DE-FOA-0002564: Request for Information on Establishing a New Manufacturing Institute

DATE: August 24, 2021
SUBJECT: Request for Information (RFI)

1.0 Description

The Advanced Manufacturing Office (AMO) is seeking information to refine the scope of a potential new Clean Energy Manufacturing Institute. This Institute will focus on reducing the overall emissions of domestic manufacturing through carbon intensity improvements, moving the Industrial Sector towards net zero emissions. This request for information (RFI) is specifically focused on aspects of industrial decarbonization associated with electrification and/or metals manufacturing, but is open to other technology areas that would have a similar level of emissions reduction in the industrial sector. AMO is particularly interested in opportunities and challenges associated with advanced manufacturing technology which are best addressed through collaborations conducted via a Manufacturing Institute[1].

1.1 Advanced Manufacturing Office

AMO is a technology office within the Department of Energy's (DOE) Office of Energy Efficiency & Renewable Energy (EERE). AMO is the only technology development office within the U.S. Government that is dedicated to improving the energy efficiency, material efficiency, productivity, and competitiveness of manufacturers across the industrial sector. The AMO Mission is to catalyze research, development, and adoption of energy-related advanced manufacturing technologies and practices to drive U.S. economic competitiveness and energy productivity[2]. To achieve its mission, AMO partners with private and public stakeholders and invests in cost-shared research, development, and demonstration (RD&D) of innovative, next generation manufacturing processes and production technologies that will improve efficiency and reduce emissions, reduce industrial waste and reduce the life-cycle energy consumption of manufactured products.

[1] Manufacturing USA Institutes. 2021. https://www.manufacturingusa.com/institutes
[2] Advanced Manufacturing Office Mission and Goals, U.S. Department of Energy, 2020. https://www.energy.gov/eere/amo/vision-mission-and-goals

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1.2 Utility of a Manufacturing Institute

Manufacturing Institutes are public-private partnerships that sponsor research and facilitate technology development in a given topic area. Currently, AMO supports six Manufacturing Institutes[3]. The goals of a Manufacturing Institute are to[1]:

- Increase the competitiveness of U.S. manufacturing;
- Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities;
- Accelerate the development of an advanced manufacturing workforce; and
- Implement a business model that ensures a long-term impact on the U.S. industrial sector, based on the value proposition to its members.

Manufacturing Institute	Topic	Home Institution
PowerAmerica	Wide-bandgap semiconductors	NC State – Raleigh, NC
IACMI	Carbon fiber composites	Collaborative Composites Solutions – Knoxville, TN
CESMII	Smart manufacturing	UCLA – Los Angeles, CA
RAPID	Chemical process intensification	AIChE – New York, NY
REMADE	Recycling and remanufacturing	Sustainable Manufacturing Innovation Alliance – Rochester, NY
CyManII	Energy efficient, cyber-secure manufacturing	UTSA – San Antonio, TX

Table 1: The six Clean Energy Manufacturing Institutes supported by AMO.

[3] R&D Consortia. Advanced Manufacturing Office. U.S. Department of Energy. 2021. https://www.energy.gov/eere/amo/research-development-consortia

The six Manufacturing Institutes cover a diverse range of technical areas and use a variety of approaches to achieve their specific missions. Regardless of the technical area, AMO's Clean Energy Manufacturing Institutes bolster U.S. energy efficiency, competitiveness, and innovation by:

- Convening industry, academia, and other stakeholders to address multi-faceted, complex problems: A successful Institute will be organized to foster an open exchange of manufacturing best-practices and research results while protecting intellectual property. By engaging the manufacturing community at all levels of the supply chain to support applied RD&D projects, an Institute will demonstrate the transition of innovations to the commercial market;
- Developing advanced manufacturing workforce skills: Institutes support technical education and workforce development to enable individuals to acquire the skills necessary to participate in a high-skilled work environment. These educational/development activities also allow stakeholders to be involved and participate meaningfully to improve their communities; and
- Catalyzing federal investment of $70 million for initial collaboration: DOE establishes Institutes with the intent to provide an ecosystem that can drive innovation beyond DOE's5-year investment. In that time, the Institute should enable demonstration of advanced manufacturing technologies at a scale significant enough to establish technical feasibility and enable business case development to attract further public and private investment. The goal of an Institute is to catalyze sufficient achievements to justify and attract future public and private investment.

<u>The responses to Categories 1 through 13 will be interpreted in the context of establishing a new DOE Clean Energy Manufacturing Institute</u>. A response to all questions in this RFI is **not** required. An organization may choose to respond to as many or as few questions as they wish.

1.3 Diversity, Equity, and Inclusion

It is the policy of the Biden Administration that the Federal Government should pursue a comprehensive approach to advancing equity[4] for all, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality. Affirmatively advancing equity, civil rights, racial justice, and equal opportunity is the responsibility of the whole of our Government. Because advancing equity requires a systematic approach to embedding fairness in decision-making processes, executive

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[4] Executive Order 13985, "Advancing Racial Equity and Support for Underserved Communities Through the Federal Government" (Jan. 20, 2021) https://www.federalregister.gov/documents/2021/01/25/2021-01753/advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government

departments and agencies must recognize and work to address inequities in their policies and programs that serve as barriers to equal opportunity. By advancing equity across the Federal Government, we can create opportunities for the improvement of communities that have been historically underserved, which benefits everyone.

