Institute of Clean Air Companies
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TO: Advanced Manufacturing Office, U.S. Department of Energy
FR: The Institute of Clean Air Companies (ICAC)
RE: Request for Information on Industrial Decarbonization Priorities (DE-FOA-0002687)

The Institute of Clean Air Companies (ICAC) appreciates the opportunity to offer comments in response to Advanced Manufacturing Office's Request for Information.

ICAC is the national trade association of companies that manufacture and supply greenhouse gas management and air pollution control and monitoring systems, equipment, and services for stationary sources. For over 60 years, ICAC member companies have helped to clean the air by developing and installing reliable and cost-effective control and monitoring systems.

ICAC's response will provide an overview of our perspective on ready-to-deploy and emerging technologies and solutions that can help develop pathways for industrial decarbonization. We support technology-neutral and flexible policies that enable cost-competitiveness and a diverse set of technologies to compete in the market.

Again, ICAC appreciates the opportunity to offer input to the Advanced Manufacturing Office and we look forward to answering any further questions or provide additional information.

Sincerely,

Clare Schulzki
Executive Director, ICAC

Introduction

The Institute of Clean Air Companies (ICAC) appreciates the opportunity to respond to the Advanced Manufacturing Office (AMO), Department of Energy's industrial decarbonization Request for Information (DE-FOA-0002687).

ICAC is a trade association headquartered in Arlington, VA, and represents more than 30 companies in the air pollution control, greenhouse gas management, and emissions measurement industry. ICAC members have successfully developed and deployed solutions to address emissions challenges for more than 60 years and are uniquely positioned to provide their expertise on emerging clean technologies and advancing clean technology markets. ICAC members have successfully commercialized solutions for the industrial, power, oil and gas, and maritime sectors, and have worked to address challenges that emerge at the nexus of air and water pollution management. Pollutants managed by member technologies include mercury, acid gases, PM, NOx, SOx, VOCs, HAPs, GHGs, HCl, and coal ash. Our members have operations in all 50 states and range from multi-national corporations with thousands of employees to small businesses focused on local emission challenges.

ICAC is recognized as a trusted, unbiased technical resource for government and other stakeholders by providing information on what is technologically achievable and the relevant costs associated with technologies. ICAC members' experience in meeting emissions challenges equips our organization with valuable insights that can help inform the development of successful policies, regulations, and other mechanisms to support the advancement of clean technologies ready to deploy now and those needing further development.

ICAC members stand ready to provide information to help inform AMO's efforts to develop and deploy 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. Our comments will start with some initial, high-level considerations of the best approaches to the energy transition, and then will respond to the various categories listed in the RFI. ICAC would welcome the opportunity to further discuss our industry's perspective on the current opportunities and challenges for decarbonizing the industrial sector.

Near and Long-Term Technology Neutral Solutions

ICAC believes policies should be technology-agnostic and flexible to enable cost-competitiveness. Many solutions will be needed to meet the anticipated clean energy demand and to reach our mid-century decarbonization goals. A variety of factors, such as geography, will help determine which clean technologies should be deployed. For example, regions with ample renewable feedstocks and energy sources may be better suited for green hydrogen deployment. Alternatively, regions with existing infrastructure and production facilities may be better suited for blue hydrogen, where developers can retrofit a facility and utilize the existing assets in the region. Likewise, in the near term, retrofitting an existing production facility could allow for larger volumes of low-carbon hydrogen to be produced. If end-users require a more limited volume of hydrogen, then green hydrogen produced by electrolysis could be a better option. There is no one "best" solution and there needs to be support for a diverse set of clean technologies to meet both current and future climate goals.

Technologies vary in their Technology Readiness Level (TRL) and commercialization stage. While some technologies are available at-scale today, others are in the scaling process and require additional demonstration and refinement to advance the technology itself or to improve costs. Likewise, some markets for clean technologies are mature, while other markets are emerging. ICAC supports policies that are technology-agnostic and flexible to enable cost-competitiveness. All solutions will be needed to meet the anticipated clean energy demand and solutions to our deployment challenges should not favor some technologies over others.

