plan be developed. Examples of conflicts of interest include, but are not limited to: financial holdings, business relationships, professional affiliations, and personal relationships and/or affiliations that currently exist or may arise during the operation of the Institute involving foreign or domestic institutions or individuals.

In addition to the Conflict of Interest Statement submitted with the Full Application (see Section IV.D.xv), the Selectee must further identify any and all potential conflicts of interest beyond those submitted with the initial Application for the Institute and the leadership team on an individual basis, with any proposed mitigation efforts. This information will be due to EERE no later than seven (7) business days after notice of selection for award negotiations. All conflicts must be identified, documented and resolved through a conflict of interest mitigation and avoidance plan approved by the

Contracting Officer. The Selectee must obtain this approval from the Contracting Officer prior to involvement by any representatives in any negotiations with EERE or Institute activities.

Further, the Selectee must provide EERE with a comprehensive COI Management Plan that addresses how the Institute will handle COI matters during the lifetime of the Institute (e.g., identification and mitigation of COI). Such COI Management Plan will be subject to further modification and review during award negotiations.

xiii. Risk Mitigation Plan

If selected for award negotiations, the details of the Selectee's Risk Mitigation Plan will be subject to review and approval by EERE. The Risk Mitigation plan will need to address control of sensitive information within and outside the Institute. Components for risk mitigation plan should include: (1) vetting of staff working on projects, and (2) identifying, handling, and managing sensitive information. As part of a Risk Mitigation Plan, EERE will require the following conditions be included:

- EERE reserves the right for final determination of identification, categorization and treatment of information generated through Institute activities.

- The Institute must document to the satisfaction of the Contracting Officer that the Institute has properly vetted all individuals proposed to participate in Institute projects in accordance with the Information Risk Mitigation Plan. This documentation must be provided to EERE with sufficient time for review prior to individuals' participation in project activities.

xiv. Export Control Plan

Some projects within the Institute may be subject to export control laws and regulations. Under no circumstances may foreign entities (organizations, companies or persons) receive access to export controlled information unless proper export procedures have been satisfied and such access is authorized pursuant to law or regulation. The Institute will address participation by foreign entities (organizations, companies or persons) on a case-by-case basis, and will ensure measures that properly protect export controlled information.

If an Applicant is selected for award negotiations, the Applicant will be required to submit an Export Control Management Plan during the award negotiations phase for review and approval by EERE. The Export Control Management Plan should adequately demonstrate that the Applicant has a strong understanding of and an adequate plan to manage export control compliance. The Export Control Management Plan should outline the specific compliance safeguards the Institute will implement across the Institute's activities.

xv. Foreign Involvement

The Recipient of the Award must be incorporated (or otherwise formed) under the laws of a State or territory of the United States with majority domestic ownership or control (See Section III). Foreign entities may be eligible to become participants, and sub-recipients of Federal support, if the entity is able to demonstrate to the satisfaction of the Institute management and DOE that: 1) their participation is in the best interest of the Institute, U.S. industry, and U.S. economic development; 2) adequate Intellectual Property (IP) and data protection protocols exist between the U.S. subsidiary and its foreign parent organization; 3) the work is conducted within the U.S. and the entity acknowledges the U.S. Manufacturing Plan; and 4) other conditions that may be deemed necessary by the Institute and DOE to protect U.S. government interests.

If an Applicant is selected for award negotiations, the Applicant must address through its governing documents (e.g., bylaws, operational plan) how it will handle the participation of foreign entities as users, members or otherwise engage in activities at the Institute or in connection with the Institute while ensuring the goal to strengthen U.S. manufacturing competitiveness is met.

xvi. Subject Invention Utilization Reporting

In order to ensure that Prime Recipients and Subrecipients holding title to subject inventions are taking the appropriate steps to commercialize subject inventions, EERE may require that each Prime Recipient holding title to a subject invention submit annual reports for 10 years from the date the subject invention was disclosed to EERE 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 EERE may specify.

xvii. Intellectual Property Provisions

The standard DOE financial assistance intellectual property provisions applicable to the various types of recipients are located at http://www1.eere.energy.gov/financing/resources.html.

xviii. Reporting

Reporting requirements are identified on the Federal Assistance Reporting Checklist, attached to the award agreement. The checklist can be accessed at http://www1.eere.energy.gov/financing/resources.html.

xix. 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. 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 and the availability of future-year budget authority; (2) meeting the objectives, milestones, deliverables, and decision point criteria of the recipient's approved project and obtaining approval from EERE to continue work on the project; and (3) the submittal of required reports in accordance with the Statement of Project Objectives.

