U.S. Department of Energy
Advanced Research Projects Agency – Energy

Announcement of Teaming Partner List for Upcoming Funding Opportunity Announcement: *Revolutionizing Ore to Steel to Impact Emissions (ROSIE)*

The Advanced Research Projects Agency Energy (ARPA-E) intends to issue a Funding Opportunity Announcement (FOA) entitled Revolutionizing Ore to Steel to Impact Emissions (ROSIE), targeting new technology pathways to enable zero direct process emissions in ironmaking (i.e., zero-process-emission ironmaking) and ultra-low life cycle emissions for steelmaking at scale.

As described in more detail below, the purpose of this announcement is to facilitate the formation of new project teams to respond to the upcoming ROSIE FOA. The FOA will provide specific program goals, technical metrics, and selection criteria; and the FOA terms are controlling. For purposes of the Teaming Partner List, the following summarizes current planning for the FOA.

ARPA-E has identified two Technical Categories for ROSIE's low emission iron and steel opportunities. Technical Category A ends with an iron product; Technical Category B ends with a steel product. Proposers in both categories must address emissions associated with ironmaking while producing either a relevant iron or steel product. An iron product may be a final product for direct use or it may be iron designed to be used in further steelmaking; the steel product must be a deliverable product in an existing or projected steel market.

ARPA-E held a workshop on this topic in September 2021; Information on this workshop can be found at https://arpa-e.energy.gov/events/zero-emission-iron-steelmaking-workshop.

The draft technical section FOA language is included as Attachment A to this document and the draft Cost and LCA Estimator Tool is included as a separate Attachment B. NOTE: THE ISSUED FOA, INCLUDING TECHNICAL SECTION AND LCA ESTIMATOR TOOL, WILL BE CONTROLLING, NOT THESE DRAFT DOCUMENTS, THOUGH NO MAJOR CHANGES ARE ANTICIPATED.

The following is a non-exhaustive list of the technologies that will be of interest for the ROSIE Program. All technologies must satisfy specified zero-emissions-ironmaking criteria.

- *Aqueous electrowinning of ores:* in acidic, basic, or neutral media; including the potential for the acids/bases to be produced on-site and recycled;
- *Non-aqueous electrolysis of ores:* using electrolytes of molten salts and eutectics; innovations in novel electrodes that will withstand operating conditions;
- *H_2 plasma-based ironmaking*: using microwave, arc, or other plasma generation methods;
- *Biomass-based ironmaking:* the use of low-cost emerging bio-feedstocks; innovative ways to process these feedstocks into bioreductants for specific utility in ironmaking;

- *Biological and biomimetic ironmaking:* siderophore derivatives or other catalyst mimics that selectively bind iron cations from ore and reduce them;
- *Novel thermochemical ironmaking:* methods to use nontraditional reductants, recycled carbon, or other new thermochemistry to process realistic feedstocks;
- *Ironmaking from unconventional ores:* mine tailings and other wastes; especially, taconite or other ores found substantially in the United States; co-production of iron and other metals or byproducts as enabled by using mixed-metal ores; and
- *Other novel technologies:* to produce iron from raw iron resources with zero greenhouse gas (GHG) process emissions.

The scope of the ROSIE program is framed to advance high-potential, high-impact technologies with the potential to reduce greenhouse gas emissions from ironmaking to zero. Submissions that do not represent a significant innovation in ironmaking technology are out of scope. These are examples of technology concepts that would **not** meet the success criteria of this program:

- Adding carbon capture to blast furnaces
- Transitioning from direct reduced iron (DRI) using natural gas to DRI using hydrogen (H_2)
- Recycling of steel scrap or improvements to scrap processing

The ROSIE program goals are to develop low emissions ironmaking technologies that have the potential to scale to meaningful production levels at cost parity with existing technologies. The performance metrics will include the amount of non-biogenic greenhouse gas emissions from ironmaking process; the cradle-to-gate lifecycle greenhouse gas emissions; the process and product scalability; the target cost per tonne of product; and the target lab scale prototype at end of the project.