Continued DOE Funding, Scaling Process and Market Incentives

ICAC encourages measures that provide sufficient support to cover the cost delta between traditional technologies and practices and emerging clean technologies. Any business case for deploying large-scale decarbonization technologies must rely on ongoing monetization or producing a sellable product. Emerging clean energy technologies cannot only rely on commodity markets, because such markets do not provide adequate long-term revenue guarantees that are required to secure project financing.

Though production, integration, design, and construction all happen rapidly (between 2-4 years), the technology development of low-carbon process technologies does not mimic the evolution of "computer tech" types of production. Maturing a process technology typically will require incorporating the lessons-learned of three completed and successful projects. DOE should focus on continued, long-term funding to see projects all the way through this 4–6-year process. The successful scale-up of flue gas desulfurization (FGD) and selective catalytic reduction (SCR) markets, driven by EPA regulation of coal plants, are great examples of quick market reaction and deployment of technology solutions.

Until the cost of carbon emissions is fully internalized, DOE must address the gap between the cost of low-carbon commodities and their market value. Cost-sharing will be needed to allow project owners to share some of the technology, schedule, and performance cost risks until the technology is proven enough for U.S. companies to take on the risks themselves.

New types of facilities are needed at scale as demand uncertainty is high in early-stage development. Full Front-End Engineering Design (FEED) studies are required, as well as new commercial arrangements and integration with early infrastructure such as the hub and cluster approach. ICAC believes DOE should consider its approach to technology advancement within the energy sector by bearing ongoing responsibility thus ensuring its investments continue to be realized commercially. This would ultimately facilitate additional Congressional funding for more aggressive investments. Projects like Petra Nova could have been supported by making Section 45Q tax credits available or by employing another long-term cost-sharing model (e.g., the “Contract for Difference” approach utilized in the United Kingdom for clean hydrogen energy hubs).

Hub and Cluster Model Benefits

Most existing industrial facilities do not tend to require a dedicated energy facility. They utilize energy from the established grid, which provides energy to a number of different industrial, transportation, commercial, and residential uses. In order to prove commercial viability for hydrogen in the energy transition, the hub and cluster approach provides the ability to bring together multiple industrial users and a transportation system to establish a balanced supply of demand at scale. Hub and cluster models promote multiple synergies between producers and users, de-risks investments, and better establishes the true cost of energy at larger scales.

Category 1: Chemical Industry Decarbonization

Syngas

Natural gas and coal-based syngas production (for hydrogen, methanol, ammonia) are responsible for ~2 % of global CO_2 emissions and ~10% of industrial emissions. Industry has started to look for cost-effective decarbonization solutions to mitigate future higher CO_2 costs and secure license to operate. Thousands of syngas plants are looking to decarbonize over the next decade as carbon pricing evolves. The greatest number of these syngas plants exist in the oil refining industry. Independent consultants such as IHS Markit have projected over $1 billion on refinery hydrogen decarbonization projects by 2030 and an additional $4 billion by 2040 for North

America. These projects will easily impact about 20 million tonnes of CO_2 annually by 2030 and 100 million tonnes annually by 2040.

Syngas plants willing to decarbonize could be incentivized to invest in technology solutions if the environment for treating these emissions were more favorable. Factors that could help include:

- Full accounting and certification to enable external reporting and claims, and to ensure sustainable emission reductions prudently and transparently.
- Ability to reduce risk of carbon storage to manage current liabilities of 50-to-100-year emission lifecycles.
- Development of emissions monitoring to utilize low carbon energy sources such as hydrogen.
- Establishing Clean Syngas standards that can be sustained and enable 2050 net-zero targets to be met and improve capital utilization.
- Incentivizing CO_2 utilization in the production of other chemical intermediate products such as methanol can help to accelerate decarbonization projects that may be lagging from carbon storage availability or transport challenges.