As part of the administration's whole of government approach, AMO seeks to encourage the participation of underserved communities and underrepresented groups. Manufacturing Institutes are highly encouraged to include individuals from groups underrepresented in Science, Technology, Engineering and Math (STEM). AMO is interested in how diversity, equity, and inclusion can be incorporated into RD&D investments to foster a productive and inclusive environment, support people from underrepresented groups in STEM, advance equity, and encourage the inclusion of individuals from these groups.

2.0 Purpose

The purpose of this RFI is to narrow the focus of a possible Manufacturing Institute that supports "Industrial Decarbonization". This RFI will gather feedback from industry, academia, research laboratories, government agencies, and other stakeholders on the potential value of a Manufacturing Institute to address the technical challenges related to emissions reduction and decarbonization of the U.S. Industrial Sector as well as the scope of challenges that are best suited to be addressed through an Institute rather than other funding mechanisms.

AMO will host an RFI webinar to maximize stakeholder engagement. More information about the RFI Webinar can be found in Section 7.0.

3.0 Administrative

3.1 Disclaimer

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

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as

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information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

3.2 Confidential Business Information

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

3.3 Evaluation and Administration by Federal and Non-Federal Personnel

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

4.0 Background

The scope of Industrial Decarbonization and specific Institute topics: (1) Electrification of Industrial Processes, and (2) Decarbonization of Metal Manufacturing; are described in sections 4.1, 4.2, and 4.3 respectively.

4.1 Industrial Decarbonization

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To avoid overshooting 1.5 degrees Celsius of global temperature rise, the United States is targeting "net-zero emissions, economy-wide, by no later than 2050"[5]. Industry accounts for 32% of the nation's primary energy use[6] and 28% of energy-related Greenhouse Gas (GHG) emissions, with refining, chemicals, iron and steel, cement, and food products representing the top energy-consuming sectors. This level of energy consumption and GHG emissions represents a need for clean and efficient manufacturing technologies and; therefore, an opportunity for innovation. The U.S. industrial sector is considered a "difficult-to-decarbonize" sector of the energy economy, due in part to the diversity of energy inputs into a wide array of heterogeneous industrial processes and operations. Technology development, demonstration, and deployment that enable emissions reduction in the industrial sector will be critical to achieving the goal of net zero emissions by 2050.

The Achievement of a low-carbon industrial sector in the United States poses a range of structural and technical challenges. The sheer multitude of materials transformations – from extraction to intermediate and final products – will require a wide range of technology solutions that will have a ripple effect across a variety of industries and their increasingly complex supply chains. Further, anticipated product demand growth of 30% by 2050 with an associated increase in GHG emissions of 15%[5] will require more than marginal improvements in reducing carbon intensity. Despite these challenges to industrial decarbonization, the industrial sector has the opportunity to improve manufacturing productivity, develop innovative products, and meet expanding societal needs while reducing its carbon dependence (i.e., decarbonizing). Because industrial decarbonization could take decades, it is imperative to start now to minimize the cumulative effects of GHG emissions and to catalyze the knowledge needed to implement the transition.

Due to the abovementioned complexity and urgency for industrial decarbonization, there are many approaches that must be pursued simultaneously. These approaches include: energy efficiency (EE); electrification and low-carbon fuels and feedstocks (LCFF); and carbon capture, utilization & storage (CCUS). As seen in Figure 1, all approaches are expected to provide significant contributions to overall emissions reduction in the industrial sub-sector. Although future emissions benefits from each approach may be roughly equivalent by 2050, the state of technology today varies quite a bit and depends not only on the approach but also on the sector to which it is applied. AMO aims to prioritize industrial decarbonization strategies that are within the scope of its Mission and to establish an Institute in a manner that has the largest impact.

[5] Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," January 27, 2021. https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad

[6] Energy Use in Industry. U.S. Energy Information Administration. 2019. https://www.eia.gov/energyexplained/use-of-energy/industry.php; including feedstocks – fossil inputs into materials (chemicals and plastics).