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, EERE may take appropriate action, including but not limited to, redirecting, suspending or terminating the award.

xx. 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.

VII. Questions/Agency Contacts

Upon the issuance of a FOA, EERE personnel are prohibited from communicating (in writing or otherwise) with Applicants regarding the FOA except through the established question and answer process as described below. Specifically, questions regarding the content of this FOA must be submitted to: ModularChemicalPI@ee.doe.gov. Questions must be submitted not later than 3 business days prior to the application due date and time.

All questions and answers related to this FOA will be posted on EERE Exchange at: https://eere-exchange.energy.gov. **Please note that you must first select this specific FOA Number in order to view the questions and answers specific to this FOA**. EERE will attempt to respond to a question within 3 business days, unless a similar question and answer has already been posted on the website.

Questions related to the registration process and use of the EERE Exchange website should be submitted to: EERE-ExchangeSupport@hq.doe.gov.

VIII. Other Information

A. FOA Modifications

Amendments to this FOA will be posted on the EERE Exchange website and the Grants.gov system. However, you will only receive an email when an amendment or a FOA is posted on these sites if you register for email notifications for this FOA in Grants.gov. EERE recommends that you register as soon after the release of the FOA as possible to ensure you receive timely notice of any amendments or other FOAs.

B. Informational Webinar

EERE will conduct one informational webinar during the FOA process. It will be held after the initial FOA release but before the due date for Concept Papers.

Attendance is not mandatory and will not positively or negatively impact the overall review of any Applicant submissions. As the webinar will be open to all Applicants who wish to participate, Applicants should refrain from asking

questions or communicating information that would reveal confidential and/or proprietary information specific to their project. Specific dates for the webinar can be found on the cover page of the FOA.

C. Government Right to Reject or Negotiate

EERE 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.

D. 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.

E. Treatment of Application Information

In general, EERE will only use data and other information contained in applications for evaluation purposes, unless such information is generally available to the public or is already the property of the Government.

Applicants should not include trade secrets or commercial or financial information that is privileged or confidential 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.

The use of protective markings such as “Do Not Publicly Release – Trade Secret” or “Do Not Publicly Release – Confidential Business Information” is encouraged. However, Applicants should be aware that the use of protective markings is not dispositive as to whether information will be publicly released pursuant to the Freedom of Information Act, 5 U.S.C. §552, et. seq., as amended by the OPEN Government Act of 2007, Pub. L. No. 110-175. (See Section VIII.I of this document, “Notice of Potential Disclosure Under the Freedom of Information Act (FOIA)” for additional information regarding the public release of information under the Freedom of Information Act.)

Applicants are encouraged to employ protective markings in the following manner:

The cover sheet of the application must be marked as follows and identify the specific pages containing trade secrets or commercial or financial information that is privileged or confidential:

Notice of Restriction on Disclosure and Use of Data:
Pages [list applicable pages] of this document may contain trade secrets or commercial or financial information that is privileged or confidential, and is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes or in accordance with a financial assistance or loan agreement 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]

The header and footer of every page that contains trade secrets or commercial or financial information that is privileged must be marked as follows: "May contain trade secrets or commercial or financial information that is privileged or confidential and exempt from public disclosure."

In addition, each line or paragraph containing trade secrets or commercial or financial information that is privileged or confidential must be enclosed in brackets.

F. Evaluation and Administration by Non-Federal Personnel

In conducting the merit review evaluation, the Go/No-Go review and Peer 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.

G. Notice Regarding Eligible/Ineligible Activities

Eligible activities under this FOA 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.

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

EERE 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).

