February 28, 2022

SUBMITTED VIA EMAIL TO Industrial-Decarb-RFI@ee.doe.gov

Advanced Manufacturing Office
Office of Energy Efficiency & Renewable Energy
U.S. Department of Energy
Washington, DC 20585

Re: DE-FOA-0002687 Request for Information on Industrial Decarbonization Priorities

To Whom It May Concern:

The American Iron and Steel Institute (AISI) is pleased to submit the following comments to the Department of Energy’s Advanced Manufacturing Office (AMO) Request for Information (RFI) to better understand industrial priorities for decarbonization, including emerging technologies that could be demonstrated or adopted by the industrial sector [DE-FOA-0002687] (January 27, 2022).

AISI serves as the voice of the American steel industry in the public policy arena and advances the case for steel in the marketplace as the preferred material of choice. AISI is comprised of steel producing member companies, including integrated and electric furnace steelmakers, and associate members who are suppliers to or customers of the steel industry.

The American steel industry is the cleanest and most energy efficient of the leading steel industries in the world. Of the seven largest steel producing countries, the U.S. has the lowest CO₂ emissions per ton of steel produced and the lowest energy intensity. Additionally, steel producers in the U.S. are undertaking significant efforts to further reduce greenhouse gas (GHG) emissions and the consumption of energy. These developments represent advancements in domestic production using commercially available technologies to produce direct reduced iron (DRI) and hot briquetted iron (HBI) and increase the use of renewable electricity.
Furthermore, American steel producers are actively investigating future decarbonization strategies that reflect the most cost effective and feasible pathways for each company given the diverse mix of technologies, geographies, and raw materials used to produce steel domestically. Today’s major obstacles to significant decarbonization for the industry include inadequate investment in renewable electricity and grid reliability, lack of commercially available and competitively priced clean hydrogen, and failure to commercialize carbon capture, utilization, and sequestration technologies. These research areas are not yet commercially viable at the scale needed for widespread adoption in the U.S. and represent technological approaches that are applicable across several domestic industries and sectors. AISI recommends DOE focus on new and emerging technologies in this regard and avoid allocating funding to existing technology solutions, with the exception of efforts to expand clean and renewable energy sources.

AISI understands that the Association for Iron & Steel Technology (AIST) is submitting a detailed response to the subject RFI. AIST is the American steel industry’s technical association in Pittsburgh, PA, whose mission is to advance the technical development, production, processing and application of iron and steel. AISI supported AIST’s efforts and encourages DOE to give careful consideration to its response.

Sincerely,

Kevin M. Dempsey
President and Chief Executive Officer
Steel needs energy — lots of it. Just as important, energy needs steel — lots of it. The relationship is interdependent and inextricably linked. Owing to this reality, the U.S. steel industry is motivated to catalyze all manufacturing in the grand challenge of industrial decarbonization.

This motivation includes expectations from society, our customers and our investors to demonstrate meaningful advancement for Environment, Social and Governance (ESG) initiatives. The building of a green energy infrastructure to support decarbonization will also underpin long-term domestic steel demand, which is both opportunistic for industry and beneficial for society.

Steel is considered a “hard-to-decarbonize” industry and the evolution of breakthrough technologies will be essential to this effort. As a corollary to this technological evolution, the creation of a skilled, diverse and inclusive workforce will be of paramount urgency. The Department of Energy is a leader in R&D and scale-up of emerging technologies, and there is strong potential for working with the U.S. steel industry.

A public/private partnership with the steel industry, perhaps in the form of a Manufacturing Institute, would facilitate the commercial transition of innovative decarbonization technologies into scalable, cost-effective and high-performing manufacturing solutions. The institute would also create and implement workforce development programs to ensure the future viability of the industry. While the U.S. steel industry may evolve these technologies and programs over time, an institute would accelerate the effort to ensure global leadership is preserved.

The capability to engage industry at all levels will be critical for the long-term success of this grand effort. The U.S. steel industry has the vigor of scale, impact and accountability for coordinating stakeholders to hasten the path toward net-zero carbon emissions.