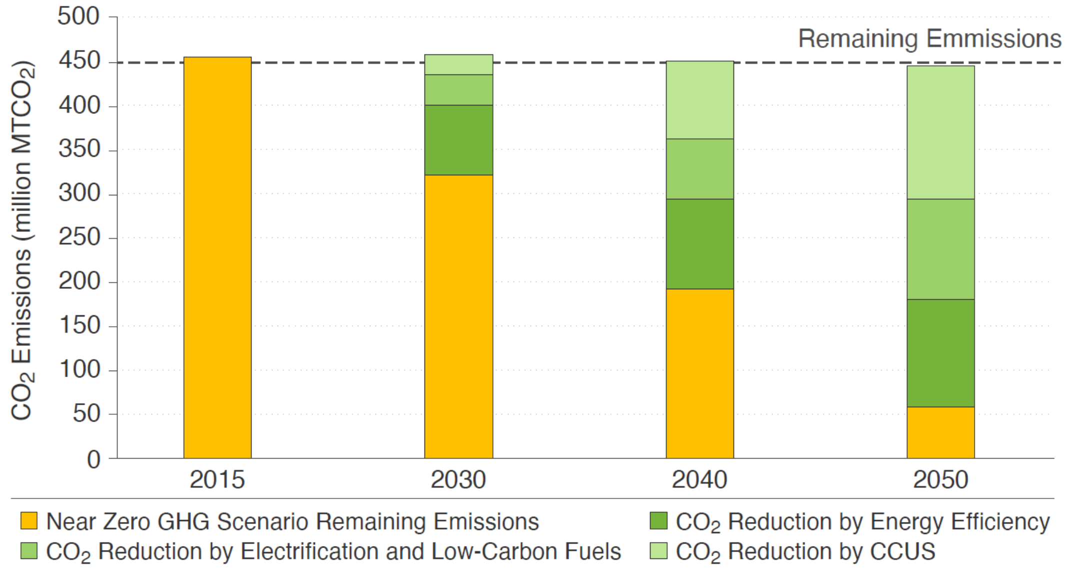

Figure 1: CO_2 emissions (million MT/year) reduction potential across the decarbonization pillars (EE, electrification & LCFF, and CCUS) for the U.S. iron and steel, chemical manufacturing, food manufacturing, refining, and cement sectors for the near zero GHG scenario (excluding feedstocks). Source: AMO Industrial Decarbonization Roadmap, currently under review.

The variety in technology needs across various industrial sub-sectors adds another layer of complexity to emissions abatement. The five highest energy-consuming industrial sub-sectors are: iron and steel, chemicals, food and beverage, petroleum refining, and cement. Figure 2 shows their contributions to the overall energy-related emissions in the industrial sector, which collectively account for roughly 70% of manufacturing-related emissions (excluding non-manufacturing and industrial electricity losses).

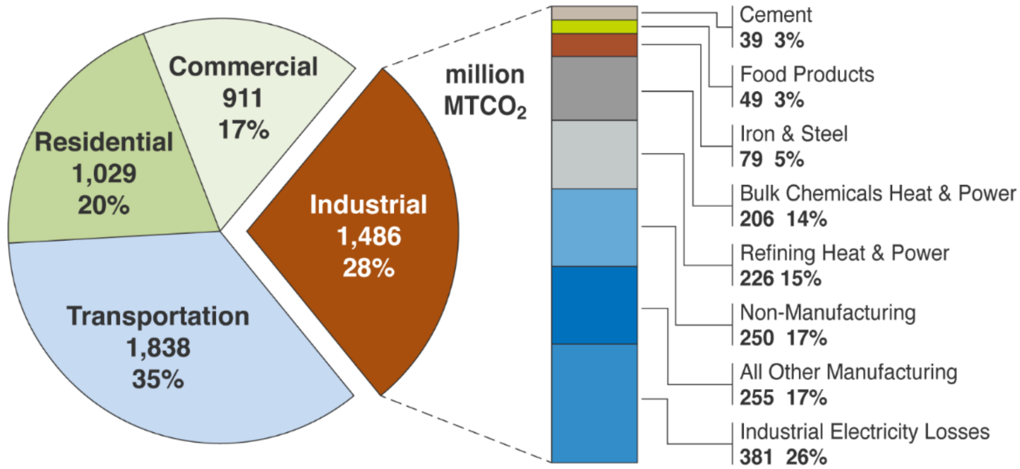

Figure 2: U.S. primary energy-related CO_2 emissions by economic sector (left pie chart) and a breakout by industrial subsector (right stacked chart) in 2015. The CO_2 emission in million metric tons is shown, as well as the percent contribution of that sector of the whole. Data source: EIA 2020[7]

Although some technology needs will be sector-specific, there are other cross-cutting technology improvements that could reduce emissions across multiple sub-sectors. Industrial heating, for example, makes up a significant fraction of the energy consumed by the industrial sector, as seen in Figure 3. Since the heat that drives these processes is overwhelmingly driven by fossil fuels, industrial heating is also a significant contributor to emissions.

[7] United States Energy Information Administration, Annual Energy Outlook 2020 with Projections to 2050. https://www.eia.gov/outlooks/aeo/

