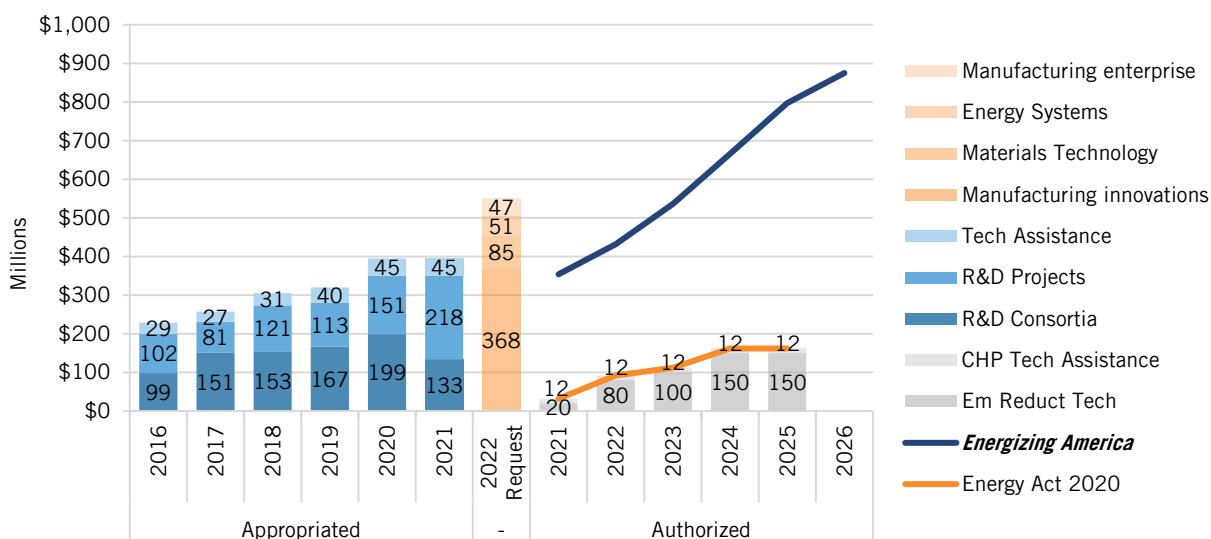


# Federal Energy R&D: Advanced Manufacturing

BY COLIN CUNLIFF AND LINH NGUYEN | JUNE 2021

The Department of Energy’s (DOE) Advanced Manufacturing Office (AMO) works to improve the energy efficiency and productivity of U.S. manufacturers by focusing research, development, and demonstration (RD&D) on cross-cutting platform technologies relevant to manufacturing in multiple fields. A key goal is to ensure new energy technologies invented in the United States are also manufactured in the United States. AMO supports RD&D through competitive funding opportunities designed to develop novel manufacturing technologies.<sup>1</sup>

**Figure 1: *Energizing America* recommends ramping up funding for clean manufacturing RD&D by 150 percent by FY 2026.<sup>2</sup>**



## What’s at Stake

The manufacturing sector accounts for 22 percent of direct U.S. greenhouse gas emissions—and 30 percent when indirect emissions from electricity generation are included. At the same time, U.S. manufacturing employs over 12 million people and plays an outside role in the health of the U.S. economy because of its impact on trade and innovation and its large multiplier effect on other sectors. Despite its importance, advanced manufacturing accounts for just 6 percent of DOE’s energy RD&D portfolio.<sup>3</sup>

Accelerated innovation in both industrial processes that use energy and manufactured products used by the energy industry would strengthen U.S. manufacturing and hasten progress toward national economic, workforce, security, and climate goals. Market failures, however, lead to many gaps in the private sector response to the manufacturing and climate innovation imperative, and have already led to significant supply-chain weaknesses, regional hollowing out, and underinvestment in workforce education and training.