Sustainable Aviation Fuel

The global aviation industry is responsible for 12% of transport related CO_2 emissions so substantial production of low carbon intensity sustainable aviation fuel (SAF) is essential. Both the EU and U.S. are setting bold targets regarding its scale up and blending which should increase SAF demand significantly. Technologies to increase the supply of SAF through efficient production at scale are necessary. Technology for providing end-to-end, optimized and highly scalable processes converting very high quantities of the CO_2 into high quality synthetic crude oil needs to be supported with proper incentives to drive demand. When successful, this synthetic crude oil can be further upgraded into sustainable drop-in fuel products including aviation fuels, renewable diesel, and naphtha. Using hydrogen fuel in the airline industry requires further development in long-haul, hydrogen-fueled engines along with delivery and storage systems within the airline itself making SAF attractive for near-term decarbonization.

Category 2: Iron and Steel Industry Decarbonization

C2.1 A productive decarbonization strategy in the steel industry is minimizing the production from blast furnaces and maximizing production from electric arc furnaces

(EAF). Blast furnaces are capable of making many of the specialty steel grades, but the steel quality is limited by the quality of the scrap for EAF production. Substituting direct reduced iron (DRI) for scrap can expand these capabilities. Even though DRI is currently produced via natural gas, this remains a good transition strategy to Carbon Intensity (CI) reduction. Integrating induction heating within the hot mill provides the opportunity to aggressively minimize the carbon input into the production process. When renewable power generation is low, the challenge for EAF production is that additional MWh from the grid primarily come from fossil fuel generation. Just like "green" hydrogen that must be produced only from renewables, qualifying steel production will likely require the same threshold. Gone are the days of buying some wind renewable energy credits (RECs) and claiming all production from renewables. Viable generation strategies range from incorporating renewables, which charge energy storage batteries or even small modular reactors (SMRs).

C2.2 Iron and steel industries have experienced 20 or more years of intense competition with Chinese steel in the world market and thus operate with some of the leanest engineering and R&D staffs compared to most industries. Based on first-hand interactions with steel industry executives, they always maintain a key focus on the business case justification. European steel owners are further ahead in funding pilot projects in European operations, but all are still in their infancy in terms of proving the integration of carbon reducing new technologies in a business model that depends greatly on economic viability.

C2.4 See *C2.2* response.

C2.5 In order to realize larger emissions reductions in the future, it will require significant investments in the development, demonstration and deployment of new technology. DOE can help by forming partnerships and cost-sharing between national labs and industry.

C2.7 Many of these iron and steel industrial complexes have a significant buffer-zone that could be ideal for solar generation.

Category 4: Cement and Concrete Industry Decarbonization

C4.1 Cement is one of the hardest-to-abate sectors due to the process heat required and due to the natural emissions from limestone decomposition, which is a key part of the process. To decarbonize all the emissions from cement production, there is no getting around the need for carbon capture as part of the portfolio of solutions. Post-combustion carbon capture technologies will likely play a role and have potential for high impact. Novel integrated direct separation technologies or oxyfuel-based technologies could similarly have significant impact in the next 10–20- years. These carbon capture or separation technologies may also be paired with opportunities to use or reinject the CO_2 into cement for sequestration. Advancements in low-carbon supplementary cementitious material will also contribute to decarbonization but still likely needs to be complimented by carbon capture.

C4.2 Key decision criteria are cost (vs access to incentives available), scalability across existing asset bases and impact on marketability of product. Line of sight to commercialization drives decisions on demonstrations. An advantage of the U.S. marketplace is its abundance of natural resources and experience with CO_2 injection/sequestration. It would be appropriate for the U.S. cement sector to utilize carbon-capture based technology solutions (mentioned in C4.1), which are ready for commercial demonstration and can make the greatest impact in the near/medium term.

C4.3 It would be possible to deliver small-scale commercial demonstration projects at total integrated capital costs of <$100MM per project in the next 5 years. The performance characteristics cannot be looked at in isolation, but blended into a cost of avoided CO_2. Once established/proven that these technologies reliably deliver costs lower than incentives (such as 45Q tax credit) adoption rates will inflect rapidly.

C4.4 The current level of the 45Q incentive is limiting. The proposed enhancement to $85/ton tax credit will increase interest and help make more commercial project investments available. Because the cement industry struggles to electrify, supporting technologies that still use hydrocarbon fuels but reduce or capture all emissions may be necessary.