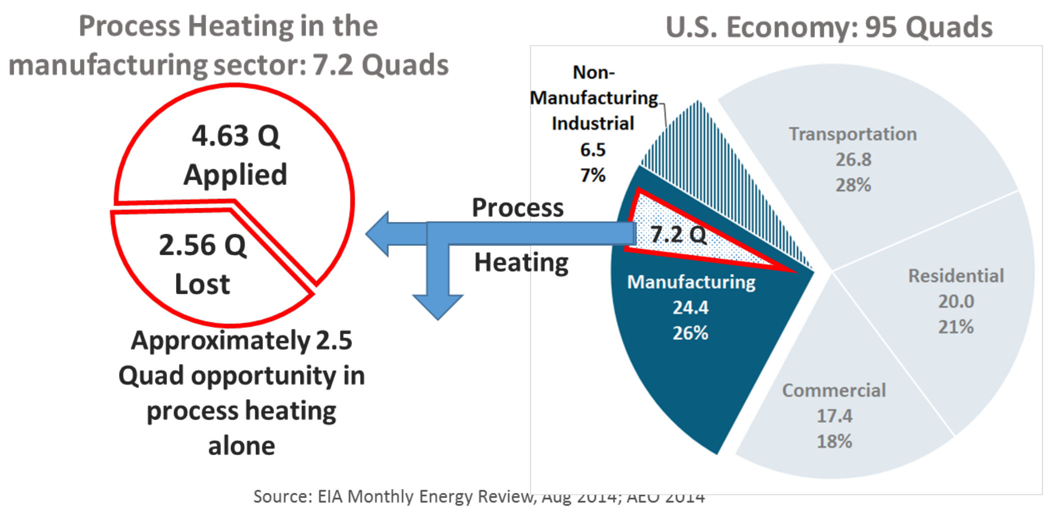

Figure 1: Process Heating Energy Use/Loss in the U.S. Economy. Process heating accounts for a sizable fraction of total U.S. energy use, and more direct energy use than any other energy consuming processes in manufacturing. Currently process heating is 95% fossil fuel based. Traditional fuel-fired industrial (thermal) processes can be inefficient, difficult to control and result in materials and products with compromised quality and performance.

Due to the complexity of industrial decarbonization, many methods must be pursued in parallel and multiple technology options are needed to fit the needs of a diverse industrial sector. The goal of this RFI is solicit feedback in what approaches, sub-sectors, cross-cutting challenges, or other focus areas are best suited to be addressed through a Manufacturing Institute. Two focus areas are of particular interest are: Electrification of Industrial Processes and Decarbonization of Metal Manufacturing.

4.2 Electrification of Industrial Processes

An Institute to support the development and scale up of industrial processes powered only by electricity produced from clean energy sources could drive substantial emissions reduction across a broad range of manufacturing sectors. Electrification of industrial processes, coupled with the use of clean energy sources, is an important strategy to decarbonization that could yield other benefits such as greater energy efficiency and improved quality control[8]. This Institute topic would aim to address challenges facing the electrification of the industrial sector, with the goal of significant industrial decarbonization by 2030.

An Institute is uniquely outfitted to augment coordination across multiple disciplines that address the interconnected challenges facing electrification. The Institute would likely be

[8] Plugging in: What electrification can do for industry. McKinsey & Company. May 2020. https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/plugging-in-what-electrification-can-do-for-industry

structured around key technology areas and would encourage cross-pollination to accelerate technology development towards deployment. Potential areas to be addressed by this Institute include:

- Electrification of industrial processes
- Materials for more effective/efficient electrification
- Scale-up and design for integration into manufacturing processes
- Life Cycle Assessment (LCA) tool and methodology development

AMO is exploring the potential to address the challenges of industrial electrification through a Manufacturing Institute and seeks stakeholder input to better define the challenges, opportunities, and benefits of an Institute in this topic area.

4.3 Decarbonization of Metal Manufacturing

The Decarbonization of Metal Manufacturing topic supports the AMO Strategic Goals related to improving productivity, competitiveness, energy efficiency, and strengthening the U.S. manufacturing workforce[9]. This topic is also in support of the DOE's priorities of addressing climate change (e.g., reducing carbon intensity), creating high-quality U.S. jobs, and energy justice [10], [11]. AMO intends to execute its Mission and achieve its goals in a manner consistent with the DOE priorities.

The metals industry is an important component of the U.S. manufacturing base, economy, energy infrastructure, and is critical to energy security. The U.S. metals industry has a presence in all 50 states and directly employees more than a half million people. The metals industry also represents an opportunity to reduce the overall carbon intensity of the U.S. manufacturing[12]. As reported in 2019, the metals industry accounts for approximately 10% of the total energy consumed[13] and 11% of the GHG emissions from the U.S. manufacturing sector[14, 15]. Over the

[9] Advanced Manufacturing Office Multi-Year Program Plan. U.S. Department of Energy. December 2016. https://www.energy.gov/sites/prod/files/2017/01/f34/Draft%20Advanced%20Manufacturing%20Office%20MYPP_1.pdf
[10] Secretary of the U.S. Department of Energy. https://www.energy.gov/person/jennifer-m-granholm
[11] DOE Homepage, Priorities section. https://www.energy.gov/
[12] Note that some of the numbers cited in Section 4.3 are specific to steel production; although, this topic is applicable to all metals manufacturing. Given that these number do not include other metals manufacturing, they are likely underestimates of the energy use and emissions output.
[13] Energy Information Administration. https://www.eia.gov/energyexplained/use-of-energy/industry.php
[14] How Clean is the U.S. Steel Industry? An International Benchmarking of Energy and CO2 Intensities. Global Efficiency Intelligence. November 2019. https://www.belfercenter.org/publication/how-clean-us-steel-industry-international-benchmarking-energy-and-co2-intensities
[15] Greenhouse Gas Reporting Program, United States Environmental Protection Agency. https://www.epa.gov/ghgreporting

past decade global steel production has increased by over 50% and is projected to continue to increase. A clean and competitive U.S. metals industry would not only reduce the carbon intensity of the overall U.S. manufacturing sector, but also potentially displace high carbon emission metals (domestically and internationally) supporting U.S. economic prosperity.