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

Under the Freedom of Information Act, (FOIA), 5 U.S.C. §552, et. seq., as amended by the OPEN Government Act of 2007, Pub. L. No. 110-175, any information received from the Applicant is considered to be an agency record, and as such, subject to public release under FOIA. The purpose of the FOIA is to afford the public the right to request and receive agency records unless those agency records are protected from disclosure under one or more of the nine FOIA exemptions. Decisions to disclose or withhold information received from the Applicant are based upon the applicability of one or more of the nine FOIA exemptions, not on the existence or nonexistence of protective markings or designations. Only the agency's designated FOIA Officer may determine if information received from the Applicant may be withheld pursuant to one of the nine FOIA exemptions. All FOIA requests received by DOE are processed in accordance with 10 C.F.R. Part 1004.

J. 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.

K. Retention of Submissions

EERE expects to retain copies of all Concept Papers, Full Applications, Replies to Reviewer Comments, and other submissions. No submissions will be returned. By applying to EERE for funding, Applicants consent to EERE's retention of their submissions.

L. Title to Subject Inventions

Ownership of subject inventions is governed pursuant to the authorities listed below.

- Domestic Small Businesses, Educational Institutions, and Nonprofits: Under the Bayh-Dole Act (35 U.S.C. § 200 et seq.), domestic small businesses,

educational institutions, and nonprofits may elect to retain title to their subject inventions.

- All other parties: The Federal Non-Nuclear Energy Act of 1974, 42. U.S.C. 5908, provides that the Government obtains title to new inventions unless a waiver is granted (see below).
- Class Patent Waiver: DOE has issued a class waiver that applies to this FOA. Under this class waiver, domestic large businesses may elect title to their subject inventions similar to the right provided to the domestic small businesses, educational institutions, and nonprofits by law. In order to avail itself of the class waiver, a domestic large business must agree 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 that the commitments proposed in the U.S. Manufacturing Plan are sufficient.
- Advance and Identified Waivers: Applicants may request a patent waiver that will cover subject inventions that may be invented under the award, in advance of or within 30 days after the effective date of the award. Even if an advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver for identified inventions, i.e., individual subject inventions that are disclosed to EERE within the timeframes set forth in the award's intellectual property terms and conditions. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784.
- Determination of Exceptional Circumstances (DEC): Each Applicant is required to submit a U.S. Manufacturing Plan as part of its application. If selected, the U.S. Manufacturing Plan shall be incorporated into the award terms and conditions for domestic small businesses and nonprofit organizations. DOE has determined that exceptional circumstances exist that warrants the modification of the standard patent rights clause for small businesses and non-profit awardees under Bayh-Dole to the extent necessary to implement and enforce the U.S. Manufacturing Plan. For example, the commitments and enforcement of a U.S. Manufacturing Plan may be tied to subject inventions. Any Bayh-Dole entity (domestic small business or nonprofit organization) affected by this DEC has the right to appeal it.

M. Government Rights in Subject Inventions

Where Prime Recipients and Subrecipients retain title to subject inventions, the U.S. Government retains certain rights.

i. Government Use License

The U.S. 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.

ii. March-In Rights

The U.S. 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 U.S. 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.

N. Rights in Technical Data

Data rights differ based on whether data is first produced under an award or instead was developed at private expense outside the award.

"Limited Rights Data": The U.S. Government will not normally require delivery of confidential or trade secret-type technical data developed solely at private expense prior to issuance of an award, except as necessary to monitor technical

progress and evaluate the potential of proposed technologies to reach specific technical and cost metrics.

Government rights in Technical Data Produced Under Awards: The U.S. Government normally retains unlimited rights in technical data produced under Government financial assistance awards, including the right to distribute to the public. However, pursuant to special statutory authority, certain categories of data generated under EERE awards may be protected from public disclosure for up to five years after the data is generated ("Protected Data"). For awards permitting Protected Data, the protected data must be marked as set forth in the awards intellectual property terms and conditions and a listing of unlimited rights data (i.e., non-protected data) must be inserted into the data clause in the award. In addition, invention disclosures may be protected from public disclosure for a reasonable time in order to allow for filing a patent application.