Several additional considerations will also be used for proposal evaluation, including the energy per tonne of iron or steel product; the process byproducts or waste streams; the process flexibility; the product viability; the pathway to scale from lab (grams/hour) to pilot plant (tonnes/year); and the final product qualification requirements.

ARPA-E project teams are required to construct and execute a commercialization strategy that is unique to their technology. Technology-to-market risks that may be addressed include the availability of the reductant for a chosen process, which may be electricity, hydrogen, sustainable carbon, or other technology-specific reagents. Other underlying cost and risk drivers that may be addressed include availability of the appropriate domestic ore feedstock and uncertainty in electricity pricing. To assist in assessing the potential for technology development and application, a basic *Ironmaking Cost and Life Cycle Assessment Estimator Tool* has been provided along with this announcement (Attachment B). The goal of this tool is to enable fair comparison of technologies using input data (e.g., CO_2 footprint of grid electricity) from a standard library.

ARPA-E is not interested in projects that exclusively consider the reduction of relatively pure iron oxide to iron. Successful applications need to demonstrate the reduction of iron oxide feedstock under conditions that will be industrially relevant to the commercial deployment of the proposed technology.

Due to a complex cross-disciplinary nature of the intended program, ARPA-E strongly encourages outstanding scientists and engineers from different organizations, scientific disciplines, and technology sectors with expertise in power electronics, optoelectronics, photonics, and other related fields, to form new project teams. Interdisciplinary and cross-sector collaboration spanning organizational boundaries enables and accelerates the achievement of scientific and technological outcomes that were previously viewed as extremely difficult, if not impossible.

The Teaming Partner List is being compiled to facilitate the formation of new project teams. The Teaming Partner List will be available on ARPA-E eXCHANGE (http://arpa-e-foa.energy.gov), ARPA-E's online application portal, starting May 2023. 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 complete all required fields in the following link: https://arpa-e-foa.energy.gov/Applicantprofile.aspx. Required information includes: Organization Name, Contact Name, Contact Address, Contact Email, Contact Phone, Organization Type, Area of Technical Expertise, and Brief Description of Capabilities.

By submitting a response to this Notice, respondents consent to the publication of the above-referenced information. **By facilitating and publishing this Teaming Partner List, ARPA-E is not endorsing, sponsoring, or otherwise evaluating the qualifications of the individuals and organizations that are self-identifying themselves for placement on this Teaming Partner List. ARPA-E reserves the right to remove any inappropriate responses to this Announcement (including lack of sufficient relevance to, or experience with, the technical topic of the Announcement).** ARPA-E will not pay for the provision of any information, nor will it compensate any respondents for the development of such information. Responses submitted to other email addresses or by other means will not be considered.

This Notice does not constitute a Funding Opportunity Announcement (FOA). No FOA exists at this time. Applicants must refer to the final FOA, expected to be issued in June 2023, for instructions on submitting an application, the desired technical metrics, and for the terms and conditions of funding.

The draft technical section and LCA tool included as attachments to this Teaming Partner List will be discussed by ARPA-E Program Director Jenifer Shafer on June 15, 2023, at an ARPA-E Industry Day.

ATTACHMENT A

Draft of Technical Section for Revolutionizing Ore to Steel to Impact Emissions (ROSIE)

B. PROGRAM OVERVIEW

SUMMARY

The iron and steel industry accounts for around 7% of global greenhouse gas (GHG) emissions and 11% of global carbon dioxide (CO_2) emissions. Global steel production has more than doubled between 2000 and 2022 to 1,840 million tonnes (Mt), and worldwide iron and steel demand is projected to rise as much as 40% by 2050. U.S. steel production was over 85 Mt in 2021 and accounted for >5% of industry emissions. Current blast furnace technologies—responsible for ~70% of global iron and steel GHG emissions—require carbon as a reductant, materials additive, and source of heat. The central role of carbon makes this sector particularly difficult to decarbonize.

