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## Department of Energy Funding for Hydrogen and Fuel Cell Technology Programs

The U.S. Department of Energy (DOE) Hydrogen Program, led by the Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE) addresses the development of applications that use hydrogen in place of today's fuels and technologies that provide modern energy services. DOE programs also consider hydrogen as an established chemical feedstock, for example, in petroleum refining. The DOE programs include over 400 projects of research and development (R&D), systems integration, demonstrations, and initial deployment activities performed by universities, national laboratories, and industry. These programs cover the hydrogen energy value chain starting with producing the hydrogen from diverse feedstocks; transporting and storing it; and finally using it in various applications.

A future "hydrogen economy" using hydrogen as an energy carrier and fuel could offer an alternative to today's economy with its prevalent combustion of fossil fuels. Initially thought of as a new technology for personal mobility services (e.g., cars) and high-value applications such as provision of electric power during space flight, hydrogen now is receiving attention for industrial processes, heavy vehicles, forklifts, portable power, and buffering and balancing of electric power.

### Federal Hydrogen Programs

#### Authorizing Legislation

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 (P.L. 94-413) authorized a hydrogen program, which initially resided with the National Science Foundation. Congress transferred overall management responsibility of the hydrogen program to DOE with the Spark M. Matsunaga Hydrogen Research, Development, and Demonstration Program Act of 1990 (P.L. 101-566). The Energy Policy Act of 2005 (EPAct, P.L. 109-58) and its subsequent amendments further defined the program scope and purpose and established administrative requirements such as annual reports.

#### The DOE Program

The DOE hydrogen program includes several offices with responsibility for supporting hydrogen work based on different sources of energy (e.g., renewable, fossil, nuclear) and types of end-use (e.g., vehicles, portable power, thermal comfort). DOE's 2020 Hydrogen Program Plan identifies key goals for the program including the cost of the hydrogen itself and the component costs of hydrogen-consuming devices. For example, DOE has programs that aim to reduce the cost of the fuel cell system that powers a vehicle to \$80 per kilowatt; DOE estimates it to be \$185/kW with current technology and an assumed 100,000

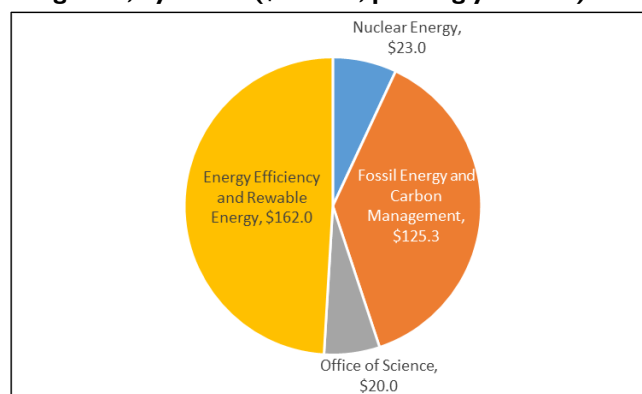
units manufactured per year (which DOE calculates would reduce the cost).

DOE describes its hydrogen program as being part of its clean energy portfolio. DOE launched a "Hydrogen Shot" initiative in June 2021, one of its "Energy Earthshots" dedicated to the scale-up of emerging clean energy technologies. The goal of Hydrogen Shot is to make hydrogen commercially available at a cost of \$1 for 1 kilogram in 1 decade. The cost, as defined by DOE, is for production using electrolyzers that split water to make the hydrogen and does not include delivery and dispensing. DOE has numerous other goals and reviews these internally and at its annual merit review, most recently in June 2022.

#### DOE Spending

Within DOE, two offices—EERE and the Office of Fossil Energy and Carbon Management—are responsible for executing over 80% of DOE's budget authority on hydrogen and fuel cells in fiscal year (FY) 2022. The Office of Nuclear Energy and the Office of Science receive smaller amounts of the DOE-wide total of \$330.3 million in FY2022. (See **Figure 1**.)

**Figure 1. FY2022 Appropriations for DOE Hydrogen Programs, by Office (\$million, pending year-end)**



**Source:** Sunita Satyapal, Director, DOE Hydrogen and Fuel Cell Technologies Office, 2022 AMR Plenary Session, June 6, 2022, <https://www.energy.gov/sites/default/files/2022-06/hfto-amr-plenary-satyapal-2022-1.pdf>.

The FY2022 total may increase by end-of-year, once DOE offices determine how to allocate extramural spending according to office and stakeholder priorities. For FY2023, DOE requested \$406 million, and while the House Appropriations Committee approved the FY2023 Energy and Water Development and Related Agencies appropriations bill on June 28, 2022 (H.R. 8255, H.Rept. 117-394), the bill and report do not provide enough detail to determine a DOE-wide total for hydrogen programs.

