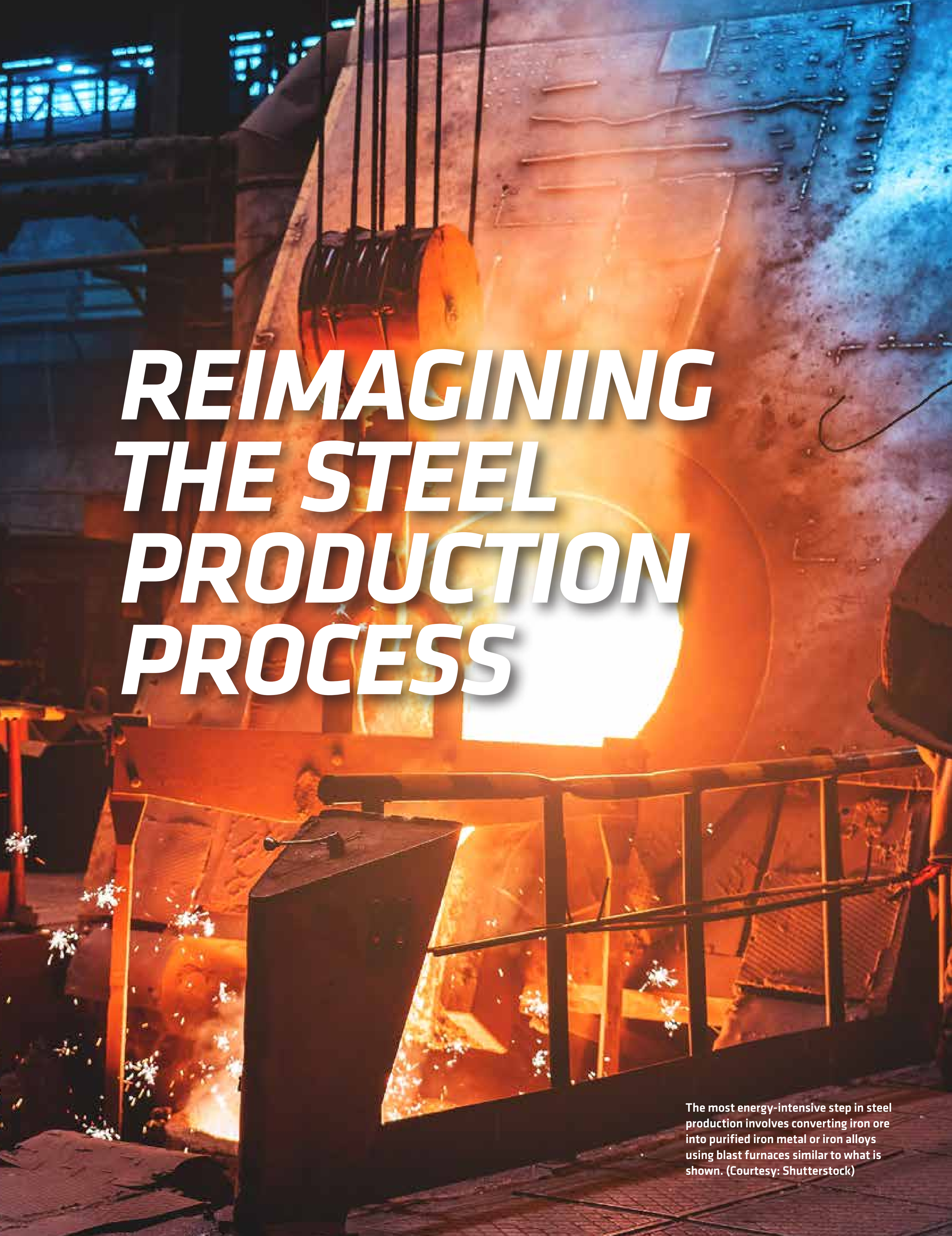
REIMAGINING THE STEEL PRODUCTION PROCESS



The most energy-intensive step in steel production involves converting iron ore into purified iron metal or iron alloys using blast furnaces similar to what is shown. (Courtesy: Shutterstock)

The Department of Energy funds new center that will develop a cost-effective method for decarbonized manufacturing for steelmaking without a blast furnace.

By JOSEPH E. HARMON

Steel has a major impact on everyone's lives and our economy. It is crucial to cars, trucks, airplanes, buildings, and more. However, there is a significant issue with its production process. Globally, it accounts for a large percentage of greenhouse gas emissions from the industrial sector.

