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Comment on “Request for Information on the Department of Energy’s Use of Demand-Side Support for Clean Energy Technologies”

Alan Krupnick, Aaron Bergman, Yuqi Zhu, and Lucie Bioret

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US Department of Energy
1000 Independence Avenue SW
Washington, DC 20585
Attn: DE-FOA-0002995
Submitted via: **keith.boyea@hq.doe.gov**

Dear Director Boyea,

On behalf of the Industry and Fuels Program at Resources for the Future (RFF), I am pleased to share the accompanying comments to the US Department of Energy's (DOE) Office of Clean Energy Demonstrations in response to its Request for Information on the DOE's Use of Demand-Side Support for Clean Energy Technologies.

RFF is an independent, nonprofit research institution in Washington, DC. Its mission is to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement. RFF is committed to being the most widely trusted source of research insights and policy solutions leading to a healthy environment and a thriving economy.

While RFF researchers are encouraged to offer their expertise to inform policy decisions, the views expressed here are those of the individual authors and may differ from those of other RFF experts, its officers, or its directors. RFF does not take positions on specific policy proposals.

Based on research undertaken at RFF, including a new publication titled **"Demand-Pull Tools for Innovation in the Cement and Iron and Steel Sectors"**, we offer comments on questions in the following section of the RFI: Most Effective Demand-Side Support Measure for Given Technologies.

The authors of these comments are Alan Krupnick, Senior Fellow and Director, Industry and Fuels Program; Aaron Bergman, Fellow; Yuqi Zhu, Senior Research Associate; and Lucie Bioret, Research Analyst.

For future reference, all of RFF's work related to industrial decarbonization can be found at **https://www.rff.org/topics/industry-and-fuels/**. If you have any questions or would like additional information, please contact me at **krupnick@rff.org**.

Sincerely,

Alan J. Krupnick
Senior Fellow and Director, Industry and Fuels Program

Comment on “Request for Information on the Department of Energy’s Use of Demand-Side Support for Clean Energy Technologies”

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Resources for the Future

Category A, Question 1: What are the potential benefits and drawbacks of DOE implementing demand-side support measures in a given industry (e.g., carbon dioxide removal, hydrogen, low-carbon cement and concrete, low-carbon steel, sustainable aviation fuels)?

Steel

The main technologies used to decarbonize steel production today are hydrogen and electrolysis. These technologies have high Technology Readiness Levels (TRLs) and could be used to decarbonize a significant portion of the industry’s current capacity.[1] Demonstration stage projects for hydrogen include the HYBRIT project, a Swedish joint venture producing fossil fuel-free steel with hydrogen direct reduction of iron to replace the traditional coal-based technology. Electrolysis-type technologies are still in the pilot stage. Our research indicates that grants and subsidized loan funding are effective support mechanisms for demonstration and pilot-level projects to decarbonize steel.

Green federal procurements are another example of a demand-pull mechanism that could be relevant for steel. The **Federal Buy Clean Initiative** seeks to provide a valuable source of demand and revenue for low-carbon steel producers.

Advanced market commitments (AMCs) are another type of demand-side measure used to support projects with new and yet undemonstrated technologies. However, our research indicates that AMCs may not be an effective mechanism for steel plants given their costs. A hydrogen based DRI-EAF process is likely cheaper than a fully integrated BF-BOF steel mill, but the overall capital costs are expected to exceed $1 billion.[2] It is not clear whether AMCs can operate on the scale necessary to significantly impact deployment of this newer production technology.

The use of AMCs would require the public and or private sector to commit funding to purchase low- to zero-carbon steel before the technology has been deployed. US steel consumption is currently on the order of 7–9 million metric tons per month. An annual AMC representing less than 1 percent of US consumption (or one million metric tons[3]) would be sufficient to purchase the output of a ‘mini-mill’, which may produce only a few

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[1] J. Bartlett and A. Krupnick, *Decarbonizing Hydrogen in the US Power and Industrial Sectors: Identifying and Incentivizing Opportunities for Lower Emissions*, Resources for the Future (2020), **https://www.rff.org/publications/reports/decarbonizing-hydrogen-us-power-and-industrial-sectors/**.
[2] F. Pratty, “H2 Green Steel Secures Support for €3.5bn Debt Financing to Build Its Hydrogen-Powered Plant,” *Sifted* (2022), **https://sifted.eu/articles/h2-green-steel-e3-5bndebt/**.
[3] U.S. Geological Survey, “Mineral Commodity Summaries: Iron and Steel” (2023) **https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-iron-steel.pdf**

hundred thousand metric tons per year. Integrated steel mills, on the other hand, can produce upward of 2 million metric tons per year, which corresponds to about 2 percent of current US steel consumption. The use of AMCs would be challenging for incentivizing these larger projects due to their size.

