Prologue

Dear Colleague:

This document summarizes peer review comments and scores for the Fiscal Year (FY) 2023 U.S. Department of Energy (DOE) Hydrogen Program Annual Merit Review and Peer Evaluation Meeting (AMR), held virtually and in person June 5–8, 2023. In response to direction from various stakeholders, including the National Academies, this review process provides project- and program-level evaluations of DOE-funded research, development, demonstration, and analysis of hydrogen and fuel cell technologies.

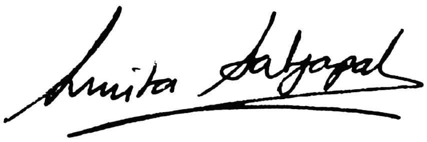
This year's AMR kicked off with opening remarks on U.S. hydrogen priorities from Deputy Secretary of Energy David Turk, followed by remarks on accelerating innovation from science through deployment by Dr. Geraldine Richmond, under secretary for science and innovation, and David Crane, director of the Office of Clean Energy Demonstrations. The opening plenary session included three panel discussions. The first panel included leaders from the U.S. Departments of Commerce, Transportation, and Labor, and the discussion focused on the national hydrogen strategy and interagency collaboration. I then provided an overview of the DOE Hydrogen Program. This was followed by a second panel, which highlighted the Program's approach to agency-wide collaboration and coordination, with perspectives from nine representatives of DOE offices involved in the Program. After the second panel, Sheri Bone, principal deputy director of the Office of Economic Impact and Diversity (since renamed the Office of Energy Justice and Equity), rounded out the plenary session with perspectives on energy and environmental justice. The final panel provided perspectives from Hydrogen and Fuel Cell Technologies Office (HFTO) program managers, complementing the Program overview I delivered.

The AMR technical session included tracks on each of HFTO's subprograms: Hydrogen Production Technologies; Hydrogen Infrastructure Technologies; Fuel Cell Technologies; Systems Development and Integration; and Analysis, Codes and Standards. It also included a dedicated two-and-a-half-day track on DOE intra-agency activities, including project updates from the Office of Fossil Energy and Carbon Management, the Office of Nuclear Energy, and the Advanced Research Projects Agency–Energy (ARPA-E), as well as several other offices within the Office of Energy Efficiency and Renewable Energy, including Solar Energy Technologies, Water Power Technologies, Wind Energy Technologies, and Industrial Efficiency and Decarbonization. A one-day session on interagency activities included presentations on hydrogen activities supported by other federal agencies, including the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, NASA, and the Departments of Defense, Transportation, and Agriculture.

The AMR was attended by more than 2,500 people, including more than 130 reviewers who reviewed more than 100 projects funded by HFTO and more than 20 reviewers who provided feedback on the overall Program and its subprograms. DOE values the transparent public process of soliciting technical input on its projects and programs from relevant experts with deep knowledge across a wide range of areas. The reviewers' recommendations are taken into consideration by DOE technology managers in generating future work plans. The summary table on the following pages lists the projects presented at the review and the overall evaluation score for each project, and Appendix A provides the scores and comments from the program reviewers. The individual reports for each project present the reviewer comments to be considered during the upcoming fiscal year (October 1, 2023–September 30, 2024). The projects have been grouped according to subprogram and reviewed according to the appropriate evaluation criteria. The scores and comments are provided to each project's principal investigators (PIs) so that they receive direct feedback (although the authors of the individual comments remain anonymous). DOE instructs the PIs to consider these summary evaluations fully—along with any comments from DOE managers—in their FY 2024 plans.

On behalf of the DOE Hydrogen Program, I would like to express my sincere appreciation to all the 2023 AMR participants—especially the reviewers, researchers, and presenters—for your strong commitment, expertise, and dedication to advancing hydrogen and fuel cell technologies and addressing our nation's critical energy and environmental needs. You make this report possible, and we rely on your comments, along with other management processes, to help make project decisions for the new fiscal year. We look forward to your participation in the 2024 AMR, which is scheduled for the week of May 6, 2024.