O. Copyright

The Prime Recipient and Subrecipients may assert copyright in copyrightable works, such as software, first produced under the award without EERE 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.

P. Personally Identifiable Information (PII)

All information provided by the Applicant must to the greatest extent possible exclude Personally Identifiable Information (PII). The term "personally identifiable information" refers to information which can be used to distinguish or trace an individual's identity, such as their name, social security number, biometric records, etc. alone, or when combined with other personal or identifying information which is linked or linkable to a specific individual, such as date and place of birth, mother's maiden name, etc. (See OMB Memordum M-07-16 dated May 22, 2007, found at: https://www.whitehouse.gov/sites/default/files/omb/memoranda/fy2007/m07-16.pdf

By way of example, Applicants must screen resumes to ensure that they do not contain PII such as personal addresses, phone/cell numbers, personal emails and/or SSNs. In short, if the PII is not essential to the application, it should not be in the application.

Q. Annual Compliance Audits

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

If an educational institution, 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.

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

Appendix A – 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. EERE 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 costs must be included in Total Project Costs. 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 EERE 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. For example, the value of ten years of donated maintenance on a project that has a project period 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 is allowable and may be counted as cost share.

Additionally, EERE 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, EERE generally does not allow pre-award costs prior to the signing of the Selection Statement by the EERE Selection Official.

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 B – Reserved

Appendix C – Waiver Requests: Foreign Entity Participation as the Prime Recipient and Performance of Work in the United States

1. Waiver for Foreign Entity Participation as the Prime Recipient

As set forth in Section III.A.iii, 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 with majority domestic ownership or control. 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 EERE 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 waiver request must include the following:

- Entity name;
- The rationale for proposing a foreign entity to serve as the Prime Recipient;
- Country of incorporation;
- 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).

EERE may require additional information before considering the waiver request.

The Applicant does not have the right to appeal EERE's decision concerning a waiver request.

2. Waiver for Performance of Work in the United States

As set forth in Section IV.K.iii, all work under EERE 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 EERE 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 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.

EERE may require additional information before considering the waiver request.

The Applicant does not have the right to appeal EERE's decision concerning a waiver request.

Appendix D - Data Management Plan

A data management plan ("DMP") explains how data generated in the course of the work performed under an EERE 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.

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, EERE 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, EERE 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 E – DEFINITION OF TECHNOLOGY READINESS LEVELS AND MANUFACTURING READINESS LEVELS

TRL 1:	**Basic principles observed and reported**	**MRL 1:**	**Manufacturing feasibility assessed**
TRL 2:	**Technology concept and/or application formulated**	**MRL 2:**	**Manufacturing feasibility defined**
TRL 3:	**Analytical and experimental critical function and/or characteristic proof of concept**	**MRL 3:**	**Manufacturing feasibility developed**
TRL 4:	**Component and/or breadboard validation in a laboratory environment**	**MRL 4:**	**Capability to produce the technology in a laboratory environment**
TRL 5:	**Component and/or breadboard validation in a relevant environment**	**MRL 5:**	**Capability to produce a prototype components in a production relevant environment**
TRL 6:	**System/subsystem model or prototype demonstration in a relevant environment**	**MRL 6:**	**Capability to produce prototype system or subsystem in a production relevant environment**
TRL 7:	**System prototype demonstration in an operational environment**	**MRL 7:**	**Capability to produce systems, subsystems or components in a production relevant environment**
TRL 8:	**Actual system completed and qualified through test and demonstrated**	**MRL 8:**	**Pilot line capability demonstrated; ready to begin low rate initial production**
TRL 9:	**Actual system proven through successful mission operations**	**MRL 9:**	**Low rate production demonstrated; capability in place to begin full rate production**