Cement

Low- to zero-carbon cement is still in the research and development (R&D) stage and as such possesses a number of characteristics that make the use of inducement prizes beneficial. Prizes can be used to drive innovation when low TRLs, a high degree of uniformity, and emissions reporting systems exist. This is most often the case in the R&D stage. Specifying a prize for green cement will require that a detailed set of material standards for green cement be established. Standards ensure uniformity in a product, which is key for substitution. The standards will also need to specify the acceptable levels or amount of carbon used in the creation of the cement.

Achievement of net-zero carbon emissions by 2050 would require the standard for carbon emissions to be set at a high percentage reduction from current carbon intensities. The standards would also need to specify whether all embodied emissions in the concrete sector should be counted or only those from process emissions that are fundamental to the chemistry of cement. Placing focus on these process emissions is an effective way to drive down emissions that cannot be abated in any other way, such as by fuel switching. Further, because some alternate cements can absorb carbon dioxide as they cure, it is possible to create a situation where the curing process generates negative emissions. A full carbon accounting of the green cement process would include such negative emissions.

For these alternatives to effectively function as a cement substitute, the technology must be deployable at scale[4]. This means that any feedstock into the green cement production process must be relatively inexpensive and available in multiple geographies in large quantities. Similarly, the price differential in relation to traditional cement, perhaps expressed in terms of an implicit carbon price, must be comparable.

AMCs and federal procurement mechanisms will be applicable to low- to zero-carbon cement technologies as they progress beyond pilot scale to a stage where they begin to drive deployment in the building material market. Moreover, the Federal Buy Clean Initiative already includes cement with carbon intensity lower than ordinary Portland cement, which will facilitate the creation or extension of programs for low- to zero-carbon cements in the near term.

Carbon Capture and Process Heat

Carbon capture, utilization, and storage (CCUS) and zero-carbon process heat are technologies that can be deployed across a wide array of sectors and are also applicable to steelmaking and cement manufacture. However, because neither of these technologies are themselves products that are purchased, it is not immediately clear whether a demand-pull policy is necessary.

It is possible to use prizes or AMCs for products produced using CCUS or zero-carbon process heat technologies, but it would likely be more efficient to instead set a standard for the carbon content of the final product. Under such a scenario, the setter is focused on achieving the standard and is agnostic with respect to how the manufacturing process achieves the standard. One exception to this may be milestone payments,

[4] J. Lehne and F. Preston, "Making Concrete Change: Innovation in Low-Carbon Cement and Concrete," Chatham House (2018), **https://www.chathamhouse.org/2018/06/making-concrete-change-innovation-low-carbon-cement-and-concrete**.

which, because they can apply at lower TRLs, could be used for funding more nascent carbon capture and process heat technologies.

There are two specific technologies, both applicable to cement, that could benefit from demand-pull policies such as AMCs, green procurement, or milestone payments. The first is the use of chemical looping, a form of carbon capture that involves limestone, a major ingredient in cement manufacture. Given this synergy, policies that target this technology could have substantial benefits for decarbonizing cement. Cement production also requires high temperature process heat that has traditionally not been able to be supplied by electricity. Demand-pull policies for process heat applicable to cement could lead to the elimination of the combustion emissions from its manufacture, leaving only a pure process emissions stream that is easier to capture.

Category A, Question 2: What would be the most effective demand-side support measure DOE could use to support commercial scale-up of a given technology (e.g., reverse auctions, advanced market commitments, contracts-for-difference, direct procurement, pooled offtake vehicles)?

Demand-side policies have strengths and tradeoffs as they pertain to the technology being developed, meaning that there is not a one-size-fits-all measure to support commercial scale-up. Each of the industries mentioned in Category A.1 could benefit from a different suite of demand-pull policies based on several factors, including technology readiness, emissions reporting, product type, and the relative scale of the end goal. For Category A.2.C, we provide a summary of potential demand-pull policies that may be applicable to commercial scale-up of clean energy technologies.

a) What are the most important considerations for DOE in exploring advanced market commitments in particular? AMCs are not a substitute for broad market development, as winning companies are picked with varying degrees of a market test, and an AMC recipient can fail to deliver. The relative cost of AMCs may vary by sector. For example, the success of AMCs in the pharmaceutical sector may not translate to greenhouse gas abatement for decarbonization technologies in the industrial sector. Capital costs are significantly higher in steel and cement, whereas new pharmaceutical products have large market potential.

Optimal AMC design also depends on the technological distance (as defined by the TRL scale) of the desired innovation. Closer targets may appear more feasible, but distant targets could be more efficient in achieving the desired outcome. AMCs must also be appropriately sized to have an impact on decision making. An AMC of a few million dollars would not generate a significant change in behavior if the total capital investment in a new plant is a large sum commensurate with those often found in the industrial sector.

b) What are the most important considerations for DOE in exploring guaranteed offtake prices or contracts-for-difference in particular? Two important considerations when designing a contract for differences (CfDs) are the determination of the volume of funding and the setting of the appropriate strike price. For CfDs to provide a meaningful market impact, significant funding in sufficient quantities to the target industries are required. Additionally, setting the appropriate strike price can be a challenge. An effective strike price considers the existing products in the market as well as the price trends of the targeted technology. These elements are difficult to model accurately for such an analysis.