The U.S. Department of Energy (DOE) recently announced $19 million in funding more than four years for DOE's Argonne National Laboratory to lead the multi-institutional Center for Steel Electrification by Electrosynthesis (C-STEEL). The center's charge is to develop an innovative and low-cost process that would replace blast furnaces in steelmaking and reduce greenhouse gas emissions by 85 percent.

"It's a big target that has a high reward if successful," said Brian Ingram, the C-STEEL director and an Argonne group leader and materials scientist.

CUTTING EMISSIONS

C-STEEL is a key project of the DOE's Industrial Heat Energy Earthshot initiative, which aims to significantly cut emissions from the energy-intensive process of industrial heating. Partners in the center include Oak Ridge National Laboratory, Case Western Reserve University, Northern Illinois University, Purdue University Northwest and the University of Illinois Chicago.

The most energy-intensive step in steel production involves converting iron ore into purified iron metal or iron alloys using blast furnaces. This demands temperatures of 2,500 to 2,700 degrees Fahrenheit, hotter than an erupting volcano. The center's target is to develop a process that will essentially eliminate that heat demand, achieving an 85 percent reduction in greenhouse gas emissions by 2035.

C-STEEL is a key project of the DOE's Industrial Heat Energy Earthshot initiative, which aims to significantly cut emissions from the energy-intensive process of industrial heating. (Courtesy: Argonne National Laboratory)

"While current steelmaking requires intense heat from blast furnaces, our electrodeposition process will need low or even no heat input at all," Ingram said. "It will also be cost efficient and adaptable to industrial-scale operations."

The electrodeposition process involves dissolving iron ore in a solution and using electricity to initiate a reaction that deposits a useable iron metal or alloy for steelmaking. The solution is a liquid electrolyte similar to those found in batteries.

"We will be building upon the immense knowledge base we gained about different battery electrolytes from the work done by the Joint Center for Energy Storage Research, led by Argonne," Ingram said.

THREE-PART PROJECT

The project has three thrusts. Two of them will investigate different processes for electrodeposition. One process will operate at room temperature using water-based electrolytes. The other will use a salt-based electrolyte and will function at temperatures 1,800 to 2,000 degrees Fahrenheit below current blast furnaces. The energy for this process is low enough that it could be provided by renewables or waste heat from a nuclear reactor.

A third thrust will focus on gaining an atomic-level understanding of each process. The goal of this thrust is to exert precise control over both the structure and composition of the metal products so they can be incorporated into existing downstream processes of steelmaking.

Each thrust will incorporate an artificial intelligence-based platform to ensure a unified approach to electrolyte design. To that end, C-STEEL will be drawing upon the world-class computational resources of two Leadership Computing Facilities, one at Argonne and the other at Oak Ridge. Both are DOE Office of Science user facilities.

PRACTICAL APPLICATIONS

C-STEEL will also take advantage of the materials characterization capabilities of two other DOE user facilities at Argonne, the Advanced Photon Source and the Center for Nanoscale Materials. The center focuses on basic energy research while aiming to ensure its findings will support eventual practical applications.

"Another key part of the center is that one of the partner universities is a minority-serving institution, the University of Illinois Chicago," Ingram said. "Through their participation and other actions, we will be forming a diverse team to contribute to our research efforts."

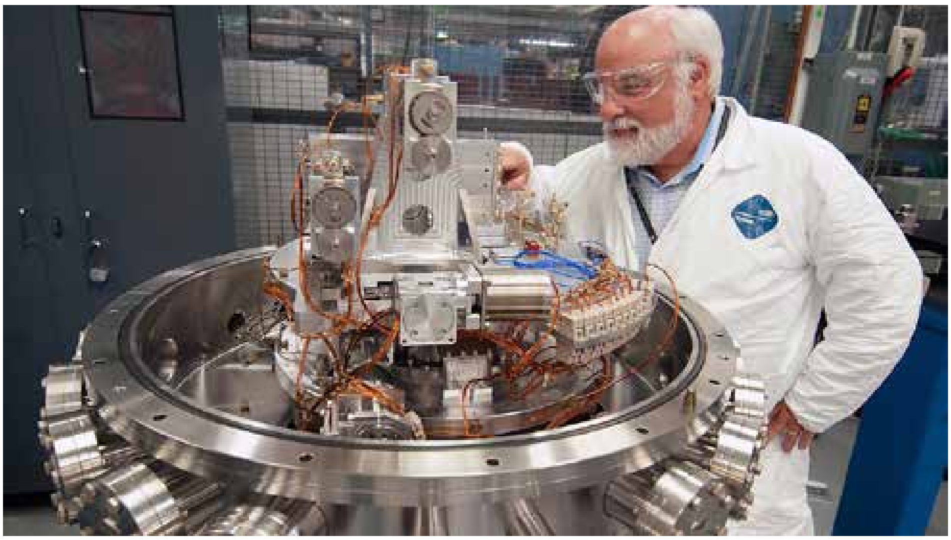
C-STEEL also plans to implement outreach initiatives, mentorship programs, and career development opportunities for students and postdocs to excite the next generation of scientists.

