ITIF | INFORMATION TECHNOLOGY & INNOVATION FOUNDATION

BOSTON UNIVERSITY

Boston University Institute for Sustainable Energy

Fraunhofer USA

EXECUTIVE SUMMARY

Clean and Competitive: Opportunities for U.S. Manufacturing Leadership in the Global-Low Carbon Economy

PETER FOX-PENNER, DAVID M. HART, HENRY KELLY, RYAN C. MURPHY, KURT ROTH, ANDRE SHARON, AND COLIN CUNLIFF | JUNE 2021

OVERVIEW

The United States needs an integrated national strategy to address the twin challenges of bolstering its manufacturing sector and averting climate change. Timely federal research, development, and demonstration (RD&D) and deployment policies targeted to specific manufacturing industries could create competitive advantage for domestic producers, expanding investment and employment.

Manufacturing has been a key engine of job creation in the United States, helping workers without a college education join the middle class. A strong manufacturing base creates a more resilient and equitable economy, accelerates innovation, strengthens international competitiveness, and improves national security.

Climate change is a national and global challenge of immense proportions. Industrial emissions account for more than 30 percent of the U.S. and global totals. Sincere efforts around the world to fulfill national pledges to achieve net-zero emissions will drive a nearly complete retooling of global manufacturing.

Until very recently, these two challenges have been treated largely within their own policy silos at the federal level. This division is counterproductive for both manufacturing and climate policies, and it overlooks a crucial opportunity to create an integrated national strategy that leverages the United States' strength in science and technology.

However, to make the most of this opportunity, the federal government will have to act more strategically and forcefully than it has in the recent past, carefully targeting federal investment toward industries and technologies in which domestic producers are most likely to succeed against international competitors. Such an approach would complement economywide policies like carbon pricing, and it can be fully compatible as well with a rules-based global economy.

This report takes a first step toward creating such a strategy. Through a series of workshops and interviews with experts and stakeholders, we examined a broad swath of technologies around which the United States might find opportunities for domestic manufacturing with a high potential for economic growth and emissions reductions. The report focuses on four industries

that exemplify these opportunities, but which have not yet received adequate attention or support: hydrogen production; heating, cooling, and drying equipment; chemicals production and recycling; and protein alternatives to meat and dairy products. It explains why each industry matters, sets out potential pathways to net-zero emissions, examines the comparative position of U.S. manufacturers, assesses opportunities and gaps, and lists policy recommendations.

Hydrogen could displace emissions from industry, power, and transportation, but current production methods are very carbon-intensive. The United States has historically been a world leader in this industry, but it has begun to fall behind just as demand for clean hydrogen is ramping up dramatically. A federal policy agenda for clean hydrogen production should set ambitious cost reduction targets and prioritize RD&D projects aimed at realizing these targets. The federal government should also support deployment by encouraging public agencies to become early adopters of clean hydrogen and enacting policies that bridge the cost differential between dirty and clean hydrogen.

Heating, cooling, and dehumidifying buildings, and the provision of low-temperature heat to industrial processes for drying, separations, and other purposes, are responsible for significant emissions globally. These emissions are likely to grow rapidly unless new solutions are widely deployed. U.S. manufacturers are not yet well-positioned to capture the markets for these solutions, like improved heat pumps. Detailed national plans should focus on developing high-efficiency, low-cost, highly reliable systems for buildings and industry, built around ambitious, specific goals. Federal funding for RD&D should target key features of these systems, accompanied by more expansive standards and incentives.

The chemical industry is responsible for about 18 percent of global carbon dioxide emissions, and it employs nearly 10 percent of the domestic manufacturing workforce. Demand for plastics is growing particularly rapidly and will likely accelerate. The United States leads the world in the skills and know-how that are most relevant to transition this industry to a low-carbon trajectory, but the federal government does not have a cohesive strategy to drive such a transition. It should invest much more in RD&D for plastics recycling and bio-based chemical production as well as large-scale test facilities, and improve and extend procurement and labeling programs.

Proteins made by microbes in fermenters and animal cells cultivated in bioreactors could substitute for many meat and dairy products, which are responsible for 12 percent or more of global emissions. Biotechnology-based alternative proteins are not generally cost competitive with conventional products today, but innovation should bring this goal within reach in the near future. The United States is a global leader in this emerging industry, thanks in large part to substantial federal investments in biotechnology and plentiful venture capital investment. A robust federal policy, including support for applied R&D, testbeds, and innovative manufacturing methods, and regulatory and procurement reform, could secure that position.