C4.5 DOE should help the U.S. cement industry accelerate decarbonization by consistently providing federal funding for pilot-scale and commercial scale demonstrations, then flexible financing to take those technologies to market.

Category 5: Significant Decarbonization Opportunities in Other Manufacturing Industries

C5.1 Fuel switching to biomass can offer a significant near-term decarbonization opportunity in manufacturing industries such as pulp and paper.

Additionally, within the wood products manufacturing sector, there are several technologies available, including new industrial air pollution control technologies, that could have a significant positive impact on multiple manufacturing processes. ICAC supports DOE investments in decarbonization strategies that improve energy efficiency and reduce or eliminate the use of fossil fuels through mitigation technologies. As the World Resources Institute notes, "the need to reduce greenhouse gas (GHG) emissions — such as through investing in energy efficiency, deploying solar panels, and reducing deforestation, among others — is critical... and efforts to reduce GHG emissions should always take priority".[1]

Category 6: Crosscutting Industrial Decarbonization Opportunities

Process heating is needed in a variety of industries and for different reasons, such as controlling chemical processes, drying, heating lines and tanks, and more. Most process heat is generated using steam generators (boilers) that are fired with fossil fuels like oil and natural gas. Replacing this status quo with low-carbon process heating alternatives presents an opportunity to reduce emissions of criteria pollutants and greenhouse gases that cuts across many industries.

Broadly, options for emissions reductions include increasing the efficiency of combustion and heating (thereby requiring less fuel per pound of steam produced), using electrical heat instead of steam (assuming electricity generated from renewable sources), or using an alternative fuel for steam boilers, such as low-CI hydrogen. Carbon capture and decarbonized hydrogen production have most potential to accomplish industrial decarbonization. Both technologies will require further research and development to create more economical solutions that are commercially viable – including technologies that have impacts to overall lifecycle path of a carbon or hydrogen molecule.

Steam produced for process heating can be replaced by electric heat, but deployment has been slow. This is cause primarily by cost constraints, rather than any technical issues. Steam typically has lower operating costs than electric heat, depending on the geographic location of the plant and the local cost of electricity. If the plant is located in an area where hydroelectric energy is abundant, the cost of electricity and the associated greenhouse gas emissions are lower. Maintenance costs should also be considered. Electric heaters typically have much lower maintenance costs than steam heaters. A significant amount of money must be allocated to steam system maintenance for a variety of reasons. Boilers alone require significant maintenance. Replacing steam heating with electric heating requires many changes in process equipment (higher capital cost) and possibly higher operating cost, depending on the relative costs of fossil fuels and electricity.

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[1] "Direct Air Capture". World Resources Institute. https://www.wri.org/insights/direct-air-capture-resource-considerations-and-costs-carbon-removal

A possible alternative is to use hydrogen to generate steam for process heating. If low-CI hydrogen is used, the greenhouse gas emissions from process heating can be greatly reduced. However, changing the boiler fuel from natural gas (or oil) to hydrogen is not a trivial operation. Furthermore, the industrial process that required on-site generation of steam would need to have a supply of hydrogen to the plant. Designing and testing hydrogen-fired steam generators are required.

DOE can help support these efforts in several ways. EERE's AMO has emphasized increasing the efficiency of steam production by conventional boilers. This area should continue to receive funding, but other key technologies need support. Innovative methods for electric process heating should be considered, such as methods that reduce the cost of operation while also maintaining process compatibility.

A more fruitful avenue for RD&D is the use of hydrogen or methane/hydrogen blends to generate process steam in boilers. The combustion process is well understood, but changing fuels requires design changes in fuel delivery systems, burners, heat transfer surfaces, etc. Pilot and small-scale demonstration work is required.

Additionally, the amount of funding required to move a technology is fixed, however, the timing for its expenditure can be adjusted. For example, flow batteries have been a victim of lack of adequate research and development investment over the past 10 years.

Conclusion

While there are too many critical technologies available that can enable industrial decarbonization to describe in this RFI, ICAC member companies would welcome additional opportunities to discuss the technologies ready for scale with the Advanced Manufacturing Office and others at DOE. Thank you again for the opportunity to provide initial input and we look forward to continued conversations.