This research is being funded by the DOE's Office of Science, Basic Energy Sciences and Advanced Scientific Computing Research.

ABOUT ARGONNE'S CENTER FOR NANOSCALE MATERIALS

The Center for Nanoscale Materials is one of the five DOE Nanoscale Science Research Centers, premier national user facilities for interdisciplinary research at the nanoscale supported by the DOE Office of Science. Together the NSRCs comprise a suite of complementary facilities that provide researchers with state-of-the-art capabilities to fabricate, process, characterize, and model nanoscale materials, and constitute the largest infrastructure investment of the National Nanotechnology Initiative. The NSRCs are located at DOE's Argonne, Brookhaven, Lawrence Berkeley, Oak Ridge, Sandia, and Los Alamos National Laboratories. For more information about the DOE NSRCs, go to science.osti.gov/User-Facilities/User-Facilities-at-a-Glance.

The Argonne Leadership Computing Facility provides supercomputing capabilities to the scientific and engineering community to advance fundamental discovery and understanding in a broad range of disciplines. Supported by the U.S. Department of Energy's (DOE's) Office of Science, Advanced Scientific Computing Research (ASCR) program, the ALCF is one of two DOE Leadership Computing Facilities in the nation dedicated to open science.



The Advanced Photon Source (APS) at Argonne National Laboratory is one of the world's most productive X-ray light source facilities. The APS provides high-brightness X-ray beams to a diverse community of researchers in materials science, chemistry, condensed matter physics, the life and environmental sciences, and applied research. (Courtesy: Argonne National Laboratory)

Argonne National Laboratory seeks solutions to pressing national problems in science and technology. The nation's first national laboratory, Argonne conducts leading-edge basic and applied scientific research in virtually every scientific discipline.

ABOUT THE ADVANCED PHOTON SOURCE

The U. S. Department of Energy Office of Science's Advanced Photon Source (APS) at Argonne National Laboratory is one of the world's most productive X-ray light source facilities. The APS provides high-brightness X-ray beams to a diverse community of researchers in materials science, chemistry, condensed matter physics, the life and environmental sciences, and applied research. These X-rays are ideally suited for explorations of materials and biological structures; elemental distribution; chemical, magnetic, electronic states; and a wide range of technologically important engineering systems from batteries to fuel injector sprays, all of which are the foundations of our nation's economic, technological, and physical well-being. Each year, more than 5,000 researchers use the APS to produce more than 2,000 publications detailing impactful discoveries, and solve more vital biological protein structures than users of any other X-ray light source research facility. APS scientists and engineers innovate technology that is at the heart of advancing accelerator and light-source operations. This includes the insertion devices that produce extreme-brightness X-rays prized by researchers, lenses that focus the X-rays down to a few nanometers, instrumentation that maximizes the way the X-rays interact with samples being studied, and software that gathers and manages the massive quantity of data resulting from discovery research at the APS.

This research used resources of the Advanced Photon Source, a U.S. DOE Office of Science User Facility operated for the DOE Office of Science by Argonne National Laboratory under Contract No. DE-AC02-06CH11357.

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The U.S. Department of Energy's Office of Science is the single largest supporter of basic research in the physical sciences in the United States and is working to address some of the most pressing challenges of our time. For more information, go to energy.gov/science.

ABOUT THE AUTHOR

Joseph E. Harmon has been a science writer, editor, and manager for four decades in several divisions within Argonne National Laboratory. He is now working as a communications manager in support of Argonne's Physical Sciences and Engineering Directorate. This article is published courtesy of Argonne National Laboratory.