The proposed program, **ROSIE (Revolutionizing Ore to Steel to Impact Emissions)** aims to develop new technology pathways to enable zero direct process emissions in ironmaking (i.e., zero-process-emission ironmaking) and ultra-low life cycle emissions for steelmaking at scale.[1] A successful program will identify technologies with equal or lower cost than the incumbent processes. This outcome supports the goals established by the Advanced Research Projects Agency-Energy (ARPA-E) to reduce GHG emissions while reducing imports of iron ore, iron products (≥92% pure iron), and steel products. This program represents an opportunity for the U.S. to recover technical leadership in a critical manufacturing discipline and to increase exportable technology for low-emissions iron and steelmaking.

While a variety of approaches could be envisioned to provide zero-process-emission ironmaking, a responsive application **must** eliminate the emissions associated with ironmaking and provide a cost competitive iron or steel product (i.e., green iron or steel without the green premium). The Inflation Reduction Act has tax credits supporting hydrogen production, carbon capture, and clean electricity. Where appropriate these credits have been accounted for in costing tools provided with this document to leverage this new legislation.

Metrics for the ROSIE program are as follows and will be discussed in more detail in section 4 of this document.

[1] Process emissions are greenhouse gas emissions released from industrial processes and manufacturing as a result of the process chemistry, e.g., CO_2 emissions derived from coke ovens, blast furnaces, natural gas-based direct reduced ironmaking, or other ironmaking processes.

- Zero non-biogenic greenhouse gas emissions from ironmaking process[2]
- Ultra-low cradle-to-gate lifecycle GHG emissions
- Process and product scalability of >15 million tonnes
- Cost parity with hot rolled coil steel (~$550 / tonne) or alternative steel product being displaced
- Materials properties consistent with relevant commercial product being displaced

The ROSIE Program has two phases: a Proof-of-Concept Phase I and a Prototype Phase II. **These phases enable the Program to both catalyze the development of several completely new, high-risk technology learning curves and streamline funding of technologies toward rapid commercial deployment.** Submissions must discuss project plans and budgets for both phases. For Phase I, ARPA-E intends to fund 10-14 teams for a 12-18 month period, with a budget of approximately $1M per team. At the conclusion of Phase I, project teams interested in proceeding to Phase II will be required to submit the following to ARPA-E:

- Detailed Phase II prototype specifications/design;
- Updated Phase II scope/schedule/budget, including status of permitting (if required); and
- Timeline to procure, build, and install the Phase II system.

Projects selected for Phase II will be assessed against the stringent Phase II metrics, and teams are expected to address the techno-economic issues with more detailed analysis and/or experimental results than in Phase I. ARPA-E intends to fund approximately 4-7 teams for a total duration of 36 months (the total of both stages), with an additional budget of $2-4 MM per team for Phase II (in addition to the respective team's Phase I budget). Advancement to Phase II represents a portfolio-wide downselect, so advancement is not guaranteed, even if all the milestones from Phase I are met.

BACKGROUND

Iron and steel manufacturing is widely recognized as among the most difficult to decarbonize industrial sectors, owing both to the sheer tonnage of product and the dependence on carbon at every step of the process. With literally millennia of development, current blast furnace technologies are very well-established, leading to outstanding efficiency dependent upon extensive existing infrastructure.

A notional map of U.S. iron and steel production is shown in Figure 1.

[2] Biogenic emissions are atmospheric emissions from plant matter that accrued carbon as a natural consequence of its life cycle and is emitted during decomposition or combustion of biomass. Non-biogenic emissions refer to those emitted from fossil fuels or minerals (e.g., oil, coal, natural gas combustion or limestone calcining) which accrued their carbon content over many years.