This RFI topic is seeking information on the challenges and opportunities for improving the energy efficacy and manufacturing productively of the metals industry to increase economic competitiveness, build a clean economy, and ensure U.S. energy security. It is also recognized that the development of advanced and clean technologies is essential for onshoring a resilient domestic supply chain that can support the transition to Industry 4.0 [16]. Areas of interest for this topic include, but are not limited to:

- Innovative Manufacturing Technologies - Technical solutions for metallic manufacturing challenges to improve energy efficiency, reduce carbon intensity, and ensure economic competitiveness.
- Improved Material Performance - Expanded design space and operational envelope through improved alloy performance to allow for increased efficiency in energy production, energy intensive applications, and applications of strategic importance to the DOE. Applications of strategic importance includes, but is not limited to, those that support industrial decarbonization and clean energy generation.
- Acceleration of Technology Adoption - Reduction of development time and accelerate material/processing certification to realize the benefits of emerging technologies.

The focus of this topic is the production of metallic feedstocks and product forms [17]. This includes all alloy families (e.g., ferrous, non- ferrous, rare-earth metals, critical materials, precious metals, and refractory metals). It is recognized that material processing/production and material performance are interdependent. Therefore, aspects of alloy development are also of interest and within the scope of this topic. Specific value-added processes [18] performed after the production of feedstock and product forms are also of interest if they are energy

[16] Industry 4.0 is the move towards digitalization of tradition manufacturing and industrial processes, using smart technologies. The "smart" concept is a process of securely integrating manufacturing operations technology with information, communication, and computation technologies, through mathematically and algorithmically defined multi-sensor data fusion, for on-time and real-time prediction and control.

[17] Feedstock (e.g., powder, consumable wire) is a material used as an input to a production/fabrication process. A product form (e.g., plate, sheet, extrusion, bar, forging, casting) is a material with characterized mechanical or physical properties which is used to make an item/component.

[18] In the context of this topic, a value-added process refers to a process/operation that occurs after the production of the feedstock or product form. A value-added process is typically associated with the fabrication of an item/component (e.g., cladding, penning, secondary heat treating, machining, stamping).

intensive, related to energy production applications, or strategically important to the DOE. Mining and mineral extraction are not within the scope of this topic.

5.0 Request for Information Questions

Section 5.1 includes general questions that may be applied to both decarbonization topics (i.e., Electrification of Industrial Processes and Decarbonization of Metal Manufacturing) while the remaining categories are specific to a each topic. The topic-specific questions in Sections 5.2 and 5.3 should be interpreted in the context of the information and scope provided in the corresponding Section 4.2 and 4.3. Section 5.4 includes questions that solicit information on additional decarbonization strategies that would be appropriately addressed by a Manufacturing Institute. Respondents are encouraged to read all sections but are not expected to address both potential Institute topics or respond to every question within a given topic. Please explicitly identify the question(s) being responded to by using the applicable number (e.g., C1.1, C1.2, ….C13.1) at the start of the response. Respondents may answer as many or as few questions as they wish.

5.1 General Questions

Manufacturing Institutes are meant to bring about transformative, long-lasting change in a specified technology area and/or industrial sector. Institutes should also consider how they can benefit their community and the communities they serve through programs, placement and/or revitalization of existing assets. For categories 1-4 please identify the decarbonization topic your response is referring to (Electrification of Industrial Processes and/or Decarbonization of Metal Manufacturing).

Category 1 Institute Scope

The objective of this category is to solicit information on the scope of a potential Institute, as a public-private partnership, to advance industrial decarbonization. Responses should focus on the contributions that an Institute could make beyond that of private industry alone.

C1.1 What are key obstacles and/or challenges facing the development and deployment of technology supporting the proposed topic areas and how can the utilities of a Manufacturing Institute (see section 1.2) address these issues?

C1.2 Is Industry sufficiently engaged and interested in the topic to invest?

- What key knowledge or capability is missing that prevents the private sector from adequately addressing the industrial decarbonization strategy by itself in the absence of public sector investment?
- If industry is currently not investing in this area, how might an Institute bridge the gap between the current state of technology and what industry is willing to invest?

C1.3 What investments are currently being made to develop technology for a given topic area and can any of them be advanced by an Institute?

- Are there sufficient early Technology Readiness Levels (TRL) technologies to advance and develop through an institute? Are the technologies in pre-competitive space or at a TRL appropriate for an Institute to advance?

C1.4 Would an Institute be a more effective mechanism for reducing GHG emissions, advancing the energy efficiency, environmental stewardship, productivity, and competitiveness than other methods of technology development?

Category 2 Institute Organization

The objective of this category is to solicit information on the potential for strategic structuring and organization to foster collaboration through a Manufacturing Institute.

C2.1 What stakeholders or collaborators should the Manufacturing Institute engage with and what are their roles?

C2.2 How should the scope of the Institute be focused to maximize its impact? What are the appropriate bounds of the scope?

C2.3 What would be the most effective manner to structure an Institute to ensure the highest impact?

- Provide any information on specific regional approaches that effectively merge innovation, economic activity, and high-skill jobs at all levels of the supply chain, as appropriate.

C2.4 How could this topic area benefit from cross-discipline collaboration and what would be the impact?

- What are the barriers to cross-discipline collaboration in this area?

