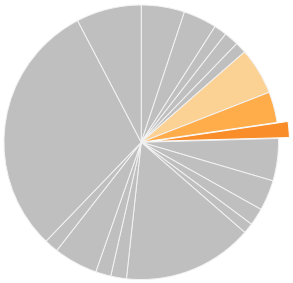
Federal Energy R&D: Hydrogen & Fuel Cells

BY COLIN CUNLIFF AND BATT ODGEREL | MARCH 2020

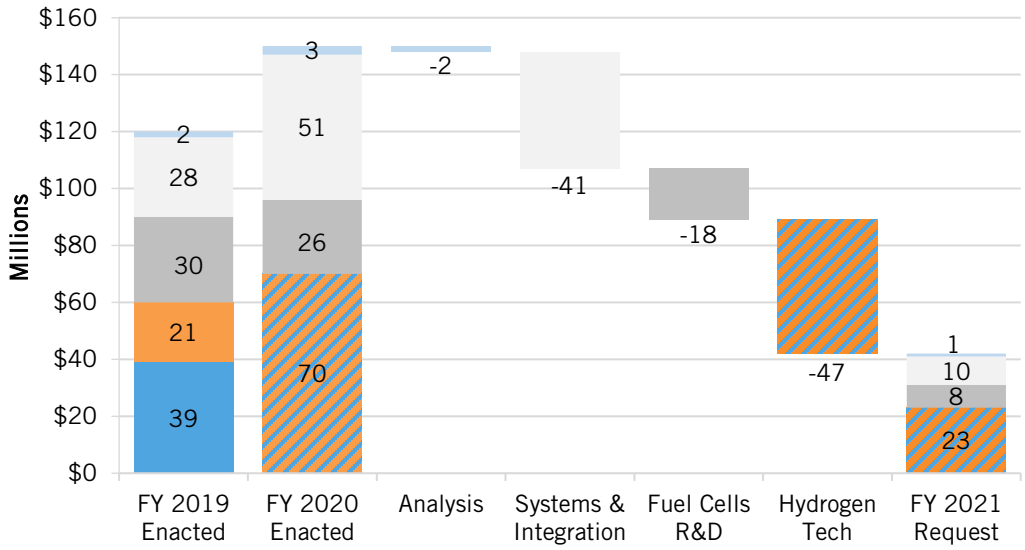
This briefing is part of a series on the U.S. energy budget. See: itif.org/energy-budget.



H2 and Fuels (orange)
Other Transportation (orange)
Energy R&D

Fuel cells use the chemical energy of hydrogen and similar fuels to cleanly and efficiently produce electricity. When hydrogen is the fuel, electricity, water, and heat are the only resulting products, with none of the carbon emissions or pollution emitted by conventional internal combustion engines. The Hydrogen & Fuel Cells program conducts research and development (R&D) on three complementary technologies: low-cost hydrogen production from domestic resources; infrastructure for hydrogen compression, transmission, storage, and delivery; and fuel-cell technologies that can be used in electric vehicles and other applications.[1]

Figure 1: The FY 2021 budget request would cut hydrogen and fuel-cell R&D by 72 percent[2]



Note: The Department of Energy (DOE) is proposing to merge the Hydrogen Fuel (blue) and Hydrogen Infrastructure (orange) subprograms into a single Hydrogen Technologies subprogram in its FY 2021 request (diagonal orange/blue stripes in figure 1).

What's at Risk

Innovations resulting from DOE R&D over the past decade have facilitated a more than 50 percent cost reduction in fuel cells. However, further reductions are necessary for fuel cells to become cost-competitive with internal combustion engine vehicles. DOE's goals for light-duty cars include decreasing fuel cell costs to 30 dollars per kilowatt ($30/kW), decreasing onboard hydrogen storage costs to 8 dollars per kilowatt-hour ($8/kWh), and

improving fuel cell durability to 8,000 hours (approximately 240,000 miles of driving) by 2030. While the program's focus is on transportation, its R&D also benefits stationary fuel cells (such as those used to provide backup power), reversible fuel cells, and small-scale cells for fuel, heat, and power that may provide resilience and flexibility to multiple sectors.[3] Reductions in R&D funding threaten to delay DOE progress toward cost-competitive fuel cells.

DOE is also targeting a hydrogen production cost of $2 per kilogram ($2/kg) and approximately $1/kg for energy storage and chemical processes, with a system-wide cost (hydrogen production plus delivery and storage) of $4/kg in order to be cost competitive with gasoline on a cents-per-mile-driven basis.[4] Hydrogen also has important applications beyond the transportation sector, and is one of the few technology options for addressing harder-to-abate sources of carbon emissions.[5] Hydrogen can serve as a form of long-duration electricity storage, a feedstock in the production of synthetic hydrocarbon fuels and chemicals, and a source of high-temperature heat for industrial applications.[6] Because of the wide range of its end uses, hydrogen can facilitate greater integration of energy systems across sectors—and has led many to call for creation of a "hydrogen economy."[7] However, realizing the enormous potential of hydrogen requires continued R&D in different production and delivery systems and end-use applications.