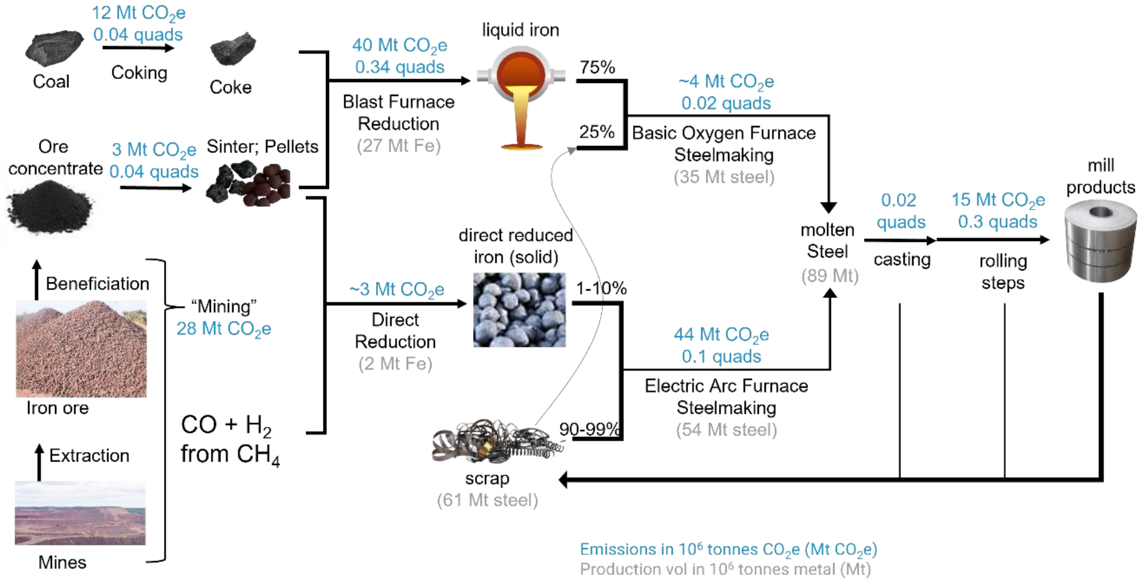

Figure 1

The proposed approach seeks to encourage the development and scaling of innovative technologies, addressing the challenges of reductant availability, electricity price uncertainty, and feedstock availability. Recent advances in electrolysis, plasma technology, and separations chemistry provide attractive opportunities, as do changes in U.S. feedstock economics, such as the availability of waste tailings for processing, domestic sourcing incentives, and the development of new mining technologies.

Examples of potential technologies that could satisfy industry requirements include novel thermochemical or electrolytic approaches to iron ore reduction, design innovations for carbon looping systems, and out-of-the-box concepts for direct ore-to-steel processing. The use of life cycle accounting will be used to advantage holistic solutions, such as incorporated beneficiation and process intensification.

C. PROGRAM OBJECTIVES

The ROSIE Program at ARPA-E seeks to fund the development and demonstration of novel technologies that produce iron-based products from iron-containing ores without process emissions. The ROSIE program's technologies will demonstrate a path to cost-competitiveness with traditional incumbent carbothermic blast furnace. The technologies funded through this program have transformative potential, because no technology route exists today that meets both this emissions constraint and this cost parity goal. If successful, these novel ironmaking technologies can ultimately supplant traditional ironmaking routes, reducing U.S. emissions by over 65 Mt CO_2 emitted annually (~1% of U.S. emissions).

Several technical risks make this program ARPA-E hard, primarily the uncertainty that a technology that works at a laboratory scale can transition to compete at an industrial scale.

TECHNOLOGIES OF INTEREST

The following is a non-exhaustive list of the technologies that are of interest for the ROSIE Program. All technologies must satisfy a zero-emissions-ironmaking criteria.