Submitted: 28 February 2022
Institution Name: Association for Iron & Steel Technology
Institution Contact: Ronald Ashburn, Executive Director
186 Thorn Hill Road • Warrendale, PA 15086
phone: +1.724.814.3062 • email: rashburn@aist.org
Category 2 Iron and Steel Industry Decarbonization

C2.1 What emerging decarbonization technologies could have the most impact in the steel industry over the next 5-10 years, and 10-20 years? Which of these technologies are applicable to:

- Integrated steelmaking (blast furnace/basic oxygen furnace) operations.
- Electric arc furnace steelmaking operations.
- Direct reduced iron operations.
- Downstream steel mill operations (e.g., reheat furnaces and finishing operations).
- Other operations or opportunities.

Based on a DOE/AMO-sponsored study by Fruehan & Paxton\(^1\), approx. 4 GJ/mt steel can be saved in the BF and approx. 0.6 GJ/mt steel can be saved in the EAF process. Virgin iron production and metallic scrap recovery remain essential raw materials for future demand. Numerous shorter-term technologies exist; widespread adoption needs to be embraced.

- **Integrated steelmaking (blast furnace/basic oxygen furnace) operations**: The BF/BOF process is the most energy-intensive portion of the iron and steelmaking route. Methods for reducing energy and carbon intensity in conjunction with CCUS will support leading to net-zero emissions.
  - **5-10 Years**: Alternative injection technologies: natural gas, hydrogen, waste plastic, biofuel, biocoke, biochar, etc. (BF); metallic feedstock additions (DRI, HBI, Scrap) (BF); oxygen enrichment (BF); CCUS (BF and BOF).
  - **10-20 Years**: Plasma-assisted heating (BF); CCUS (BF and BOF).

- **Electric arc furnace steelmaking operations**: The EAF process is an energy efficient process for producing steel from primarily recycled steel scrap, however the EAF process still produces GHG emissions. New technologies are needed to lead to net-zero. The EAF process often requires the addition of varying volumes of virgin iron such as pig iron, or DRI/HBI to dilute residual elements found in metallic scrap such as Cu, Ni, Cr, Sn and Mo which reduce product quality.
  - **5-10 Years**: Energy generation and storage: natural gas, renewable and nuclear; raw materials: pig iron, DRI, HBI; injectants: biofuels, waste plastics, natural gas; scrap sorting, optimization and valorization (mitigating residuals); scrap pre-heating technologies (e.g., Consteel); alternative scrap pre-heating technologies (conduction, induction, radiation); direct hot charging technologies for temperature conservation; enhanced energy efficiency; smart sensors and control technologies; CCUS.
  - **10-20 Years**: Energy generation: nuclear, plasma heating; injectants: hydrogen, biocoke; alternative slag foaming technologies; CCUS.

- **Direct reduced iron operations**: The co-location of DRI production facilities with steelmaking operations can enable significant energy savings via direct hot charging into the BF and EAF. DRI transfer has been reported to save approximately 26 kWh/ton liquid steel for every 100°C increase in hot-charge DRI temperature in the EAF\(^2\). Hot charging may be an

---

important enabling technology to improve the efficiency of melting carbon-free, high-melting-point, green hydrogen-produced DRI.

- **5-10 Years**: Synthetic gas reduction; replacement of hydrogen for iron ore reduction; fluidized process.
- **10-20 Years**: Plasma reduction; molten system reduction processes (direct smelting); metallic vapor exchange.

- **Downstream steel mill operations (e.g., reheat furnaces and finishing operations)**: Enhancing thermal process fuels with utilization efficiency and low-carbon fuels; recycling heat and waste energy effectively; alternatives to natural gas heating, e.g., hydrogen, induction heating or thermal radiation; avoidance of re-heating through hot charging; and near-net shape technologies.

- **Other operations or opportunities**: The challenges with modern steelmaking caused by raw material constraints, such as prime scrap scarcity, increasing restrictions on emissions, and renewable power and grid parity are pushing the frontiers of innovation. We must identify the pathways to merge smart solutions with advanced processes that enable raw material and energy flexibility, low-emission metallization, recycling and waste stream valorization, near-net-shape manufacturing, and lighter-weight, higher-performance steel products.

- **Cross-cutting technologies (affecting all or some of the above)**: Smart control technologies, e.g., ML, AI, robotics, big data analytics; advanced sensors including fiberoptics; electrolysis (water, molten oxide, etc.); synergistic production of carbon and hydrogen, e.g., natural gas pyrolysis; non-combustion heating; waste heat recovery; slag valorization; wastewater treatment/reuse.

C2.2 What primary factors are driving decisions on demonstrations of new technologies that reduce GHG emissions? Which promising technologies are most appropriate for demonstrating in the U.S. marketplace? Which technologies are ready for pilot plant scale-up, and which are ready for commercial demonstration?