Hydrogen & Fuel Cells R&D Subprograms

R&D in the Hydrogen & Fuel Cells program is distributed across six subprograms:[8]

- **Fuel Cell Technologies** supports R&D to develop technologies that enhance the durability, reduce the cost, and improve the performance of fuel cells, with a goal of achieving cost competitiveness with internal combustion engine light-duty vehicles and heavy-duty trucks.
- **Hydrogen Fuel R&D** focuses on novel hydrogen production—including hydrogen production by electrically splitting water—and storage technologies, as well as direct conversion of natural gas to hydrogen and carbon coproducts (beyond the conventional steam methane reforming process). The FY 2021 budget request proposes merging the subprogram with Hydrogen Infrastructure R&D.
- **Hydrogen Infrastructure R&D** focuses on reducing costs of such hydrogen fueling infrastructure systems as liquid pumps, compressors, storage, chillers, dispensers, and other hydrogen delivery and station components.
- **Data, Modeling, & Analysis** performs analytical research that provides a technical basis for informed decision-making for the program's R&D direction and prioritization.
- **Systems Development & Integration** focuses on developing the technologies to integrate hydrogen systems with a wide range of sectors, including marine, trucking, rail, steelmaking, ammonia production, electrofuels production from CO_2 and renewable and nuclear resources.

Key Elements of the FY 2021 Budget Proposal

- **A 69 percent reduction in Fuel Cell Technologies**, including reduced funding for the Fuel Cell Performance and Durability (FC-PAD) consortium; reduced funding for high-temperature proton exchange membrane R&D that aids efficient fuel cell operation; no new funding for alkaline-membrane fuel cell technologies; and no funding for reversible fuel cells that can store energy and generate power.

- **A 67 percent reduction in the Hydrogen Technologies,** including reduced funding for the HydroGEN Consortium, a collaborative effort between six national laboratories, industry, and university partners to identify new catalysts, membranes, and other materials to reduce the cost of hydrogen production from water splitting; and reduced funding for the Hydrogen Materials Advanced Research Consortium (HyMARC), an R&D effort to reduce the cost of hydrogen storage.

- **An 80 percent reduction in Systems Development & Integration,** with no funding for industry-led projects to reduce the cost of polymer electrolyte membrane electrolyzer manufacturing technologies; reduced funding for hydrogen use in steel manufacturing; reduced funding for R&D to enable adoption of codes and standards applicable to hydrogen and fuel-cell technologies for large-scale applications; and new funding for research focused on improving the energy and operational efficiency medium-duty and heavy-duty trucks.

- **A 67 percent reduction in Data, Modeling & Analysis**, including a narrowed focus on emerging applications of hydrogen and fuel cell technologies; and no funding for analysis of the potential for hydrogen generation through nuclear baseload sources.

ENDNOTES

1. U.S. Department of Energy (DOE), "FY 2021 Congressional Budget Justification," Volume 3 Part 1, 67–84 (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.
2. The Technology Acceleration ($21 million in FY 2019) and Safety, Codes and Standards ($7 million in FY 2019) subprograms are combined in a single entry in the waterfall chart. DOE, "FY 2021 Congressional Budget Justification" Volume 3 Part 1, 69.
3. Ibid, 67.
4. Ibid, 67 & 75.
5. Davis et al., "Net-Zero Emissions Energy Systems," *Science* (2018), http://dx.doi.org/10.1126/science.aas9793.
6. David M. Hart, "Making 'Beyond Lithium' a Reality: Fostering Innovation in Long-Duration Grid Storage" (Information Technology and Innovation Foundation, November 2018), https://itif.org/publications/2018/11/28/making-beyond-lithium-reality-fostering-innovation-long-

duration-grid; Colin Cunliff, "An Innovation Agenda for Deep Decarbonization: Bridging Gaps in the Federal Energy RD&D Portfolio" (Information Technology and Innovation Foundation, November 2018), 35–39, http://www2.itif.org/2018-innovation-agenda-decarbonization.pdf.

7. Mary-Rose de Valladares, "Global Trends and Outlook for Hydrogen" (International Energy Agency, December 2017), http://ieahydrogen.org/pdfs/Global-Outlook-and-Trends-for-Hydrogen_WEB.aspx.; M. Hashem Nehrir and Caisheng Wang, "Fuel cells," in Muhammad H. Rashid's, *Electric Renewable Energy Systems* (Elsevier, 2016), 92–113, https://doi.org/10.1016/C2013-0-14432-7.

8. DOE, "FY 2021 Congressional Budget Justification" Volume 3 Part 1, 67–84. Definitions for the Hydrogen Fuel R&D and Hydrogen Infrastructure R&D subprograms are taken from the FY 2020 Congressional Budget Justification, as the current budget request proposes a merger these subprograms into Hydrogen Technologies. See DOE, "FY 2020 Congressional Budget Justification," Volume 3 Part 2, 79–100, (DOE Chief Financial Officer DOE/CF-0153, March 201(), https://www.energy.gov/sites/prod/files/2019/04/f61/doe-fy2020-budget-volume-3-Part-2.pdf.

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