- Aqueous electrowinning of ores: in acidic, basic, or neutral media; including the potential for the acids/bases to be produced on-site and recycled;
- Non-aqueous electrolysis of ores: using electrolytes of molten salts and eutectics; innovations in novel electrodes that will withstand operating conditions;
- H_2 plasma-based ironmaking: using microwave, arc, or other plasma generation methods;
- Biomass-based ironmaking: the use of low-cost emerging bio-feedstocks; innovative ways to process these feedstocks into bioreductants for specific utility in ironmaking;
- Biological and biomimetic ironmaking: siderophore derivatives or other catalyst mimics that selectively bind iron cations from ore and reduce them;
- Novel thermochemical ironmaking: methods to use nontraditional reductants, recycled carbon, or other new thermochemistry to process realistic feedstocks;
- Ironmaking from unconventional ores: mine tailings and other wastes; especially, taconite or other ores found substantially in the United States; co-production of iron and other metals or byproducts as enabled by using mixed-metal ores; and
- Other novel technologies: to produce iron from raw iron resources with zero GHG process emissions.

DISCOURAGED TECHNOLOGY CONCEPTS

The scope of the ROSIE program is framed to advance high-potential, high-impact technologies with the potential to reduce greenhouse gas emissions from ironmaking to zero. Submissions that do not represent a significant innovation in ironmaking technology are out of scope. These are examples of technology concepts that would not meet the success criteria of this program:

- Adding carbon capture to blast furnaces;
- Transitioning from direct reduced iron (DRI) using natural gas to DRI using hydrogen (H_2); and
- Recycling of steel scrap or improvements to scrap processing.

TECHNOLOGY-TO-MARKET (T2M)

ARPA-E project teams are required to construct and execute a commercialization strategy that is unique to their technology. The preparation of the commercialization plan includes conducting comprehensive market analyses, developing and refining business models, formulation of an intellectual property strategy, and preparing the appropriate cost and technoeconomic models that validate value propositions to the customer.

Some of the primary potential partners for low emission iron and steelmaking projects are product consumers in buildings and transportation seeking green steel to meet impending sustainability targets, as well as venture capital and industry partners eager to invest in vetted technologies. It should be noted that having a supplier or an industry advisor is encouraged but not required for a project team to be considered for this ARPA-E award.

Tech-to-market risks that may be addressed include the availability of the reductant for a chosen process, which may be electricity, hydrogen, sustainable carbon, or other technology-specific reagents. Other underlying cost and risk drivers that may be addressed include availability of the appropriate domestic ore feedstock and uncertainty in electricity pricing.

FEEDSTOCK CONSIDERATIONS

ARPA-E is not interested in projects that exclusively consider the reduction of relatively pure iron oxide to iron. Successful applications need to demonstrate the reduction of iron oxide under conditions that will be industrially relevant to the commercial deployment of the proposed technology. Reduction of iron ore, or simulant ores, is appropriate with the observation that the ability to economically and effectively reduce and recover an iron product from iron ore of lower quality would be more responsive to this funding opportunity than less domestically available hematite or magnetite deposits. When possible, proposals should include information on the source, composition, and microstructure of the feedstock for their process. Information regarding the geography, iron content, trace minerals, and especially the energy and emissions required to extract and beneficiate the feedstock is critical to understanding process operations and cost.

A non-exhaustive list of feedstocks or feedstocks that could be used or simulated is as follows:

- Taconite or hematite ore, either as-mined or after any beneficiation processing;
- Iron ore tailings with iron content that was not economically viable to extract when it was mined;
- Tailings from other mineral processes (e.g., aluminum or copper) that contain valuable iron that could be economically extracted with improved technology;
- Iron oxide fines, in the instance a clear source can be identified; and
- Other iron sources.

If using a feedstock simulant, characteristics regarding trace metals and oxides, carbonates, manganates, and silicates as well as particle size, should be considered. The tonnage available annually is also a factor. Preliminary efforts may examine the reduction of pure iron oxide, but tests must ultimately be completed on relevant feedstock or simulants.