AMO helps address such market failures in several ways, with the goal of improving the energy productivity of U.S. manufacturing, reducing lifecycle energy and resource impacts of manufactured goods, and transitioning DOE-supported technologies and practices into U.S. manufacturing. Together, these efforts assist manufacturers in cutting energy costs, which has already been an important driver in the “reshoring” of manufacturing to the United States over the past decade.<sup>4</sup>

The Clean Energy Manufacturing Initiative (CEMI) institutes are central to AMO’s efforts to accelerate innovation in key technology areas: wide band-gap semiconductor manufacturing, carbon-fiber composite manufacturing, smart manufacturing, chemical process intensification, sustainable manufacturing, and improving cybersecurity. The institutes were originally funded at \$14 million per year for five years, with a requirement of at least a 50/50 cost-share from private sector partners. DOE adopted a five-year window for CEMI institutes to transition fully to non-federal funding sources; however, comparable programs in other countries—such as the Fraunhofer Institutes in Germany—receive core institutional funding from the national government on a permanent basis. The Information Technology and Innovation Foundation (ITIF) has previously recommended that DOE provide ongoing funding, contingent on continued industry participation, beyond the initial five-year window.<sup>5</sup>

While AMO has primarily focused on reducing the energy intensity of manufacturing, ITIF and other research organizations have recommended expanding the mandate of AMO to include decarbonization of the industrial sector, which comprises about a quarter of global emissions, including many of the most difficult-to-decarbonize sources.<sup>6</sup> In the FY 2020 budget cycle, the Senate directed AMO to develop a series of sector-specific decarbonization roadmaps to guide RD&D activities across DOE.<sup>7</sup> While encouraging, such a refocusing should have been accompanied by a significant scale-up in funding, commensurate with the challenge of addressing industrial emissions.

The Energy Act of 2020 authorizes \$12 million annually for FY 2021 to FY 2026 for DOE to carry out a technical assistance program that encourages the deployment of combined heat and power (CHP), waste heat to power, and efficient district energy through education and outreach.<sup>8</sup> Moreover, the bill includes the Clean Industrial Technology Act, which establishes a new Industrial Emissions Reduction Technology Development program within DOE. The program focuses on the development and evaluation of innovative emissions reduction technologies from non-power industrial sectors, including iron, steel, steel mill products, aluminum, cement, glass, pulp, paper, and industrial ceramics. The bill authorizes \$20 million for FY 2021, \$80 million for FY 2022, \$100 million for FY 2023, \$150 million for FY 2024, and \$150 million for FY 2025 for DOE to carry out industrial decarbonization demonstration projects.<sup>9</sup> It does not specify the relationship between the new program and the rest of DOE’s RD&D programs, and it is unclear whether the new program will be housed within AMO or be external to AMO. The Energy Act does not include authorized funding levels for other AMO programs.

Figure 1 shows historical DOE investment in advanced manufacturing technologies RD&D by subprogram, for FY 2016 through 2021, and the FY 2022 budget request. The orange line shows authorized funding levels from the Energy Act of 2020. The blue line shows recommended funding levels from the *Energizing America* report (see box 1). Because clean manufacturing makes up a disproportionately small share of the federal energy RD&D budget—the industrial

sector accounts for 22 percent of direct U.S. greenhouse gas emissions but only 6 percent of DOE's portfolio—*Energizing America* recommends a fast ramp-up to 150 percent above FY 2020 levels over the next five years.

### **Box 1: An Innovation Agenda for Advanced Manufacturing Technologies**

The *Energizing America* report co-authored by ITIF and Columbia University's Center on Global Energy Policy offers several recommendations to accelerate industrial decarbonization. Similarly, ITIF's March 2021 report "Building Back Cleaner With Industrial Decarbonization Demonstration Projects" makes recommendations to scale up clean manufacturing technologies in heavy industry. And ITIF's December 2018 report "Manufacturing USA at DOE: Supporting Energy Innovation" makes recommendations to DOE and Congress to maximize the effectiveness of DOE's clean energy manufacturing innovation institutes programs:

- The Biden administration's infrastructure package should include \$5 billion over five years in cost-shared demonstration projects that seek to drastically reduce greenhouse gas emissions from heavy industries such as steel, cement, and chemicals.<sup>10</sup>
- Congress should ramp up investment in industrial decarbonization and clean manufacturing RD&D by 150 percent over the next five years. This increase is needed to rebalance the research portfolio and make up for historical underinvestment. The industrial sector accounts for 22 percent of direct U.S. greenhouse gas emissions (30 percent when emissions from electricity are distributed by end use), but accounts for only 6 percent of DOE's portfolio.
- Congress and DOE should provide opportunities for CEMI institutes to receive federal funding beyond the five-year window, and consider establishing a permanent support program.<sup>11</sup>
- DOE should establish additional CEMI institutes that focus on other high-priority advanced manufacturing technologies as identified in the Quadrennial Technology Review.<sup>12</sup>
- DOE should expand programs in carbon capture technologies to include industrial process applications such as steel and cement, as current programs focus on power plant applications.<sup>13</sup>
- AMO should expand research on uses of zero-carbon fuels and feedstocks (such as hydrogen) in the industrial sector to mitigate direct carbon dioxide emissions from chemical transformations and high-temperature heat.<sup>14</sup>

### **Advanced Manufacturing RD&D Subprograms**

Unlike other DOE technology programs structured around technical focus areas, AMO subprograms are structured around modes of program implementation: individual research and development (R&D) projects, collaborative R&D consortia, and technology partnerships.<sup>15</sup>

- **R&D Projects** focuses on high-impact manufacturing technology and process challenges in areas such as advanced materials manufacturing for energy applications, improved energy-efficient process technologies, high-performance computing for manufacturing, additive manufacturing processes, roll-to-roll processing, wide-bandgap power electronics, chemical and thermal process intensification, and structures used in extreme environments.
- **R&D Consortia** brings together manufacturers, research institutions, suppliers, and universities in public-private R&D partnerships, each of which focuses on a specific set of challenges at the nexus of manufacturing and energy. AMO consortia include the Manufacturing Demonstration Facility (MDF), which focuses on advanced manufacturing technologies to reduce energy and production costs, the Carbon Fiber Test Facility (CFTF), six CEMI institutes that focus on clean energy technologies, the Energy-Water Desalination Hub, and the Critical Materials Hub.<sup>16</sup>
- **Technical Assistance** helps small and medium-sized manufacturers improve their energy productivity and reduce waste and water use; demonstrates the viability of improved energy-management approaches; and promotes combined heat and power and waste heat to power technologies to improve efficiencies and lower energy costs.

### Key Elements of the FY 2022 Budget Proposal<sup>17</sup>

The proposal seeks \$550.5 million for the AMO, a 39 percent boost from FY 2021 enacted levels. Through FY 2021, AMO subprograms have been structured around modes of program implementation: individual R&D projects, collaborative R&D consortia, and technology partnerships. The FY 2022 budget presents a new subprogram structure across four technical areas to address industrial decarbonization and manufacturing innovation.

- **Materials** will focus on enabling domestic manufacturing of critical materials for energy technologies, including energy conversion materials, nanomaterials, and materials for extreme or harsh conditions, and developing advanced materials that reduce life-cycle carbon emissions through materials reuse and recycling. AMO will establish a new lab-industry consortium to validate critical materials technology innovation and solicit new projects on critical material needs.
- **Manufacturing Innovations** will focus on developing new manufacturing technologies that improve energy efficiency and reduce carbon emissions. The subprogram will fund the second year of the CEMI institute and launch two additional CEMI institutes. It will also support the Decarbonizing Industry Initiative through research and demonstration projects focused on zero-carbon production technologies, electrification, electrochemical manufacturing, enhanced drying, and direct air capture, and green hydrogen.
- **Energy Systems** will focus on RD&D for energy conversion, utilization, and storage technologies and innovative use of these technologies to improve production processes within industrial facilities. AMO will cut funding for fossil fuel-based district energy systems and increase funding for research focused on advance integrated high temperature electrolyzers and energy storage.

- **Manufacturing Enterprises** will provide technical assistance and workforce development for implementing energy and water efficiency projects and practices.

