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An Earthshot for Clean Steel and Aluminum

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Summary

The scale of mobilization and technological advancement required to avoid the worst effects of climate change has recently led U.S. politicians to invoke the need for a new, 21st century “moonshot.” The Obama Administration launched the SunShot Initiative to dramatically reduce the cost of solar energy and, more recently, the Department of Energy (DOE) announced a [series of “Earthshots”](#) to drive down the cost of emerging climate solutions, such as long-duration energy storage.

While DOE’s Earthshots to date have been technology-specific and sector-agnostic, certain heavy industrial processes, such as steel and concrete, are so emissions-intensive and fundamental to modern economies as to demand an Earthshot unto themselves. These products are ubiquitous in modern life, and will be subject to increasing demand as we seek to deploy the clean energy infrastructure necessary to meet climate goals. In other words, there is no reasonable pathway to preserving a livable planet without developing clean steel and concrete production at mass scale. Yet the sociotechnical pathways to green industry – including the mix of technological solutions to replace high-temperature heat and process emissions, approaches to address local air pollutants, and economic development strategies – remain complex and untested. We urgently need to orient our climate innovation programs to the task.

Therefore, this memo proposes that DOE launch a **Steel Shot to drive zero-emissions iron, steel, and aluminum production to cost-parity with traditional production within a decade**. In other words, zero dollar difference for zero-emissions steel in ten years, or **Zero for Zero in Ten**.

Challenge and Opportunity

As part of the Biden-Harris Administration’s historic effort to [quadruple federal funding](#) for clean energy innovation, DOE has launched a [series of “Earthshots”](#) to dramatically slash the cost of emerging technologies and galvanize entrepreneurs and industry to hone in on ambitious but achievable goals. DOE has announced Earthshots for carbon dioxide removal, long-duration storage, and clean hydrogen. New programs authorized by the Infrastructure Investment and Jobs Act, such as hydrogen demonstration hubs, provide tools to help DOE to meet the ambitious cost and performance targets set in the Earthshots. The Earthshot technologies have promising applications for achieving net-zero emissions economy-wide, including in sectors that are challenging to decarbonize through clean electricity alone.

One such sector is heavy industry, a notoriously [challenging and emissions-intensive sector](#) that, despite contributing to nearly one-third of U.S. emissions, has received relatively little focus from federal policymakers. Within the industrial sector, production of iron and steel, concrete, and chemicals are the [biggest sources of CO2 emissions](#), producing climate pollution not only from their heavy energy demands, but also from their inherent processes (e.g., clinker production for cement).

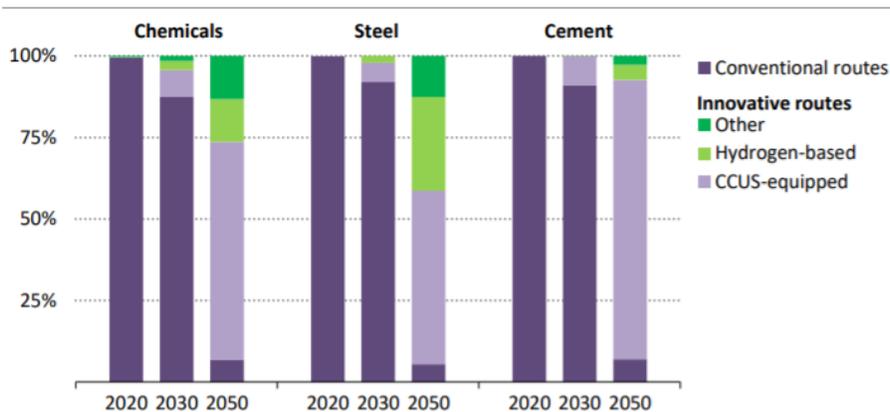
Meanwhile, global demand for cleaner versions of these products – the basic building blocks of modern society – is on the rise. [The International Energy Agency \(IEA\) estimates](#) that CO2 emissions from iron and steel production alone will need to fall from 2.4 Gt to 0.2 Gt over the next three decades to meet a net-zero emissions target economy-wide, even as overall steel consumption *increases* to meet our needs for clean energy buildout. Accordingly, by 2050, global investment in clean energy and sustainable infrastructure materials will grow to \$5 trillion per year. The United States is well-positioned to seize these economic opportunities, particularly in the metals industry, given its long history of metals production, skilled workforce, the initiation of talks to reach [a carbon emissions-based steel and aluminum trade agreement](#), and strong labor and political coalitions in favor of restoring U.S. manufacturing leadership.

“The metals industry is foundational to economic prosperity, energy infrastructure, and national security. It has a presence in all 50 states and directly employs more than a half million people. The metals industry also contributes 10% of national climate emissions.”