Industry has begun to address several areas within the manufacturing value chain to achieve cost and efficiency improvements as well as emissions reductions. However, these efforts are not sufficiently mature for deployment and require further insights about complex phenomena through enhanced innovation and R&D, which is best achieved through a public-private partnership with the steel industry. There are several themes that emerge:

- **Decarbonizing existing BF assets**: The blast furnace is the most efficient technology to produce virgin metallic iron at scale. The need for pure metallic iron is essential for value-added steel products, such as those required by the automotive industry. Globally, roughly 1,800 kg of CO₂ per ton of steel is emitted by blast furnaces³, making it the largest emitter of CO₂ within steelmaking although domestic BFs are typically lower in carbon intensity. To remain cost competitive through 2050 to a net-zero economy, it is essential to evolve blast furnace mitigation technologies for reducing CO₂ emissions and energy consumption. Technologies related to CCUS, oxygen use in place of air, and injection of alternative reductants such as plastics and biocoke would be potential targets for demonstration.

³ AIST 2019 Elliott Lecture, Lawrence J. Heaslip
• **Decarbonizing existing downstream assets:** There are myriad combustion processes within steel manufacturing that could be decarbonized through electrification, e.g., process pre-heating, heating, reheating, cutting, etc.

• **Metallic Scrap Optimization:** The primary challenge for scrap recycling is the presence of residual tramp elements, such as Cu, S, P or Sn, in scrap. These residual elements cannot easily be removed during liquid steel processing and require dilution via the addition of varying levels of virgin iron to prevent adverse effects downstream. This problem will become more significant with increasing global demand for quality scrap. Adoption of advanced sensors, automation and machine vision for scrap sorting would be suitable for demonstration.

• **Low- or Non-Carbonaceous Iron Reductants** — The U.S. steel industry is less carbon intensive than other major steel-producing regions due in part to increased use of natural gas, which is not as plentiful in other regions of the world. The most considered alternative for carbon-based (coke or natural gas) reduction of iron ore has been H2. European steelmakers are already engaged in projects that employ H2 in steelmaking. GrInHy (Salzgitter in Germany) and H2FUTURE (voestalpine in Austria) are focusing on electrolyzer development. The Swedish consortium HYBRIT (SSAB, LKAB and Vattenfall) considers the entire fossil-free value chain for primary steel through H2 electrolysis used for DRI and steelmaking in an EAF at the pilot plant scale (approx. 1 ton/hour). If successfully integrated with electric grids, the impact would be cost-effective and could decarbonize ironmaking. There are significant technical barriers to wide-scale adoption of hydrogen for steelmaking in the U.S. that will require further research, development and investment.

• **Iron Smelting via Electrolysis** — The use of electric power to produce metallic iron using an electrolysis reactor rather than the traditional blast furnace offers an attractive route to replace carbon with electrons to produce iron electrolytically. This conversion process could be achieved through both low- and high-temperature electrolysis reactors, which have been proven in the laboratory. However, the process requires significant electrical power and is not yet a viable technology route for steelmaking.

• **Creating Markets for Green Steel** — Steel requires energy, but energy also requires steel. The interdependence for a transition to green energy and associated infrastructure will open new markets: 1. Advanced high-strength steel grades for light-weighting, transportation and mobility, renewable energy facilities, including wind-turbine structures and solar fields, etc.; 2. Electrical steels for high-efficiency power generation and distribution; 3. Special steels resistant to hydrogen-induced cracking will be critical to the generation and storage of energy in a hydrogen-powered future.

**C2.3 What is the magnitude (e.g., output rate and cost) of potential pilot or demonstration scale projects that could be undertaken in the next five years? What are the most critical performance characteristics (e.g., efficiency, GHG emissions, capital or operating costs, product quality) these projects need to demonstrate?**

There are several government-subsidized steel industry decarbonization projects in Europe that provide local industry the opportunity to focus on implementing breakthrough technologies that may otherwise not have been financially successful. Four recent European
steel decarbonization projects in the pilot stage account for nearly €2.5 billion in investment: SALCOS, HYBRIT, H2FUTURE and tkH2steel. If the U.S. wants to preserve its leadership role in climate neutrality, our government should support research into breakthrough technologies that lead to decarbonization for the U.S. steel industry. A public-private partnership would be critical to support these investments.