Sincerely,



Dr. Sunita Satyapal
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DOE Hydrogen Program Coordinator
U.S. Department of Energy

Hydrogen Production Technologies

Hydrogen Production

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
P-148	HydroGEN Overview: A Consortium on Advanced Water-Splitting Materials *Huyen Dinh, National Renewable Energy Laboratory*	3.4	X		
P-170	Benchmarking Advanced Water-Splitting Technologies: Best Practices in Materials Characterization *Olga Marina, Pacific Northwest National Laboratory*	3.7	X		
P-179	BioHydrogen (BioH2) Consortium to Advance Fermentative Hydrogen Production *Katherine Chou, National Renewable Energy Laboratory*	3.2	X		
P-184	Scalable and Highly Efficient Microbial Electrochemical Reactor for Hydrogen Generation from Lignocellulosic Biomass and Waste *Hong Liu, Oregon State University*	3.0	X		
P-196	H2NEW Consortium: Hydrogen from Next-Generation Electrolyzers of Water *Bryan Pivovar, National Renewable Energy Laboratory, and Richard Boardman, Idaho National Laboratory*	3.4	X		
P-197	Advanced Manufacturing Processes for Gigawatt-Scale Proton Exchange Membrane Water Electrolyzers *Andrew Steinbach, 3M Company*	3.4	X		
P-198	Enabling Low-Cost Proton Exchange Membrane Electrolysis at Scale Through Optimization of Transport Components and Electrode Interfaces *Chris Capuano, Nel Hydrogen*	3.2	X		
P-199	Integrated Membrane Anode Assembly and Scale-up *Adam Paxson, Plug Power Inc.*	3.2	X		
P-200	Low-Cost Manufacturing of High-Temperature Electrolysis Stacks *Scott Swartz, Nextech Materials, Ltd.*	3.3	X		
P-201	Automation of Solid Oxide Electrolyzer Cell and Stack Assembly *Todd Striker, Cummins Inc.*	3.0	X		
P-202	Novel Microbial Electrolysis Cell Design for Efficient Hydrogen Generation from Wastewaters *Bruce Logan, The Pennsylvania State University*	3.0	X		
P-203	Novel Microbial Electrolysis System for Conversion of Biowastes into Low-Cost Renewable Hydrogen *Noah Meeks, Southern Company Services, Inc.*	3.1	X		
P-204	Hydrogen Production Cost and Performance Analysis *Brian James, Strategic Analysis, Inc.*	3.3	X		

Hydrogen Production: HydroGEN Seedling[1]

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
P-190	A Multifunctional Isostructural Bilayer Oxygen Evolution Electrode for Durable Intermediate-Temperature Electrochemical Water Splitting *Kevin Huang, University of South Carolina*	3.2			X
P-191	Perovskite–Perovskite Tandem Photoelectrodes for Low-Cost Unassisted Photoelectrochemical Water Splitting *Yanfa Yan, The University of Toledo*	3.0	X		
P-192	Development of Composite Photocatalyst Materials That Are Highly Selective for Solar Hydrogen Production and Their Evaluation in Z-Scheme Reactor Designs *Shane Ardo, University of California, Irvine*	3.0	X		
P-193	Highly Efficient Solar Water Splitting Using Three-Dimensional/Two-Dimensional Hydrophobic Perovskites with Corrosion-Resistant Barriers *Aditya D. Mohite, William Marsh Rice University*	2.9			X

Hydrogen Infrastructure Technologies

Hydrogen Infrastructure

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
H2-041	H2@Scale Cooperative Research and Development Agreement: California Research Consortium (Reference Station, Fueling Performance Test Device, Station Cap Model) *Sam Sprik, National Renewable Energy Laboratory*	3.0	X		
IN-001a	Hydrogen Materials Compatibility Consortium (H-Mat) Overview: Metals *Chris San Marchi, Sandia National Laboratories*	3.6	X		

[1] HydroGEN seedling projects marked “Continue” are on track, but project continuation is contingent on passing a go/no-go decision.