D. TECHNICAL CATEGORIES OF INTEREST

This funding opportunity seeks to encourage the formation of multi-disciplinary teams to overcome the technology barriers for the development of low emission iron and steel production that can simultaneously achieve the required emissions reduction, product quality, and cost viability. Proposing teams should incorporate expertise in relevant processes and process modeling, and iron or steel product economics and commercialization.
ARPA-E has identified two Technical Categories for low emission iron and steel opportunities. Technical Category A ends with an iron product; Technical Category B ends with a steel product, see Figure 2. All proposals must address emissions associated with ironmaking while providing either a relevant iron or steel product.

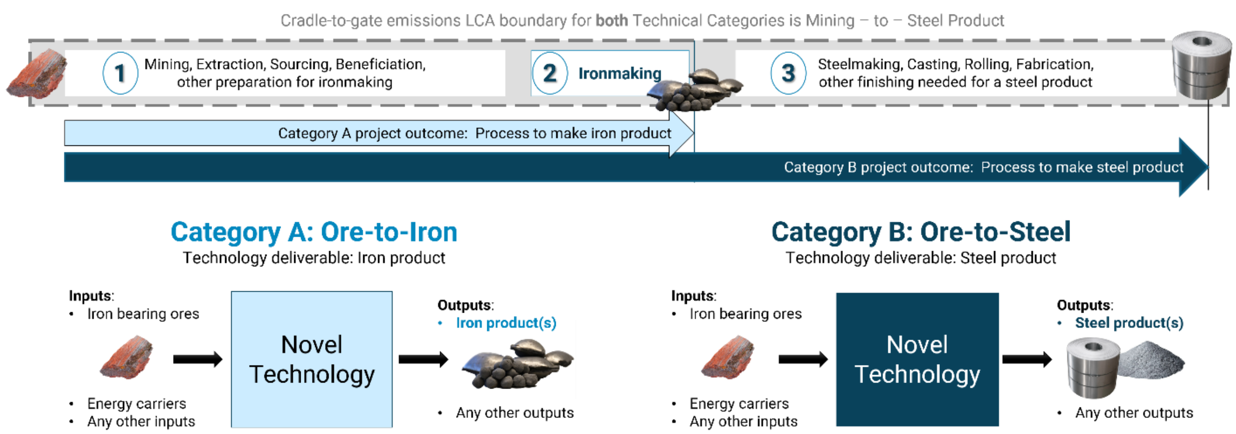

Figure 2

TECHNICAL CATEGORY A. IRON PRODUCT

A proposal in Category A must describe a novel process to produce an iron product, as shown in Figure 2. Examples of iron products include pig iron, direct-reduced iron (DRI), hot-briquetted iron (HBI), iron powder, or other iron products; the actual composition and microstructure of any iron product will vary depending on the product requirements. Because the development of zero emissions ironmaking is at the core of the ROSIE Program, proposers to Category A must propose an innovation in Step 2: zero non-biogenic-process-emissions ironmaking[2]. Applicants may also, optionally, choose to propose innovations in, deletions of, or alternatives to any parts of Step 1 (mining, extraction, sourcing, beneficiation, and other preparation for Step 2). The applicant's work plan and budget should reflect all proposed innovations.

The iron product may be a final product for direct use or it may be iron designed to be used in further steelmaking. The chemistry, microstructure, and other characteristics should be appropriate for the designated use, and a method for verification and validation of the performance of the iron product should be discussed in the proposal.

A successful proposal in Category A must include a preliminary cradle-to-gate life-cycle assessment (LCA) and technoeconomic assessment (TEA), accounting for the energy, costs, and GHG emissions from mining/extraction/sourcing of the iron-containing ore; beneficiation and preparation for the ironmaking process; any agglomeration processes; ironmaking; and casting, rolling, or other fabrication to produce a steel product. Even though the iron product may not be designed for use in steelmaking, this comparison of process cost and emissions will be valuable for consistent evaluation purposes. A tool for this with common assumptions is provided along with this document along with use instructions.