To be successful, the critical performance characteristics will be cost effectiveness, scalability and overall decarbonization rate. In a February 2022 AIST survey of the U.S. steel industry, the below observations were gleaned relative to steel decarbonization technologies; all companies responded favorably about public-private partnerships.

<table>
<thead>
<tr>
<th>Avg Rank</th>
<th>Industry Priority for Iron &amp; Steel Decarbonization Technologies (Rank 1-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>Thermal Process Fuels</td>
</tr>
<tr>
<td>4.6</td>
<td>Carbon Capture, Use and Sequestration</td>
</tr>
<tr>
<td>4.7</td>
<td>Metallic Scrap Feedstock</td>
</tr>
<tr>
<td>4.7</td>
<td>Electrification</td>
</tr>
<tr>
<td>4.8</td>
<td>Smart Manufacturing</td>
</tr>
<tr>
<td>5.2</td>
<td>Effective Use of Existing Assets</td>
</tr>
<tr>
<td>6.0</td>
<td>Direct Carbon Avoidance</td>
</tr>
<tr>
<td>6.8</td>
<td>Alternative Iron Ore Reductants</td>
</tr>
<tr>
<td>7.3</td>
<td>Metallic Ore-Based Feedstock</td>
</tr>
<tr>
<td>7.5</td>
<td>Materials for Service</td>
</tr>
</tbody>
</table>

The survey requested current project status and total investments required through viability.

<table>
<thead>
<tr>
<th>Avg Rank</th>
<th>Industry Priority for Government Initiatives (Rank 1-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>Develop supporting infrastructure for decarbonization technologies</td>
</tr>
<tr>
<td>2.8</td>
<td>Increase international co-operation and ensure a level global playing field</td>
</tr>
<tr>
<td>3.1</td>
<td>Support the demonstration of decarbonization technologies</td>
</tr>
<tr>
<td>4.3</td>
<td>Track progress and improve data collection</td>
</tr>
<tr>
<td>4.4</td>
<td>Create a market for decarbonized steel</td>
</tr>
<tr>
<td>4.5</td>
<td>Communicate the long-term importance for decarbonization efforts</td>
</tr>
</tbody>
</table>
C2.4 What limiting factors or challenges does the steel industry face in broadly deploying decarbonization technologies in the United States?

The U.S. steel industry is among the world leaders in terms of safety, productivity, sustainability and product quality. To strengthen this leadership position, we must continue to evolve breakthrough technologies. With any such effort, there will always be strategic risks including those associated with decarbonization. Known concerns include:

- Creating competitive technologies which are cost effective and scalable.
- Closing knowledge gaps to de-risk capital intensive investments in new technologies.
- New process technologies, e.g., utilizing different raw materials or energy sources and power infrastructure, need to maintain or improve product quality and properties.
- New technologies when adopted should continue to protect the health and safety of the workforce and related Environmental, Social and Governance (ESG) imperatives.
- Promoting a skilled, diverse and inclusive workforce to address the future workforce needs when new technologies are adopted.
- Developing appropriate supply chain economics for new feedstocks and clean energy markets, e.g., contracts, availability of raw materials, etc.

C2.5 What DOE resources would most benefit the U.S. steel industry to accelerate decarbonization? For example:

- RD&D options could include R&D projects, technology testbeds, pilot testing/demonstrations, and cost-share for commercial demonstrations.
- Technical assistance options could include emerging technology validation, deployment assistance for new energy- and carbon-saving technologies, energy/carbon assessments, analysis tools, and workforce training.
- Financial options could include the DOE Loan Program (access to capital, flexible financing).

The steel industry is a capital-intensive, hard-to-decarbonize sector; therefore, additional investment in this sector is critical for de-risking future capital expenditures. Unlike some European and Asian countries, no nationally coordinated research effort for decarbonization of the steel industry is in place in the U.S. Coordinating such an effort between industry, academia and national labs in the U.S. would accelerate:

- Public-private investment in RD&D.
- Coordinated industrial and academic access to national lab expertise, e.g., HPC and renewable- and nuclear- energy development.
- Coordinated workforce development, diversification and training.
- Transformation through an innovation and investment ecosystem which includes utilities, steelmakers, raw-material providers, equipment manufacturers, universities and emerging technology providers.
C2.6 How can technologies leading toward decarbonization of the iron and steel industry be commercialized and deployed with positive impacts to the surrounding community?