### Where DOE Spends the Money

DOE's hydrogen programs include grants, contracts, and cooperative agreements awarded to investigators at universities, industry, and national laboratories, encompassing more than 400 projects. These include R&D focused on the hardware for a hydrogen economy and improving its technology, where R&D is intended to reduce cost and improve performance of the fuel cell and other parts of the hydrogen value chain. The projects also include work at higher levels of integration, such as to validate first-of-a-kind systems across applications, reduce technological risk, and address the "software" needs of a hydrogen economy such as safety, codes, standards, and workforce development. In H.Rept. 117-394, the House Appropriations Committee directed DOE to prioritize partnerships with academia and national laboratories.

Some of DOE's hydrogen program's projects progress in stages, starting with a policy decision or congressional requirement leading to a funding opportunity announcement (FOA), receipt of proposals, and awarding of funds (grants, etc.). An example of this is the Regional Clean Hydrogen Hubs designated in the Infrastructure Investment and Jobs Act (§40314, P.L. 117-58), discussed further below in "Recent Developments." Other projects arise using funds not specifically designated by Congress as intended for hydrogen (i.e., where the selection of a hydrogen-related topic is below the point of congressional control). DOE takes input from networks of stakeholders to inform its project selections. For example, Advanced Research Projects Agency-Energy (ARPA-E) funding for hydrogen is determined annually based on programs developed through office and stakeholder priorities and defined, in part, by the proposals it receives and awards; in FY2021 this included \$34.3 million.

### Hydrogen Programs at Non-DOE Federal Agencies

Several other agencies—Department of the Army, National Aeronautics and Space Administration, and Department of the Navy, among others—administer hydrogen programs; DOE estimates that, for FY2019 and FY2020 combined, projects funded by these other hydrogen programs totaled over \$40 million. Their projects range from basic research on materials and novel methods of producing hydrogen to activities aimed at early deployment, including demonstrations of fuel cells in applications such as shore power or emergency response ground vehicles. DOE's HFTO has a coordinating role within the federal government as a whole. Congress has directed agencies to cooperate on hydrogen and fuel cell activities and, in EPAct (§806), directed the President to create, and DOE to lead, an interagency working group; the group continues to meet monthly. The language in the IIJA (§40314) requires the Secretary of Energy to develop a strategy and roadmap that, among other purposes, identifies points of interaction with federal agencies involved with hydrogen and clarifies the responsibilities of those agencies.

### Recent Developments

IIJA appropriated \$9.5 billion for three hydrogen- and fuel cell-related DOE programs (Division J, Title III) in addition to those amounts shown in **Figure 1**. In the largest of these,

the Regional Clean Hydrogen Hubs, DOE is to make awards totaling \$8 billion to support at least four demonstration projects involving networks of clean hydrogen producers and consumers and the connecting infrastructure. Congress directed DOE to choose hubs with a diversity of feedstocks (i.e., the primary resources converted into hydrogen), together with varied types of end-use of the hydrogen in its various applications. DOE has conducted initial consultations and Requests for Information (RFIs) and on June 6, 2022, issued a Notice of Intent to Issue a Funding Opportunity Announcement.

IIJA also appropriated \$500 million for the Clean Hydrogen Manufacturing Recycling Research, Development, and Demonstration Program, with funding appropriated in five equal, annual installments starting with FY2022. DOE has allocated these funds into two programs authorized by EPAct (§815a and b; IIJA §40314) on manufacturing and recycling. IIJA further appropriated \$1 billion for the Clean Hydrogen Electrolysis Program, also appropriated in five equal annual installments, to achieve the goal of \$2 per kilogram of produced hydrogen by 2026 (§40314). IIJA specifically calls for a demonstration project on electrolysis to validate information on cost and performance and to demonstrate electrolysis for clean hydrogen (§40314). DOE issued an RFI on both the IIJA programs in March 2022 "to obtain feedback on the status of and opportunities for technologies" and to "develop and refine the programs."

DOE approved a \$504 million loan guarantee in June 2022 to construct 220 megawatts of electrolyzers in Delta, UT, paired with underground storage caverns to store the hydrogen produced. DOE says this will address cost reduction of hydrogen though the project is not explicitly tied to the \$2 per kilogram by 2026 goal. DOE used its Title XVII authority under EPAct.

### Congressional Considerations

In H.Rept. 117-394, the House Appropriations Committee reiterated that DOE should coordinate hydrogen and fuel cell programs across DOE offices and specifically between HFTO and the Vehicle Technologies Office. The report noted that while the committee requested, in its report on the FY2022 bill, a briefing on DOE cooperation with civil society and on low carbon intensity hydrogen, DOE had not yet conducted the briefing.

IIJA required that DOE consider a number of goals (e.g., long-term employment) for the \$8 billion Regional Clean Hydrogen Hubs and established timetables for DOE's implementation of these hubs. How and to what extent DOE implements these goals and how quickly it can make the awards may be of continued interest to Congress. IIJA further set a target for the cost of hydrogen that is to be achieved roughly five years earlier than DOE's own Hydrogen Shot cost goal. How these two goals align in practice may also be of interest to Congress.

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