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
IN-001b	Hydrogen Materials Compatibility Consortium (H-Mat) Overview: Polymers *Kevin Simmons, Pacific Northwest National Laboratory*	3.5	X		
IN-015	Optimizing the Heisenberg Vortex Tube for Hydrogen Cooling *Jacob Leachman, Washington State University*	3.3	X		
IN-016	Free-Piston Expander for Hydrogen Cooling *Devin Halliday, Gas Technology Institute*	3.3	X		
IN-019	Ultra-Cryopump for High-Demand Transportation Fueling *Kyle Gross, RotoFlow*	2.1		X	
IN-020	Self-Healable Copolymer Composites for Extended-Service Hydrogen Dispensing Hoses *Marek Urban, Clemson University*	2.6	X		
IN-021	Microstructural Engineering and Accelerated Test Method Development to Achieve Low-Cost, High-Performance Solutions for Hydrogen Storage and Delivery *Kip Findley, Colorado School of Mines*	3.5	X		
IN-022	Tailoring Carbide-Dispersed Steels: A Path to Increased Strength and Hydrogen Tolerance *Gregory Thompson, The University of Alabama*	2.5	X		
IN-025	Hydrogen Delivery Technologies Analysis *Amgad Elgowainy, Argonne National Laboratory*	3.4	X		
IN-026	Tailoring Composition and Deformation Modes at the Microstructural Level for Next-Generation Low-Cost, High-Strength Austenitic Stainless Steels *Petros Sofronis, University of Illinois Urbana–Champaign*	3.5	X		
IN-029	Reducing the Cost of Fatigue Crack Growth Testing for Storage Vessel Steels in Hydrogen Gas *Kevin Nibur, Hy-Performance Materials Testing, LLC*	3.1	X		
IN-030	Micro-Mechanically Guided High-Throughput Alloy Design Exploration toward Metastability-Induced Hydrogen Embrittlement Resistance *C. Cem Tasan, Massachusetts Institute of Technology*	3.0	X		
IN-034	HyBlend: Pipeline Cooperative Research and Development Agreement (CRADA) Cost and Emissions Analysis *Mark Chung, National Renewable Energy Laboratory*	3.5	X		
IN-035	HyBlend: Pipeline Cooperative Research and Development Agreement (CRADA) Materials Research and Development *Chris San Marchi, Sandia National Laboratories*	3.7	X		
IN-036	Cost-Effective Pre-Cooling for High-Flow Hydrogen Fueling *Devin Halliday, GTI Energy*	3.1	X		
IN-037	Autonomous Fueling System for Heavy-Duty Fuel Cell Electric Trucks *Renju Zacharia, Nikola Motor Company*	2.4		X	

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
IN-039	Analytic Framework for Optimal Sizing of Hydrogen Fueling Stations for Heavy-Duty Vehicles at Ports *Todd Wall, Pacific Northwest National Laboratory*	3.2	X		
IN-040	The HyRIGHT Project: 700 bar Hydrogen Refueling Interface for Gaseous Heavy-Duty Trucks *Will James, Savannah River National Laboratory*	3.2	X		
TA-049	High-Pressure, High-Flow-Rate Dispenser and Nozzle Assembly for Heavy-Duty Vehicles *Spencer Quong, Electricore Inc.*	3.6	X		

Hydrogen Storage

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
ST-127	Hydrogen Materials Advanced Research Consortium (HyMARC) Overview *Mark Allendorf, Sandia National Laboratories*	3.0	X		
ST-236	Low-Cost, High-Performance Carbon Fiber for Compressed Natural Gas Storage Tanks *Xiaodong Li, University of Virginia*	3.3	X		
ST-237	Carbon Composite Optimization Reducing Tank Cost *Duane Byerly, Hexagon R&D*	3.2	X		
ST-238	Low-Cost, High-Strength Hollow Carbon Fiber for Compressed Gas Storage Tanks *Matthew Weisenberger, University of Kentucky*	3.2	X		
ST-240	Cost-Optimized Structural Carbon Fiber for Hydrogen Storage Tanks *Amit Naskar, Oak Ridge National Laboratory*	2.9	X		
ST-241	First Demonstration of a Commercial-Scale Liquid Hydrogen Storage Tank Design for International Trade Applications *Ed Holgate, Shell*	2.9	X		