The Biden administration is focused on two key areas that can unite U.S. industry: decarbonization and infrastructure. Decarbonization will lead to an environmentally sustainable and socially acceptable industry. The required deployment of new technologies will lead to new manufacturing jobs and additional employment throughout the supply chain. Infrastructure will increase demand for steel consumption, catalyzing economic development and employment while also improving quality of life in adjacent areas, which may have particular impact in communities with aging steelmaking capacity and under-privileged populations.

C2.7 What DOE resources or actions could support improvement of areas surrounding iron and steel industry facilities, particularly those in areas of historical environmental injustice in the transition to a decarbonized energy economy?

The substantial economic activity supported by the steel industry provides major opportunities to invest in public services, thus generating prosperity and welfare. Over the past few decades, the steel industry has also transformed its manufacturing economy into one driven by knowledge and technology. This transition brings enormous potential to deliver jobs, economic opportunities and neighborhood improvements to disadvantaged communities. However, the benefits of new growth and development will not be automatically achieved without a focus on equitable development.

Initiatives could include the development of programs for management education and mentorship, best practice and benchmark reporting, and the establishment of strategic partnerships to create internships specifically for underrepresented groups. It will require a plan to partner with community colleges, trade schools, minority-serving organizations and universities to provide an infrastructure for workforce development to meet industry needs for a skilled, diverse and inclusive workforce by 2030. Collaboration is essential to identify effective and desirable opportunities for workforce development, especially around DEI. Leaders in academia (intellectual leadership), industry (development leadership) and government (policy leadership) as the stakeholders in this effort must work together.

Investment by the DOE in something such as a Manufacturing Institute for Steel Decarbonization will provide stakeholders an opportunity to collaborate on a common goal: achieving climate neutrality by 2050. An Institute would leverage DOE and each stakeholder’s best strengths for the partnership to avoid breakdowns along the innovation value chain and to ensure the strategy to achieve climate-neutral steel includes equitable development.

C2.8 Provide any additional information relevant to the energy efficiency and GHG reduction opportunities/challenges of the steel industry that do not fit into the previous questions in this Category. This could include various industry data, references, or technical information.

The U.S. steel industry is among the cleanest in the world. Working in coordination with academia and the national labs, it has the rigor of scale, impact, and accountability to hasten the path to net-zero carbon emissions and to preserve its global leadership.
Decarbonization solutions must be scalable, cost-effective and offer high performance for industrial adoption, and a Manufacturing Institute would address barriers for TRL 1-9 spectrum, innovations that no single company would tackle on its own. These challenges represent favorable attributes in support of a public-private partnership to de-risk these efforts.

Furthermore, there is no single technological solution for decarbonizing the nation’s steel sector. Regional raw material sources and clean energy resources, logistics, and markets will necessitate a range of solutions specific for each region. In addition to accelerating RD&D technologies for decarbonization, the U.S. steel industry is also motivated to reinforce and grow its workforce development infrastructure.

With steel being the engineered material solution for the manufacturing economy, the U.S. steel industry has key tailwinds to motivate its support for an institute. These forces include infrastructure readiness, decarbonization and ESG progress. There are mounting societal, customer and investment community expectations, and the steel industry is positioned to answer the call. Further, there are competitive pressures from significant decarbonization technology investments already underway globally. These breakthrough investments, if unanswered, will threaten U.S. leadership in the global production of clean steel.

The DOE/AMO working in direct cooperation with the U.S. steel industry would yield a significant impact to increase U.S. competitiveness within the grand challenge of industrial decarbonization. Technological advances in manufacturing will enable decarbonization for other sectors such as transportation, residential and commercial, which will carve the path to economywide net-zero emissions by 2050.

Category 6 Cross-Cutting Industrial Decarbonization Opportunities

C6.1 What emerging decarbonization technologies could have the most impact in the industrial sector over the next 5-10 years, and 10-20 years?

Numerous shorter-term technologies exist; widespread adoption needs to be embraced. Cross-cutting themes with both short and long-term durations include:

- Smart Solutions, including advanced sensors, robotics, AI and data analytics, in addition to facilities and tools for high-performance computing applications.
- Infrastructure for renewable and nuclear energy, e.g., mini reactors with excess power
- Hydrogen combustion applications.
- Biomass and biofuels applications.
- Co-generation of electrical power by the utilization of the offgases currently generated by coke, iron and steel production. The co-generated electrical energy can supplement internal electrical needs or passed to community power grid.
- Electrification of heating such as induction. In EAF steelmaking, emissions from stationary combustion (reheating) are as large as emissions from the melting furnaces themselves, amounting to some 100 kg CO₂ per ton steel or more.⁴
- Co-products such as slags and mill scale for application in other industries.