Department of Energy [request for information](#) on a new Clean Energy Manufacturing Institute, 2021

However, the exact solutions that will be deployed to decarbonize heavy industry remain to be seen. According to the aforementioned IEA Net-Zero Energy (NZE) scenario, steel decarbonization could require a mix of carbon capture, hydrogen-based, and other innovative approaches, as well as material efficiency gains. It is likely that electrification – and in the case of steel, increased global use of electric arc furnaces – will also play a significant role. While technology research funding should be increased, traditional “technology-push” efforts alone are unlikely to spur rapid and widespread adoption of a diverse array of solutions, particularly at low-margin, capital-intensive manufacturing facilities. This points to the potential for creative technology-neutral policies, such as [clean procurement programs](#), which create early markets for low-emissions production practices without prescribing a particular technological pathway.

Figure 3.19 ▶ Global industrial production of bulk materials by production route in the NZE



Source: IEA

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Therefore, as a complement to its Earthshots that “push” promising clean energy technologies down the cost curve, DOE should also consider adopting technology-neutral Earthshots for the industrial sector, even if some of the same solutions may be found in other Earthshots (e.g., hydrogen). It is important for DOE to be very disciplined in identifying one or two essential sectors, where the opportunity is large and strategic, to avoid creating overly balkanized sectoral strategies. **In particular, DOE should start with the launch of a Steel Shot to buy down the cost of zero-emissions iron, steel, and aluminum production to parity with traditional production within a decade, while increasing overall production in the sector.** In other words, zero dollar difference for zero-emissions steel in ten years, or **Zero for Zero in Ten.**

The Steel Shot can bring together applied research and demonstration programs, public-private partnerships, prizes, and government procurement, galvanizing public energy around a target that enables a wide variety of approaches to compete. These efforts will be synergistic with technology-specific Earthshots seeking dramatic cost declines on a similar timeline.

Plan of Action

Develop and launch a metals-focused Earthshot:

- **Design and announce the Steel Shot in close partnership with industry, labor, and communities.** DOE should hold a series of roundtables with industry, labor, and communities to define and calculate the gap between zero-emissions and traditional production, often called the “green premium,” for clean steel and aluminum. This should incorporate measures to achieve near-zero carbon dioxide emissions as well as deep reductions in other harmful air and water pollutants to achieve a “Zero for Zero in Ten” goal – zero dollar difference for zero emissions steel within one decade. DOE should launch the Steel Shot with pledges from major steelmakers and steel purchasers, such as automakers.
- **Calculate targets along the way to the decadal goal and define how success will be measured.** After launching the new Earthshot, DOE should release a Request for Information (RFI) and use an initial Steel Shot Summit to compile projections for anticipated cost parity milestones along the way to the decadal target. DOE should plan to update assessments of the current “green premium” on a regular basis to ensure that research, development, and demonstration efforts are targeted at continued reductions in the cost of clean steel – not just improvements over the original baseline. To assess the emissions footprint of various steel production processes, DOE should work closely with the White House’s [Buy Clean Task Force](#), which was tasked with developing recommendations for improving transparency and reporting around embodied emissions, particularly through environmental product declarations.
- **Hold an annual Steel Shot Summit to bring together technologists, industry, and financiers to share solutions and develop projects.** DOE should hold an

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annual Steel Shot event to help to highlight existing innovation efforts underway and connect stakeholders. This summit will build on existing Eartshot stakeholder gathering efforts underway, such as the [Hydrogen Shot Summit](#) and the [Long Duration Storage Shot Summit](#).

Invest in domestic clean steelmaking capacity:

- **Stand up the seventh Clean Energy Manufacturing Institute with funding for cooperative applied R&D and a demonstration facility.** Last year, AMO put out a [Request for Information](#) on the establishment of a seventh Manufacturing USA institute on industrial decarbonization. The RFI had a particular focus on metals manufacturing. In 2022, DOE should formally issue a funding opportunity for the institute, with a requirement that the institute conduct cooperative R&D in industrial decarbonization practices and operate a manufacturing demonstration and workforce development facility for low- and zero-emissions manufacturing processes.
- **Launch an annual competition for entrepreneurs and companies demonstrating low- and zero-emissions processes that reduce the green premium.** Modeled after the SunShot’s American Made Solar Prize, AMO could issue a series of smaller-scale prize competitions targeted at challenges for clean metals. Prizes are particularly effective for challenges where [the desired end target is defined and clearly measurable](#), but the optimal solution to achieve this target is not yet known. The variety of [potential solutions](#) for steel decarbonization makes the sector an excellent candidate for a prize program with multiple rounds and awardees. DOE could consider subprograms within the Steel Shot prize that align with reducing key sources of emissions – EPA identifies the [three sources of emissions](#) as 1) process emissions, 2) direct fuel combustion, and 3) indirect emissions from electricity consumption.
- **Pass legislation to directly invest in deployment of commercial-scale solutions.** While a prize program can promote prototype and pilot-stage technologies, real-world demonstration and deployment will buy down the cost of clean steel. These investments should pursue a range of decarbonization opportunities across blast-oxygen furnaces, electric arc furnaces, and emerging direct reduction approaches. They should also ensure that federal funds go to projects with strong labor standards, building on a long legacy of quality U.S. steelmaking jobs. The original [American Jobs Plan](#) released by President Biden proposed ten “pioneer facilities” to demonstrate clean industrial processes, including steel. Several proposals included in House-passed bills, such as the [Build Back Better Act](#) and the [America COMPETES Act](#), would provide new authorities to DOE to fund commercial-scale retrofits and first-of-a-kind facilities employing clean steelmaking technologies. For instance, an [amendment](#) to America COMPETES expands the industrial decarbonization RD&D program authorized in the Energy Act of 2020 to include “commercial deployment projects.” Should these provisions pass, they can be leveraged to rapidly retrofit facilities and achieve the goals of the Steel Shot.