TECHNICAL CATEGORY B. STEEL PRODUCT

A proposal in Category B must describe a novel process to produce a steel product, as shown in Figure 2. Examples of steel products include carbon or alloy steels (e.g., mild steel, alloy steel, silicon/electrical steel, stainless steel, coated steel), in various product forms (e.g., powder, plate, coil, pipes, sheet); the actual composition and microstructure of any steel product will vary depending on the product requirements. Because the development of zero emissions ironmaking is at the core of this Program, proposers to Category B must propose an innovation in Step 2: zero-process-emissions ironmaking. Applicants may also, optionally, choose to propose innovations in, deletions of, or alternatives to any parts of Step 1 (mining, extraction, sourcing, beneficiation, and other preparation for Step 2). Applicants to Category B must also propose an innovation path that includes steelmaking, and may also, optionally, choose to propose innovation(s) in, deletions of, or alternatives to Step 3 (steelmaking, casting, rolling, fabrication and other finishing steps for a steel product). The applicant's work plan and budget should reflect all proposed innovations.

The steel product must be a deliverable product in an existing or projected steel market. The chemistry, microstructure, and other characteristics should be appropriate for the designated use, and a method for verification and validation of the performance of the steel product should be discussed in the proposal. Applicants should note that while scrap may be a component in the steelmaking process, relying on additional, improved, or 'unobtanium' scrap to achieve lower life cycle emissions will be considered non-responsive. Any inclusion of scrap in a proposed project must be related to understanding the materials properties of a final steel product. Any processes using scrap must be done such that there is a net increase in iron to the system.

Analogous to Category A, a successful proposal in Category B must also include a cradle-to-gate LCA and TEA, including an account for the energy, costs, and GHG emissions from mining/extraction/sourcing of the iron-containing ore; beneficiation and preparation for the ironmaking process; ironmaking; steelmaking (including the embedded emissions from any added scrap), and casting, rolling, or other fabrication to produce a steel product. A tool for this with common assumptions is provided along with this document along with use instructions.

E. TECHNICAL PERFORMANCE TARGETS

The ROSIE program goals are to develop low emissions ironmaking technologies that have the potential to scale to meaningful production levels at cost parity with existing technologies.

Performance Metrics

To the extent possible, provide quantitative metrics in a table that compares the proposed technology concept to current and emerging technologies and to the Technical Performance Targets.

E.1a. Non-biogenic greenhouse gas emissions from ironmaking process

The incumbent value is assumed to be 1 to 2 tonnes CO_2 emitted per tonne Fe produced; the program target is zero.

E.1b. Cradle-to-gate lifecycle greenhouse gas emissions

The lifecycle 'cradle to gate' are carbon emissions released during (Step 1) raw material extraction, processing, and transportation of materials to the ironmaking site, Step 2 ironmaking, and (Step 3) steelmaking, casting, and hot rolling to produce hot rolled coil (HRC). Any proposed zero-emissions ironmaking technologies must not increase emissions in Steps 1 and 3. Teams that substantially limit the emissions in Steps 1 and 3 courtesy the use of their ironmaking technology, will be viewed as more responsive. The incumbent value is assumed to be 1.4 to 3 tonnes CO_2 emitted per tonne of HRC steel; the long-term program target is ≤ 0.7.

E.1c. Process and product scalability

The incumbent value of the tonnage demand for any specific iron or steel product will vary widely. The U.S. iron and steel industry today uses tonnes of iron ore, coking coal, lime, process water, and other resources to produce ~85 tonnes of steel annually. The long-term program target is to establish the sufficient supply of process inputs to enable production of ≥ 15 million tonnes of iron or steel products via the proposed processes per year in in 2040.