## Further Reading

- David M. Hart, “Building Back Cleaner With Industrial Decarbonization Demonstration Projects” (ITIF, 2021) <https://itif.org/sites/default/files/2021-industrial-decarbonization.pdf>.
- Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), <http://www2.itif.org/2020-energizing-america.pdf>.
- Colin Cunliff, “An Innovation Agenda for Deep Decarbonization: Bridging Gaps in the Federal Energy RD&D Portfolio” (ITIF, 2018) <http://www2.itif.org/2018-innovation-agenda-decarbonization.pdf>.
- David M. Hart and Peter L. Singer, “Manufacturing USA at DOE: Supporting Energy Innovation” (ITIF, 2018), <https://itif.org/publications/2018/05/16/manufacturing-usa-doe-supporting-energy-innovation>.

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## ENDNOTES

1. U.S. Department of Energy (DOE), “FY 2021 Congressional Budget Justification,” Volume 3 Part 1, 161–162 (DOE Chief Financial Officer DOE/CF-0163, February 2020), [https://www.energy.gov/sites/prod/files/2020/02/f72/doe-fy2021-budget-volume-3-part-1\\_1.pdf](https://www.energy.gov/sites/prod/files/2020/02/f72/doe-fy2021-budget-volume-3-part-1_1.pdf).
2. Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), 116, <https://itif.org/publications/2020/09/15/energizing-america-roadmap-launch-national-energy-innovation-mission>.
3. U.S. Environmental Protection Agency (EPA), “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2017” (EPA, 2019), <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017>; Colin Cunliff, “Senate Appropriations: Where the Rubber Meets the Road for Energy Innovation” (ITIF, 2019), Table 1, <https://itif.org/publications/2019/09/03/senate-appropriationswhere-rubber-meets-road-energy-innovation>.
4. Stephen Ezell, Robert Atkinson, and David M. Hart, “ITIF Comments Responding to Administration RFI for National Strategic Plan for Advanced Manufacturing” (ITIF, 2018), <http://www2.itif.org/2018-comments-national-strategic-plan-advanced-manufacturing.pdf>.
5. David M. Hart and Peter L. Singer, “Manufacturing USA at DOE: Supporting Energy Innovation” (ITIF, 2018), <https://itif.org/publications/2018/05/16/manufacturing-usa-doe-supporting-energy-innovation>.
6. Colin Cunliff et al., “Comments to the House Select Committee on the Climate Crisis” (ITIF, 2019), <https://itif.org/publications/2019/11/22/comments-house-select-committee-climate-crisis>.
7. S. Rept. 116-102, Energy and Water Development Appropriations Bill 2020, to accompany S. 2470, 86, <https://www.appropriations.senate.gov/imo/media/doc/FY2020%20Energy%20and%20Water%20Development%20Appropriations%20Act,%20Report%20116-1021.pdf>.
8. Consolidated Appropriations Act, 2021, Division Z, Sec. 1013, <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf>.
9. Consolidated Appropriations Act, 2021, Division Z, Sec. 6003, <https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf>.
10. David M. Hart, “Building Back Cleaner With Industrial Decarbonization Demonstration Projects” (ITIF, 2021) <https://itif.org/sites/default/files/2021-industrial-decarbonization.pdf>.
11. David M. Hart and Peter L. Singer, “Manufacturing USA at DOE.”
12. Ibid.
13. Varun Sivaram et al., *Energizing America*, 66–67.
14. Ibid.
15. DOE, “FY 2021 Congressional Budget Justification,” Volume 3 Part 1, 161–173.
16. The Manufacturing USA initiative refers to a network of 15 manufacturing institutes sponsored by the Department of Defense, the National Institutes of Standards and Technology, and DOE. The six Manufacturing USA institutes hosted by DOE are commonly called CEMI institutes.
17. DOE, “FY 2022 Congressional Budget Justification” Volume 3 Part 1, 303, (DOE Chief Financial Officer DOE/CF-0173, June 2021), 379–397, <https://www.energy.gov/sites/default/files/2021-06/doe-fy2022-budget-volume-3.1-v2.pdf>.