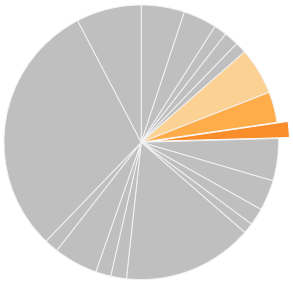
Federal Energy R&D: Hydrogen & Fuel Cells

BY COLIN CUNLIFF | APRIL 2019

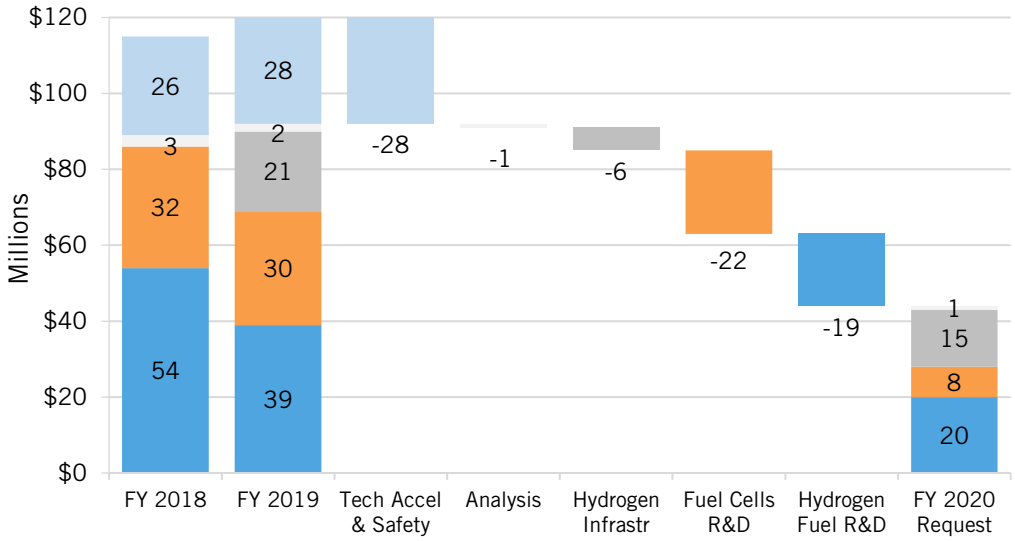
This briefing is part of a series on the U.S. energy budget. See: itif.org/energy-budget.



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

Fuel cells use the chemical energy of hydrogen or similar fuel 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 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 2020 Budget Request Would Cut Hydrogen and Fuel-cell R&D by 63 Percent[2]



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 include decreasing the modeled high-volume cost of automotive fuel cells to $30 per kilowatt ($30/kW) 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 tri-generation of 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 gallon gasoline equivalent ($2/gge), with a system-wide cost (hydrogen production plus delivery) of $4/gge 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 as a source of high-temperature heat for industrial applications.[6] Because of the wide range of 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 hydrogen production and delivery systems.

Hydrogen & Fuel Cells R&D Subprograms

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

- **Fuel Cell** 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 by 2030.
- **Hydrogen Fuel R&D** focuses on the development of novel hydrogen production and storage technologies, including hydrogen production by electrically splitting water, as well as direct conversion of natural gas to hydrogen and carbon co-products (beyond the conventional steam methane reforming process).
- **Hydrogen Infrastructure R&D** is a new subprogram established in FY 2019 that focuses on reducing costs of hydrogen fueling infrastructure systems, such as liquid pumps, compressors, storage, chillers, dispensers, and other hydrogen delivery and station components.
- **Systems Analysis** performs analytical research that provides a technical basis for informed decision-making for the program's R&D direction and prioritization.
- **Safety, Codes, and Standards** collaborates with government, industry, standards-development organizations, universities, and National Laboratories to harmonize regulations, codes, and standards (RCS), and develop best practices to ensure safety in the operation, handling, and use of hydrogen and fuel-cell technologies.
- **Technology Acceleration** supports technology transition from R&D to commercial viability through validation, evaluation, and testing of advanced hydrogen and fuel-cell technologies under real-world conditions.

Figure 1 displays recent and proposed funding levels for each of the subprograms, with the Technology Acceleration and Safety, Codes, and Standards subprograms displayed in a single entry (light blue).

Key Elements of the FY 2020 Budget Proposal

- **Elimination of the Safety, Codes, and Standards subprogram**, including R&D to develop safety codes and standards through the H-Mat Consortium, validate cryogenic hydrogen behavior models, improve existing quantitative risk assessment models, develop hydrogen sensor technologies, and address technical gaps for safety-related hydrogen infrastructure components.

- **Elimination of the Technology Acceleration subprogram**, including a first-of-a-kind demonstration of integrated renewable energy and hybrid hydrogen production systems, R&D on fueling technologies for heavy-duty applications, and industry-led projects to reduce the cost of electrolyzer manufacturing technologies.

- **A 73-percent reduction in Fuel Cell R&D**, including reduced funding for the Fuel Cell Performance and Durability (FC-PAD) consortium, as well as reduced focus on reversible fuel cells that can be used in power-to-gas-to-power systems.

- **A 49-percent reduction in the Hydrogen Fuel R&D subprogram,** 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 water splitting.

- **A 29-percent reduction in the Hydrogen Infrastructure R&D subprogram,** including substantial reductions in funding for the Hydrogen Materials (H-Mat) consortium to identify materials for bulk storage and hydrogen dispensing, as well as reduced funding for dispensing technologies for heavy-duty applications and chemical carriers with improved hydrogen storage capacity. The proposal includes $5 million to fund electrolyzer integration R&D as part of the administration's proposed crosscutting Advanced Energy Storage Initiative.

ENDNOTES

1. DOE, "Congressional Budget Justification" Volume 3 Part 2, 79-100, (DOE Chief Financial Officer DOE/CF-0153, April 2019), https://www.energy.gov/sites/prod/files/2019/04/f61/doe-fy2020-budget-volume-3-part-2_0.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. The administration is proposing to eliminate both in its FY 2020 budget request. The FY 2020 budget request for EERE would use $353 million in prior year (FY 2018 and FY 2019) balances to fund FY2020 programs. Thus the numbers shown in the figure underestimate the magnitude of cuts included in the proposed budget. Department of Energy, "FY 2020 Congressional Budget Request: Budget in Brief," (DOE CFO, March 2019), p 3, https://www.energy.gov/sites/prod/files/2019/03/f60/doe-fy2020-budget-in-brief.pdf; DOE, "FY 2020 Congressional Budget Justification" Volume 3 Part 2, 81.
3. DOE, "Congressional Budget Justification" Volume 3 Part 2, 83.

4. Ibid, 87-92.
5. Davis et al., "Net-zero emissions energy systems," Science **360** (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.
8. DOE, "Congressional Budget Justification" Volume 3 Part 2, 79-100. Definitions for the Safety, Codes and Standards and Technology Acceleration subprograms are taken from the FY 2019 Congressional Budget Justification, since the proposed elimination of these subprograms has not received Congressional support during previous budget cycles. See DOE, "Congressional Budget Justification" Volume 3 Part 2, 103-106, (DOE Chief Financial Officer DOE/CF-0141, March 2018), https://www.energy.gov/sites/prod/files/2018/03/f49/FY-2019-Volume-3-Part-2.pdf.

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