C2.5 How would an Institute attract sufficient private sector investments and what metrics would provide short-term indicators of success within the first 5 years? Please include a discussion on long-term operations and the technical achievements needed to remain relevant to industry. Discuss the value proposition to the private and public stakeholders/members.

Category 3 Institute Benefit

The object of this category is to solicit information on the potential benefits of establishing an Institute, as a public-private partnership, to advance industry topics of importance to the DOE Mission. Responses should focus on the impact that an Institute could have beyond that of private industry alone.

C3.1 What are potential quantitative impacts of a Manufacturing Institute targeting a given topic area? Consider impacts on energy efficiency, life-cycle energy benefits, U.S. productivity, U.S. manufacturing base, economy, energy infrastructure, greenhouse (GHG) emissions, and/or related environmental impacts in manufacturing or use.

- What impact can an Institute have in 5 years, and beyond?

C3.2 Industry uptake is critical to realizing the impacts of a Manufacturing Institute. What is the potential for industry to adopt innovative technologies developed through a Manufacturing Institute?

- What are the R&D breakthroughs/milestones necessary to integrate specific decarbonization strategies at the industrial level?
- What factors ensure U.S. manufacturing derives sustained benefits from a Manufacturing Institute beyond the 5 planned years of federal funding?

C3.3 How could an Institute in this topic area provide opportunities for advancing environmental justice [19,**Error! Bookmark not defined.**] and Equitable Economic Opportunity?

- How could an Institute in this topic area benefit their community and communities they serve, particularly underrepresented communities?
- How can an Institute engage with local leadership and organizations?
- How can diversity and inclusivity be leveraged as a source of strength while Manufacturing USA Institutes establish their science and technology communities?
- What is the potential that an Institute in each topic area could have to lessen overall environmental impacts and to ensure those impacts are experienced more equitably in the community and across the nation?
- What diversity, equity, and inclusion efforts can be incorporated into RD&D investments to foster a productive and inclusive environment, support people from underrepresented groups in STEM, and advance equity?

C3.4 If you are a minority serving organization, what are the barriers to joining a Manufacturing Institute?

- How can an Institute be leveraged to engage more diverse populations (racially, geographically, gender, SES, academic institutions (e.g., community colleges))?

Category 4 Education and Workforce Development

The objective of this category is to solicit information on education, workforce development, and training needs of the new and incumbent workforce facing each topic area. The deployment of any new technology and the growth of any manufacturing industry requires a supply of workers skilled in the unique aspects for producing, installing, and using that technology. This includes developing a diverse and inclusive pipeline in education and workforce. To ensure that any new innovations are not hampered by workforce needs, we seek input from stakeholders on the most important workforce challenges and the most promising education and workforce developments that could address them.

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[19] Promoting Environmental Justice. U.S. Department of Energy. 2021. https://www.energy.gov/lm/services/environmental-justice/what-environmental-justice

C4.1 Describe the workforce gap facing the specific industrial decarbonization strategy. How large is the gap? What training and education resources are needed to fill the gap? Who is the target audience? What other workforce needs are not currently addressed?

- What organizations/programs exist to strengthen workforce pipeline in the specified area?
- What role can a Manufacturing Institute have in workforce development to maximize long term impact?

C4.2 How can an Institutes encourage the participation of underserved communities and underrepresented groups in clean energy education and manufacturing jobs?

The following questions are organized by decarbonization strategy. Please refer to the corresponding background section to understand the scope of each strategy and to provide context for responding to the questions.

5.2 Questions Addressing Electrification of Industrial Processes

Category 5 Institute Scope and Organization Around Key Areas

C5.1 How could the scope of this topic as described in section 4.2 be improved to frame a Manufacturing Institute?

C5.2 Given industrial electrification will be an important pathway to decarbonization in the industrial sector, what are the most critical areas to focus on to maximize decarbonization/impact?

C5.3 Please rank the 2-3 most important R&D areas that, if addressed, would accelerate electrification and decarbonization of the Industrial Sector?

- What are the challenges to addressing those areas?

C5.4 What are the gaps in tools, data, and analysis methodologies that would accelerate industry electrification?

Category 6 State of Technology

The objective of this category is to solicit information on the need, implementation, and impact of advancing technology enabling industry electrification and decarbonization.

C6.1 What are the pros and cons of decarbonizing a thermal process by switching to recovered thermal energy or renewable (e.g. solar or geothermal) rather than electrifying?

C6.2 What is the opportunity for using electricity to reduce energy used for thermal processes in the industrial sector? What is the potential impact?

C6.3 Within the manufacturing sector, electricity is largely used for motor-driven systems. What is the opportunity to improve these systems to achieve improved efficiency and decarbonization? What is the potential impact?

C6.4 Materials in electrical systems, such as conductive materials, have made considerable strides that have not necessarily been included in the baselining for determining efficiency of electrified systems. What is the potential opportunity to use of state-of-the-art materials to improve energy efficiency and decarbonize industrial processes? What is the potential impact?

C6.5 What are the largest technical and non-technical challenges that prevent deployment of technologies that lead to electrification of industrial processes?

Category 7 Benefits of Industry Electrification

In order to avoid a high probability of irreversible catastrophic changes in the climate, scientists have determined that significant cuts in carbon emissions should be made by 2030 and that world economy should be completely decarbonized by 2050. The objective of this category is to solicit information on the potential impact of rapid decarbonization and electrification of the industrial sector.