---

⁴ P. Chris Pistorius, Carnegie Mellon University; EPA Flight Tool http://ghgdata.epa.gov/ghgp
These cross-cutting technological developments will have a multiplying factor to create capital spending throughout the industry and for all manufacturing. To succeed, the U.S. must be an early adopter and lead technology development and deployment.

C6.4 What limiting factors or challenges do these crosscutting technology areas face regarding broad deployment in the United States?

There is a lack of inter-industry collaborative platforms to develop technological awareness of cross-cutting opportunities for steel, cement, chemical and other high emitters. These platforms could include educational tools to draw awareness of specific industry issues to identify crossover opportunities, e.g., conferences, symposia, benchmarking, databases, etc.

Category 7 Specific Industrial Decarbonization Challenges

C7.1 What are the challenges unique to small and medium-sized manufacturers?

Capital intensity and technological risk represent significant barriers to entry for the many small and medium-sized enterprises that support the U.S. steel industry. A public-private partnership with the steel industry would be ideally suited to overcome these barriers.

C7.2 What are the challenges unique to specific geographic regions of the United States?

Access to: decarbonized energy, e.g., hydrogen, CCUS, etc.; raw material sources; transportation sources, e.g., waterways, rails, interstate, etc.; workforce and customer base.

C7.3 What are the challenges related to utilizing onsite carbon-free power generation (e.g., solar, wind) in industrial applications?

The challenge with intermittent renewable power (solar/wind) is the lack of sufficient energy storage and ability to operate fossil-free operation during downtimes. A manufacturing plant must operate continuously to generate sufficient output to return its cost of capital. Co-locating near continuous renewable power sources, e.g., hydro-electric or geothermal stations or nuclear power, is a viable option, but the co-location requires elements identified in Q7.2 and must consider competition from other sectors needing access to the same power, which may make it prohibitively expensive. There is a risk of overdependence on clean electric power in the face of limited supply.

Several domestic steel facilities have announced plans to collaborate with local utility companies to take advantage of the benefits of their geographic location to integrate locally generated green electricity into the local grid that supplies their facilities. Examples are: Cleveland-Cliffs’ renewable power purchases and partnerships with Wisconsin Electric and Minnesota Power to retire coal-fired power plants; EVRAZ North America’s collaboration with Xcel Energy and Lightsource BP to develop a new 240 MW solar facility in Pueblo, CO; and Nucor Steel Sedalia’s collaboration with local wind power company Evergy in MO.
Matching green energy supply with peaks in demand will remain a challenge, and new grid-balancing solutions or new operating paradigms for aligning steel production to off-peak power availability will be needed to make the transition to carbon-free steelmaking. Grid balancing using large-scale low-cost battery storage, such as FORM energy’s iron air battery, or supplemental power generation using natural gas may provide full or partial solutions. Balancing off-peak power through nuclear may also be an option.

C7.4 What are the challenges in retaining or reclaiming a domestic competitive advantage in energy-intensive, trade-exposed industries as GHG emissions in those industries are reduced?

The challenges are the lack of a coordinated effort for public-private investment in decarbonization technologies and the lack of a carbon border adjustment mechanism (tax, etc.), which could prevent carbon leakage and avoid shifting steel production to countries with weaker environmental standards that result in a global increase in GHG emissions.

C7.5 What are the challenges related to key unit operations equipment and supply chain gaps that need to be addressed to enable decarbonization?

The challenges are cost-effective green hydrogen, electricity and renewable energy storage and supply.

C7.6 What are the challenges and opportunities to support and grow market demand for low-carbon, U.S. made industrial products? Would the collection, tracking, and reporting of transparent data on GHG intensity and embodied carbon of industrial products be supportive?

The challenges are maintaining cost-effective, low-carbon products and determining appropriate measurement methodologies and benchmarks. The opportunity is enabling ESG initiative progress. Data tracking and transparency via a private third-party would be beneficial for affirmation of individual company decarbonization efforts.

C7.7 How can DOE most effectively and transformatively support industrial decarbonization? For example, supporting facilities to reduce emissions through efficiency improvements versus demonstrations of “best-in-class” facilities that accelerate the development and commercialization of zero emission industrial processes. What are the trade-offs between the various approaches?