A number of variations on CfDs have arisen in recent years. In one variant discussed by Bollerhey et al. (2022), an entity is created that procures a clean commodity such as hydrogen via long-term contracts.[5] The entity then sells the commodity to off-takers on a short-term basis through a competitive bidding process. The

[5] T. Bollerhey, M. Exenberger, F. Geyer, and K. Westphal, *H2GLOBAL – Idea, Instrument and Intentions*, H2GLOBAL Stiftung (2022), **http://files.h2-global.de/H2Global-Stiftung-Policy-Brief-01_2022-EN.pdf**

government entity covers any losses due to price differences in the contracts. In this way, the government entity provides both price and duration certainty to the producers, reducing their risk. The competitive nature of procurement and sales should, to some extent, reduce the risk to the government to cover the entity's losses and bridge the gap in prices between the supply and demand sides over time.

c) What are the most important considerations for DOE in exploring other demand-side support measures? Demand-side support measures carry the risk of potential technology lock-ins, which may prevent or delay significant future innovations. This lock-in risk applies to standards that are already preventing the deployment or commercialization of some technologies. Low-carbon cement is one example. Attention may also be given to federal procurements which often incorporate standards to select 'winners.'

Issues may also arise with federal clean procurement. Proper guidance and training for personnel in charge of procurement, at DOE and other relevant agencies, on how to balance costs and traditional attributes of a desirable product against low- to zero-carbon intensity requirements can ensure that emissions reductions goals are considered alongside other technology deployment goals. Prizes are well suited for early-stage R&D, and staging can help extend the pool of participants while still selecting the innovators most likely to achieve prize goals.

The table below provides a summary of demand side policy options relative to their TRL. One important aspect not reflected in the table is that the size of the monetary reward must be comparable to the scale of the goal. This is particularly important for demonstration projects in the energy sector, where costs for an individual project can exceed a billion dollars. RFF's March 2023 publication **"Demand-Pull Tools for Innovation in the Cement and Iron and Steel Sectors"** contains more details.

Table 1. Summary of Report Results

Policy	Policy type	Inducement mechanism	Technology readiness level	Distinct Innovation Role
Inducement prizes	Demand-pull with push elements	Sets up competition to meet well-specified objectives by offering reward	3-6	Funding early-stage R&D with well-defined targets and many competitors
Public procurement	Demand-pull	Government demand for products with low-embodied carbon, which can then shape the market	8-9	Creates market-driven incentives for commercial-ready innovations
Advance market commitments	Demand-pull	Demand guarantee at a given price and performance level	7-9	Can be forward looking Can be implemented by private actors Contracts with chosen producers, ex post reward Reduces purchaser risk
Milestone payments	Supply-push with pull elements	Funding where increments are conditional on	2-9	Complementary policy with other innovation tools

		reaching pre-defined goals		De-risks (particularly large) projects
Technology standards	Demand-pull	Standardization of performance of new technologies Reduces transactions costs	6-9	Often a necessary condition for other tools, such as prizes and public procurement Provides information of performance
Contracts for difference	Demand-pull	Government sets a strike price and covers any losses due to price difference	7-9	Provide price and duration certainty to producers

References

Bartlett, J. and A. Krupnick. 2020. "Decarbonizing hydrogen in the US Power and Industrial Sectors: Identifying and Incentivizing Opportunities for Lower Emissions," Resources for the Future, **https://www.rff.org/publications/reports/decarbonizing-hydrogen-us-power-and-industrial-sectors/**.

Bollerhey, T., M. Exenberger, F. Geyer, and K. Westphal. 2022. *H2GLOBAL – Idea, Instrument and Intentions*. H2GLOBAL Stiftung. **http://files.h2-global.de/H2Global-Stiftung-Policy-Brief-01_2022-EN.pdf**.

Lehne, J., and F. Preston. 2018. "Making Concrete Change: Innovation in Low-Carbon Cement and Concrete." Chatham House. **https://www.chathamhouse.org/2018/06/making-concrete-change-innovation-low-carbon-cement-and-concrete.**

Pratty, F. 2022. "H2 Green Steel Secures Support for €3.5bn Debt Financing to Build Its Hydrogen-Powered Plant." *Sifted*. **https://sifted.eu/articles/h2-green-steel-e3-5bndebt/**.

US Geological Survey. 2023. "Mineral Commodity Summaries: Iron and Steel." **https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-iron-steel.pdf**.