C7.1 Besides cutting carbon emissions, what other benefits could come from rapid decarbonization from electrification of the industrial sector?

C7.2 To what extent can existing non-electric processes be made more energy efficient and the quality of the product improved through electrification?

C7.3 Aside from carbon emission reductions, what are other appropriate metrics of success? If successful, what would the impact of this Institute be other than avoiding climate damage?

5.3 Questions Addressing Decarbonization of Metal Manufacturing

Category 8 Productivity and Competitiveness

The objective of this category is to solicit information on the challenges/opportunities in the metals industry, as they relate to productivity and global competitiveness. Responses should focus primarily on technical aspects of the topic and how establishing an Institute would address the topic; however, relevant supporting information should be included when applicable.

C8.1 What are the greatest opportunities for increasing productivity, without increasing energy consumption or carbon emissions? Provide a detailed description of the opportunities and challenges. How would a public-private Institute effectively address these opportunities/challenges to increase the productivity of the U.S. metals industry?

- Elimination or significant modification of established processing routes (e.g., robotics/automation, sensors, industrial controls, legacy systems/equipment).
- Incorporation of new processing routes and methodologies (e.g., hybrid processing, machine tools, near net shape processing, flexible/adaptable processing systems).

- Improved testing, experimental capabilities, and predictive capabilities (e.g., prototyping capabilities, empirical data sets, computational tools, design tools, material-process-structure relationships, visualization tools, artificial intelligence / machine learning (AI/ML)).
- What is the highest technical priority for the metals industry related to productivity?

C8.2 What is the greatest opportunity to increase U.S. competitiveness? How would a public-private Institute effectively contribute to the competitiveness of the U.S. metals industry?

- Investment in RD&D; specify technology areas and TRL level(s).
- Creating an innovation ecosystem with a focus on U.S. prosperity.
- Strengthened domestic supply chain through the onshoring of materials, processes, and support activities.

C8.3 Are there technology areas where international competitors are outpacing or have the potential to outpace the domestic metals industry? How would a public-private Institute effectively position the U.S. metals industry to close this technology/competition gap?

C8.4 Provide any additional information relevant to the productivity and competitiveness opportunities/challenges of the metals industry that do not fit into the previous questions in this Category. This could include various industry data (e.g., economic, import/export, trends), references, or technical information.

Category 9 Energy Efficiency and Energy Intensity

The objective of this category is to solicit information on the challenges/opportunities in the metals industry, as they relate to energy efficiency and energy intensity. Responses should focus primarily on technical aspects of the topic and how establishing an Institute would address the topic; however, relevant supporting information should be included when applicable. Note that information specifically related to decarbonization, environmental justice, and climate change is requested in **Category 11**, and not the focus of this question.

C9.1 What are the greatest opportunities for increasing energy efficiency in the metals industry? Provide a description of the opportunity and be quantitative, if possible. What are the technical challenges associated with achieving this increased efficiency? How would a public-private Institute effectively facilitate making the metals industry less energy intensive?

- What are the most energy intensive material processes for producing feed stock and product forms? How can these processes become more energy efficient without decreasing productivity or increasing carbon intensity?
- What are the most energy intensive value-added processes [20]? This includes processes up to (but not including) the assembly level of a metallic component/item. How can

[20] In the context of this topic, a value-added process refers to a process/operation that occurs after the production of the feedstock or product form. A value-added process is typically associated with the fabrication of an item/component (e.g., cladding, penning, secondary heat treating, machining, stamping).

these processes become more energy efficient without decreasing productivity or increasing carbon intensity?

C9.2 Are there significant opportunities to reduce the embodied energy of metals using secondary feed stocks? This includes the quality of scrap and recycling (upcycling).

C9.3 Are there opportunities to increase energy efficiency by collocating metals manufacturing facilities with other industrial facilities. This includes manufacturing and nonmanufacturing facilities (e.g., water treatment, infrastructure). How would a public-private Institute help the metals industry to realize these energy efficiencies?

C9.4 Provide any additional information relevant to the energy efficiency and energy intensity opportunities/challenges of the metals industry that do not fit into the previous questions in this Category. This could include various industry data, references, or technical information.

Category 10 Material Performance and Alloy Development

The objective of this category is to solicit information on the challenges/opportunities for improving material performance and new alloy development, as it relates to reducing the carbon intensity of the overall U.S. economy. It is recognized that material performance and processing are interdependent, and that advancements in one area will impact the other.

C10.1 How will alloy development impact decarbonization of the metals industry? How would a public-private Institute effectively ensure that process development and alloy development occur in a synergetic manner?

- To what extent will the evolution of metals production and processing to be less carbon intensive require modifications to existing alloys?
- Are there opportunities to develop alloys whose processing will be less carbon intense?

C10.2 Are there opportunities to design or produce alloys that are considered enabling or used to position other industries to innovate and become less carbon intensive (e.g., automotive/transpiration, renewable energy equipment, energy storage, sustainable agriculture)? Provide a high-level description of the material and application.

- What are the most important aspects of improved alloy performance needed to expanded design space and/or operational envelope?
- Characteristics related to the producibility and manufacturability of a material with the desired improved performance level is of interest.