Create demand for “green steel” through market pull mechanisms:

- **Match innovators and steelmakers with private purchasers to generate demand for clean metals.** Demand-pull incentives can reduce risk for U.S. steelmakers and move the innovations that emerge from DOE R&D and prize programs into commercial adoption, which is critical for additional “learning-by-doing” at scale. DOE can work with domestic industries that are major purchasers of steel to develop sector-based advanced market commitments as part of the Earthshot launch. For instance, DOE should leverage its relationships with major automakers with ambitious climate goals, such as Ford and GM, to spur auto sector commitments to purchasing clean steel. In developing these advanced market commitments, DOE can work with the [First Movers Coalition](#), a consortium of private sector buyers of innovative, clean products, launched by the State Department and the World Economic Forum in Glasgow in 2021. They included both steel and aluminum in their initial round of target products.
- **Use federal procurement power to favor “green steel” for government-funded projects, including infrastructure and defense.** AMO and DOE’s Federal Energy Management Program should advise the General Services Administration, Department of Defense, Department of Transportation, and other major federal procurers as they execute federal sustainability plans and procurement working groups, including the Buy Clean Task Force [announced in December 2021](#). For instance, DOE can utilize the Earthshot to provide recommendations on reasonable costs for steel included in a Buy Clean program, and provide technical assistance to innovators to access federal clean procurement efforts.

Frequently Asked Questions

1. Is a sector-focused Energy Earthshot really necessary?

The lower technology prices targeted by the Hydrogen Earthshot and the Carbon Negative Shot are necessary but not sufficient to guarantee that these technologies are deployed in the highest emissions producing sectors, such as steel, cement, and chemicals. The right combination of approaches to achieve price reduction remains uncertain and can vary by plant, location, process, product, as noted in a [recent McKinsey study](#) on decarbonization challenges across the industrial sector. Additionally, there is a high upfront cost to deploying novel solutions, and private financiers are reluctant to take a risk on untested technologies. Nonetheless, to avoid creating overly balkanized sectoral strategies, it will be important for DOE to be very disciplined in identifying one or two essential sectors, such as metals, where the opportunity is large and strategic.

2. Why are metals the best opportunity for a sector-focused Earthshot?

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These products are ubiquitous and increasingly crucial for deploying the clean energy infrastructure necessary to reach net-zero. The United States of America has a long history of metals production, a skilled workforce, and strong labor and political coalitions in favor of restoring U.S. manufacturing leadership. Additionally, carbon-intensive steel from China has become a growing concern for U.S. manufacturers and policymakers; China [produces](#) 56% of global crude steel, followed by India (6%), Japan (5%), and then the U.S. (4%). The U.S. already maintains a strong competitive advantage in clean steel, and the technologies needed to double-down and fully decarbonize steel are close to commercialization, but still require government support to achieve cost parity.

3. Will this Earthshot reduce U.S. metals manufacturing competitiveness?

U.S. steel production is already less polluting than many foreign sources, but that typically comes with [additional costs](#). Reducing the “green premium” will help to keep US metal producers competitive, while preparing them for the needs of buyers, who are increasingly seeking out green steel products. End users such as [Volkswagen](#) are aiming for zero emissions across their entire value chain by 2050, while Mercedes-Benz and Volvo have already begun [sourcing low-emissions steel](#) for new autos. Meanwhile, the EU is preparing to implement a [carbon border adjustment mechanism](#) that could result in higher prices for steel and aluminum-produced products from the United States. The ramifications of the carbon border tax are already being seen in steel agreements, such as the recent [US-EU announcement](#) to drop punitive tariffs on each other’s steel and aluminum exports and to begin talks on a carbon-based trade agreement.

4. What is the right baseline to use for calculating the “green premium” of metals?

[Breakthrough Energy](#) estimated that the “green premium” for steel using carbon capture is approximately 16% - 29% higher than “normally” produced steel. Because there are a variety of processes that could be used to reduce emissions, and thus contribute to the “green premium,” there may not be a single number that can be estimated for the current costs. However, wherever possible, we advocate for using real-world data of “green” produced steel to estimate how close DOE is to achieving its benchmark targets in comparison to “traditional” steel.

About the Authors



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About the Day One Project



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