For the steel industry, the most effective and transformative approach for decarbonization would be via a Manufacturing Institute for Steel Decarbonization. It is essential to coordinate industry-wide participation and support from producers, technology suppliers, research institutions, academia and national labs.
Category 8 Industrial Decarbonization Workforce, Community, and Equity Considerations

C8.1 In what ways, if any, do you anticipate decarbonization processes could impact your workforce?

The decarbonization of the steel industry will require a diverse workforce, skilled in newly developed and emerging opportunities including AI, ML, HMI, robotics and data analytics. These technologies intersect with new innovations in materials development, management and processing including iron recycling, coke carbon reduction, electric arc production, and more. Further, the USW, through partnerships with the BlueGreen Alliance et al., has also committed to steel decarbonization in conjunction with seeking quality employment opportunities.

The steel industry is committed and invested in its effort to lead the industrial decarbonization challenge, which it believes will also help attract its future workforce. By 2025, 75% of the workforce will be made up of millennials, who are seeking socially responsible employers with strong ESG policies.⁵

C8.2 What are the challenges in developing and retaining a skilled, diverse workforce to achieve industrial decarbonization? How should DOE best engage and partner with the skilled workforce to pioneer new approaches? How can industrial decarbonization support improved job quality and provide a competitive advantage?

The challenges include the following: Lack of encouragement for trade careers; public perception in support of the steel industry; dwindling number of metallurgical institutes; a shrinking pool of skilled, diverse workers, compounded by interindustry competition; and unfair global competition, which undermines the national manufacturing base.

AIST has many steel industry partners, including steel producers, technology suppliers, academia, national government laboratories and cross-discipline associations.

C8.4 As the industrial sector decarbonizes, what are the challenges in delivering equitable outcomes? What DOE resources or actions could support improvement of areas surrounding industrial facilities, particularly those in areas of historical environmental injustice?

DOE can look to leverage synergies between steel and electric grid decarbonization, and infrastructure improvement utilizing Bipartisan Infrastructure Law funding and other recent funding opportunities to advance the administration’s energy and climate initiatives.

C8.5 Provide any additional information relevant to workforce, community, and equity considerations that do not fit into the previous questions in this Category. This could include various industry data, references, or technical information.

Steel decarbonization has the potential to not only reduce greenhouse gas emissions, but also other pollutants that have historically affected marginalized communities. Capital

⁵ https://online.hbs.edu/blog/post/corporate-social-responsibility-statistics#:~:text=A%20majority%20of%20American%20consumers,doesn't%20come%20without%20risk
investments in steelmaking and associated processes throughout the supply chain can also positively affect local communities. Many domestic steelmakers hold community engagement in the highest regard with robust foundations, non-profit collaborations, and annual giving to improve the communities where their facilities are located. Consideration should be given to new communities, communities where steelmaking operations will be changing, and to communities where steelmaking operations or supply chain processes will end or relocate.

**Category 9 Iron, Steel, Manufactured Products, or Construction Materials**

DOE is collecting [...]information to help inform the implementation of the Buy American Preference requirements set forth in section 70914 of the Bipartisan Infrastructure Law.

Just as steel requires energy, energy requires steel. The U.S. goal of providing net-zero emissions economy-wide by 2050 will require significant steel as part of the infrastructure in power generation, transmission, etc. For example, steel accounts for 80% of the material required to produce a wind turbine, including electrical steels in the nacelle and structural steels for the towers, and other specialty steels for critical applications such as bearings, etc.

The domestic steel industry is a strong supporter of the IIJA’s Build America, Buy America requirements and appreciates DOE’s efforts to strengthen America’s manufacturing base. The IIJA’s landmark domestic content provisions will ensure that federally funded infrastructure projects are supplied by the cleanest, most efficient steel industry in the world: our own. We should not subsidize jobs overseas when cost-competitive, sustainably produced, high quality goods are available here. Because the United States has more stringent environmental and labor standards, it is critically important to support Buy America policies that promote domestic steelmakers and lower CO₂ emissions.

Moreover, in the buildout of new infrastructure – and new clean energy technologies – DOE and other stakeholders must recognize the critical role of domestic materials in achieving secure and enduring supply chains. This approach will not only ensure secure supply chains, it will also grow the U.S. economy, create high-quality jobs for future generations, and further safeguard our energy security.