C10.3 What alloys are of the most strategic importance to the prosperity of the domestic metals industry, clean economy, or energy infrastructure? Provide a high-level description of the material and application.

- Refractory metals, precious metals, critical materials, and rare earth metals are of interest (in addition to traditional alloy families).
- What is the impact of pursuing or not pursuing these strategically important alloys?

C10.4 Provide any additional information relevant to the material performance and alloy development opportunities/challenges in the metals industry that do not fit into the previous questions in this Category. This could include various industry data, references, or technical information (e.g., performance requirements).

Category 11 Decarbonization and Environmental Justice

The objective of this category is to solicit information on the challenges/opportunities associated with the decarbonization of the metals industry. Responses should focus primarily on technical topics but also include social aspects when applicable.

C11.1 What are the greatest opportunities for decarbonizing the metals industry? How would a public-private Institute effectively facilitate the metals industries transition to carbon neutrality?

- What are the largest technical challenges to decarbonizing the metals industry? It is recognized that these challenges will vary across the industry depending on the alloys and processing routes.
- What are the most viable approaches to decarbonization of the metals industry and what approaches will have the greatest impact?
- What are the opportunities to significantly reduce or eliminate the use of carbon-based fuels/energy in the metals industry?

C11.2 What are the challenges/opportunities related to utilizing onsite carbon-free power generation (e.g., solar, wind)? What are the challenges/opportunities to collocating metals manufacturing facilities with carbon-free power generation stations (e.g., hydroelectric, nuclear, geothermal)?

C11.3 What role does electrification have in decarbonizing the metals industry? What specific opportunities/applications are there in the metals industry for electrification.

C11.4 What is the greatest opportunity for reducing or eliminating environmentally harmful by-products or co-products? This question is focused on technical solution to avoid the creation of harmful co/by-products, not finding alternative uses for the co/by-products.

C11.5 What is the greatest opportunity for advancing environmental justice [21], as it relates to the metals industry? How would a public-private Institute effectively advance environmental justice, as it relates to the metals industry.

C11.6 Provide any additional information relevant to the environmental stewardship opportunities/challenges of the metals industry that do not fit into the previous questions in this Category. This could include various industry data (e.g., equitable economy opportunities), references, or technical information (e.g., clean energy technologies or innovations).

[21] What is Environmental Justice? U.S. Department of Energy. 2021. https://www.energy.gov/lm/services/environmental-justice/what-environmental-justice

Category 12 Transition and Adoption of New Technologies

The objective of this category is to solicit information on barriers to transitioning and adopting new technologies into full rate production or low-rate initial production (LRIP). New technology includes, but is not limited to, new materials, advanced processes, modeling/simulation tools, and testing/inspection methodologies.

C12.1 What are the most significant obstacles to successfully transitioning a technology and realizing the associated benefits? How would a public-private Institute effectively address these obstacles and/or significantly accelerate the adoption of new technologies?

- What obstacles are unique to transiting technologies that are focused on reducing the carbon intensity of the metals industry?
- Does the qualification or certification process for new technologies prevent or significantly delay the adoption of new materials and processes?
- What is the greatest opportunity to accelerate the timeframe for adopting a new technology?

C12.2 What additional facilities or equipment resources are needed to accelerate technology adoption? How would the metals industry benefit for shared resources such as testbeds, prototypes, pilot scale equipment, and/or demonstration facilities.

C12.3 Provide any additional information relevant to the opportunities/challenges associated with the transition and adoption of new technologies to the metals industry that does not fit into the previous questions in this Category. This could include various industry data, references, or technical information.

Category 13 Disruptive Technology

The objective of this category is to solicit information on disruptive technologies and how to prepare the metals industry to benefit from them. If the technology was discussed in an earlier response, identify the technology again with additional information, as appropriate.

C13.1 What is the most potentially disruptive metals development, production, or processing technology to the domestic metals industry? What activities are needed to prepare to adapt and benefit from this disruption? How would a public-private Institute position the domestic metals industry to adapt and benefit from this technology?

6.0 Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to Decarb-Institute@ee.doe.gov no later than 5:00pm (ET) on September 23, 2021. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) attachment to the email, and no more than 20 pages per topic in length, 12 point font, 1 inch margins. Only electronic responses will be accepted.

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

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

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

- Company / institution name;
- Company / institution size (Small: 1-50 employees, Medium: 51-500 employees, or Large: 501+ employees);
- Industrial Sector and North American Industry Classification System (NAICS) code;
- Company / institution contact;

Contact's address, phone number, and e-mail address.

7.0 RFI Informational Webinar

AMO will host an RFI webinar or webinars to maximize stakeholder engagement. The webinar will introduce the RFI topics and provide context for responding to the questions. A brief introduction to Clean Energy Manufacturing Institutes will also be provided. RFI responses will not be accepted during the webinar and will only be an accepted as described in Section 6.

The webinar will be open to all who wish to participate. Participation in the webinar(s) is not required to respond to the RFI. Details regarding the date and time of the webinars will be announced on the AMO News site: [Advanced Manufacturing Office | Department of Energy](https://www.energy.gov/eere/amo/advanced-manufacturing-office).