E.1d. Target cost

The ROSIE Program requires that each project describes as a baseline the cost to produce HRC via their proposed process. The incumbent price of HRC steel is ~$800 per tonne. If an alternative steel product is targeted, the proposed process at scale must be able to match or beat the cost of the incumbent steel product.

E.1e. Target lab scale prototype

By project end, a lab scale prototype should be demonstrated that has at a minimum, a product rate of 1 kg product / hour, is operated for 100 hours, and produces an absolute value of 10 kg of iron product. Stated values are a minimum and higher metric targets may be more appropriate depending on the technology being developed.

	Parameter	Project Target
E.1a.	Non-biogenic emissions from ironmaking process**Error! Bookmark not defined.**	
E.1b.	Cradle-to-gate lifecycle GHG emissions	
E.1c.	Process and product scalability	
E.1d.	Target cost	
E.1e.	Target lab scale prototype	

LIFE CYCLE ANALYSIS

To assist in assessing the potential for technologies, a basic *Ironmaking Cost and Life Cycle Assessment Estimator Tool* has been provided along with this document. The goal of this tool is to enable fair comparison of technologies using input data (e.g., CO_2 footprint of grid electricity) from a standard library.

The basic spreadsheet tool is not designed to model every possible iron or steelmaking technology, although it should be possible to illustrate the basic benefits of your proposed technology using the data provided. If there are significant barriers to modeling your technology with the tool, do the best you can and discuss any limitations in your application. Proposers invited to provide full applications will be provided a more detailed tool for their life cycle assessment.

ADDITIONAL CONSIDERATIONS

The following are not designated technical performance metrics but should be assessed in your proposal.

E.2a. Energy per tonne of iron or steel product
Please discuss the projected energy needed to produce each tonne of iron or steel using your process. This may be easily calculated from the data you input into the Ironmaking Cost and Life Cycle Assessment Estimator Tool.

E.2b. Process byproducts or waste streams
Beyond greenhouse gas emissions, applicants should comment on the technology's environmental footprint. Please discuss waste streams, water and land use factors, manufacturing and delivery methods, as well as other supply chain considerations.

E.2c. Process flexibility
While ARPA-E does not expect any new technology to find 100% adoption across the breadth of the iron and steel industries, feedstocks are important. Discuss how robust the proposed technology is to common impurities in iron ore (i.e., silica, alumina, magnesia, calcium oxide, sulfur, potassium), the possible tradeoffs between ore quality and process constraints, the

potential for use of various iron containing feedstocks in your process, as well as the sensitivity of your process to other process contaminants. Also discuss the ability for the technologies to potentially produce multiple iron or steel products.

E.2d. Product viability

While ARPA-E doesn't expect any new product to find 100% adoption across the breadth of the iron and steel industries, markets are important. Please discuss the market impact of your product proposed product.

E.2e. Pathway to scale from lab (grams/hour) to pilot plant (tonnes/year)

Please discuss your pathway to scale from 10 grams per hour to 100 grams per hour to 1 kilogram per hour.

E.2f. Product qualification requirements

Iron or steel products must meet the requirements – composition, microstructure, strength, and so on – of their designated application. Please discuss these requirements and how the product will be verified and validated.

	Parameter	***Project Target***
E.2a.	Energy per tonne of iron or steel product	
E.2b.	Process byproducts or waste streams	
E.2c.	Process flexibility	
E.2d.	Product viability	
E.2e.	Pathway to scale from lab (grams/hour) to pilot plant (tonnes/year)	
E.2f.	Product qualification requirements	

C. OTHER

3. SUBMISSIONS SPECIFICALLY NOT OF INTEREST

Submissions that propose the following will be deemed nonresponsive and will not be merit reviewed or considered:

- Adding carbon capture to blast furnaces
- Transitioning from direct reduced iron (DRI) using natural gas to DRI using hydrogen (H_2)
- Recycling of steel scrap or improvements to scrap processing