Manufacturing Innovation Institute Target

APPENDIX F – LIST OF ACRONYMS

AMNPO	Advanced Manufacturing National Program Office
AMO	Advanced Manufacturing Office
AMP	Advanced Manufacturing Partnership
CAx	Computer-Aided x (example, Design, Engineering, Manufacturing, Process planning)
CEMI	Clean Energy Manufacturing Initiative
CFR	Code of Federal Regulation
COI	Conflicts of interest
CRADA	Cooperative Research and Development Agreement
D&B	Dun and Bradstreet
DEC	Determination of Exceptional Circumstances
DMP	Data Management Plan
DOD	Department of Defense
DOE	Department of Energy
DUNS	Dun and Bradstreet Data Universal Numbering System
EERE	Energy Efficiency and Renewable Energy
ERP	Enterprise Resource Planning
FAR	Federal Acquisition Regulation
FFATA	Federal Funding and Transparency Act of 2006
FFRDC	Federally Funded Research and Development Centers
FOA	Funding Opportunity Announcement
FOIA	Freedom of Information Act
FWP	Field Work Proposal
GAAP	Generally Accepted Accounting Principles
GDP	Gross Domestic Product
GHG	Greenhouse gas
IP	Intellectual Property
ISO	International Organization for Standardization
IT	Information Technology
MEP	Manufacturing Extension Partnership
MES	Manufacturing Execution System
MPIN	Marketing Partner ID Number
MRL	Manufacturing Readiness Level
NEPA	National Environmental Policy Act
NNMI	National Network for Manufacturing Innovation
NNSA	National Nuclear Security Administration

NSF (ATE)	National Science Foundation (Advanced Technological Education)
NSTC	National Science and Technology Council
OEM	Original Equipment Manufacturer
OMB	Office of Management and Budget
OSTI	Office of Scientific and Technical Information
PDCA	Plan-Do-Check-Act
PII	Personally Identifiable Information
POC	Point of Contact
QTR	Quadrennial Technology Review
Quad	Quadrillion British Thermal Unit
RD&D	Research and Development
RD&D	Research, Development and Demonstration
SAM	System for Award Management
SMEs	Small and Medium-sized Enterprises
SOPO	Statement of Project Objectives
TBTU	Trillion British Thermal Unit
TIA	Technology Investment Agreement
TRL	Technical Readiness Level
U.S.C	United States Code
UQ	Uncertainty Quantification
WBS	Work Breakdown Structure

APPENDIX G – FREQUENTLY ASKED QUESTIONS ABOUT ENERGY INTENSIVE, ENERGY DEPENDENT, ADVANCED AND CLEAN ENERGY MANUFACTURING

What is meant by the term Energy Intensive Manufacturing? Energy Intensive Manufacturing is defined as industry that uses significant (total) quantities of energy as part of its primary economic activity." Energy Independence and Security Act (EISA - 2007) PL 110-140 Title IV Sec 452.

What are examples of Energy Intensive Industries? Petroleum refining, chemicals production, primary metals production, mining, food and beverage and forest products are examples of energy intensive manufacturing sub-sectors. Each of these subs-sectors consumes more than 1 quadrillion BTUs of energy per year. Further information on energy intensive industries may be found at DOE Quadrennial Technology Review (QTR), Chapter 6 "Innovating Clean Energy Technologies in Advanced Manufacturing" http://energy.gov/qtr. Energy Intensive Industries are highlighted in Section 6.3 "Technology Opportunities for Production/Facility Systems – Energy and Resource Utilization"

What is meant by the term Energy Dependent Manufacturing? Energy Dependent Industries are defined for the purposes of this FOA as "industry that uses significant (relative) quantities of energy as a part of its primary activity." As a result, energy dependent industry sectors have the potential to become energy intensive industries but are not because of the current size of the sector. There are several clean energy technologies which are energy dependent. By developing technologies which limit the energy dependency of manufacturing these products these products may not become energy intensive as their cost effective production becomes more prevalent.

What are examples of Energy Dependent Industries? Semiconductor solar cells, carbon fiber composites, corrosion resistant alloys, light emitting diodes and electric vehicle batteries are examples of products for clean energy applications which are energy dependent. Semiconductors microprocessors and memory chips for computation, advanced textiles for fashion, exotic metals for space exploration and nanomaterials for healthcare are all examples of potentially energy dependent industries for which the primary application is not clean energy.

What is meant by the term Clean Energy Manufacturing? Clean energy manufacturing is the production of goods and services where either the method of production or the application of the good or service results in reduced energy consumption or reduced impact on the environment.