The United States faces the twin issues of rebuilding a vibrant, inclusive economy that includes a strong manufacturing sector while simultaneously accelerating progress toward net-zero emissions. The federal government should respond to these challenges by adopting an integrated strategy that targets specific industries with a high potential for both emissions reduction and high-quality job growth. The United States will not be alone in seeking to develop such industries, but sophisticated strategies can secure and sustain competitive advantage in many.

Acknowledgments

The authors thank Robert Allen, Matthew Anderson, Marlene Arens, Jens Burchardt, Scot Bryson, Pinakin Chaubal, Daniel Cooper, Randy Cortright, Jonathan Cullen, Douglas Densmore, Tom Dower, Douglas Friedman, Matthias Jahn, Maria Juenger, Bartholome Kilian, John King, Herve Lavelaine de Maubeuge, Jeff Lievense, Karthish Manthiram, Mary Maxon, Davide Pico, Steffen Rupp, Jan Schlageter, Rainer Schweppe, Kate Simonen, Liz Specht, Bill Tumas, Gerd Unkelback, Mark Warner, and numerous other interview subjects and workshop participants for ideas and suggestions. Thanks as well to Rob Atkinson, Bill Bonvillian, Abigail Regitsky, Ed Rightor, Dorothy Robyn, Saloni Shah, and Alex Smith for comments on drafts. Research for this report was supported by grants from Breakthrough Energy and the Spitzer Trust.

About the Authors

Peter Fox-Penner is director of the Boston University Institute for Sustainable Energy, professor of practice at the Questrom School of Business, and a partner and chief strategy officer of Energy Impact Partners. He serves as an advisor to several public and private sector organizations. For more information and conflict-of-interest disclosure, see https://www.bu.edu/ise/profile/peter-fox-penner/.

David M. Hart is a senior fellow and director of the Clean Energy Innovation Policy Program at ITIF and professor of public policy at the Schar School of Policy and Government at George Mason University. He is co-author of *Energizing America* (2020).

Henry C. Kelly is a senior fellow at the Boston University Institute for Sustainable Energy. He has served in senior positions at DOE and the White House Office of Science and Technology Policy. He also served as president of the Federation of American Scientists and assistant director of the Solar Energy Research Institute (now NREL).

Ryan C. Murphy is a graduate research assistant at the Boston University Institute for Sustainable Energy and a master's student in mechanical engineering at Boston University.

Kurt Roth leads Energy Systems Applied R&D at Fraunhofer USA. He has led several multiyear DOE technology development and demonstration projects, presented at numerous conferences and meetings, and authored more than sixty *ASHRAE Journal* "Emerging Technology" articles.

Andre Sharon is a professor of mechanical engineering and executive director of the Fraunhofer USA Center for Manufacturing Innovation (CMI) at Boston University. He has over 30 years of experience developing and deploying new technologies from the laboratory to industry.

Colin Cunliff was a senior policy analyst at ITIF until May 2021, when he joined the Department of Energy's Office of Policy. He is co-author of *Energizing America* (2020) and lead author of ITIF's recent report *Energizing Innovation* (2021).

About ITIF

The Information Technology and Innovation Foundation (ITIF) is an independent, nonprofit, nonpartisan research and educational institute focusing on the intersection of technological innovation and public policy. Recognized by its peers in the think tank community as the global center of excellence for science and technology policy, ITIF's mission is to formulate and promote policy solutions that accelerate innovation and boost productivity to spur growth, opportunity, and progress. For more information, visit www.itif.org.

About BU ISE

The Boston University Institute for Sustainable Energy (ISE) translates sustainable energy research into urgent action. The ISE is a university-wide center dedicated to developing energy systems that will provide abundant, universally accessible, and sustainable energy sources for emerging and advanced economies. It combines interdisciplinary research, policy analysis, and collaborative engagement with partners at every level. For more details, visit bu.edu/ise.

About CMI

As part of Fraunhofer Gesellschaft, Europe's largest nonprofit R&D organization, CMI bridges the gap between academic research and industrial needs. In collaboration with Boston University, CMI conducts applied research and development leading to the deployment of technological solutions that enhance the productivity and competitive position of its customers, while educating engineering students in the process. Its objective is to help companies and universities translate academic research into marketable technologies in an efficient manner. For more information, please visit www.cmi.fraunhofer.org.