Fuel Cell Technologies

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
FC-160	ElectroCat 2.0 (Electrocatalysis Consortium) *Deborah Myers, Argonne National Laboratory, and Piotr Zelenay, Los Alamos National Laboratory*	3.3	X		
FC-317	Stationary Direct Methanol Fuel Cells Using Pure Methanol *Xianglin Li, University of Kansas*	2.8			X
FC-323	Durable Fuel Cell Membrane Electrode Assembly through Immobilization of Catalyst Particle and Membrane Chemical Stabilizer *Nagappan Ramaswamy, General Motors, LLC*	3.4			X
FC-326	Durable Membrane Electrode Assemblies for Heavy-Duty Fuel Cell Electric Trucks *John Slack, Nikola Motor Company*	2.6		X	
FC-327	Durable High-Power-Density Fuel Cell Cathodes for Heavy-Duty Vehicles *Shawn Litster, Carnegie Mellon University*	3.4	X		
FC-330	High-Efficiency Reversible Solid Oxide System *Hossein Ghezel-Ayagh, FuelCell Energy, Inc.*	3.3	X		
FC-331	A Novel Stack Approach to Enable High Round-Trip Efficiencies in Unitized Proton Exchange Membrane Regenerative Fuel Cells *Katherine Ayers, Nel Hydrogen*	3.0	X		
FC-333	Advanced Membranes for Heavy-Duty Fuel Cell Trucks *Andrew Baker, Nikola Motor Company*	3.4		X	
FC-336	A Systematic Approach to Developing Durable, Conductive Membranes for Operation at 120°C *Tom Zawodzinski, University of Tennessee, Knoxville*	2.8		X	
FC-337	Cummins Proton Exchange Membrane Fuel Cell System for Heavy-Duty Applications *Jean St-Pierre, Cummins Inc.*	2.5		X	
FC-338	Domestically Manufactured Fuel Cells for Heavy-Duty Applications *Karen Swider-Lyons, Plug Power Inc.*	2.5		X	
FC-339	M2FCT: Million Mile Fuel Cell Truck Consortium *Rod Borup, Los Alamos National Laboratory, and Adam Weber, Lawrence Berkeley National Laboratory*	3.4	X		
FC-344	Low-Cost Corrosion-Resistant Coated Aluminum Bipolar Plates by Elevated Temperature Formation and Diffusion Bonding *Tianli Zhu, Raytheon Technologies Research Center*	3.1	X		

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
FC-345	Development and Manufacturing for Precious-Metal-Free Metal Bipolar Plate Coatings for Proton Exchange Membrane Fuel Cells *CH Wang, Treadstone Technologies, Inc.*	2.9		X	
FC-346	Fully Unitized Fuel Cell Manufactured by a Continuous Process *Jon Owejan, Plug Power Inc.*	3.2	X		
FC-347	Development of Low-Cost, Thin Flexible Graphite Bipolar Plates for Heavy-Duty Fuel Cell Applications *David Chadderdon, NeoGraf Solutions, LLC*	3.2	X		
FC-348	Fuel Cell Bipolar Plate Technology Development for Heavy-Duty Applications *Siguang Xu, General Motors LLC*	2.8		X	
FC-349	Foil-Bearing-Supported Compressor–Expander *Giri Agrawal, R&D Dynamics Corporation*	3.1	X		
FC-350	High-Efficiency and Transient Air Systems for Affordable Load-Following Heavy-Duty Truck Fuel Cells *Doug Hughes, Eaton Corporation*	3.0	X		
FC-351	Durable and Efficient Centrifugal Compressor-Based Filtered Air Management System and Optimized Balance of Plant *Mike Bunce, MAHLE Powertrain, LLC*	3.1	X		
FC-352	Leveraging Internal Combustion Engine Air System Technology for Fuel Cell System Cost Reduction *Paul Wang, Caterpillar Inc.*	3.3	X		
FC-353	Fuel Cell Cost and Performance Analysis *Brian James, Strategic Analysis, Inc.*	3.2	X		
FC-363	Advanced Fuel Cell Vehicle DC-DC Converter Development *Vivek Sujan, Oak Ridge National Laboratory*	3.0	X		

Systems Development and Integration

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
SDI-001	Integrated Modeling, Techno-Economic Analysis, and Reference Design for Renewable Hydrogen to Green Steel and Ammonia *Steve Hammond, National Renewable Energy Laboratory*	3.1	X		

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
SDI-002	Hydrogen Energy Storage System at Borrego Springs Toward a Hydrogen-Enabled 100% Renewable Microgrid *Kumaraguru Prabakar, National Renewable Energy Laboratory*	3.1	X		
SDI-004	Hydrogen Coach Bus Fueling Demonstration *Richard Boardman, Idaho National Laboratory*	3.7	X		
TA-001	Membrane Electrode Assembly Manufacturing Research and Development *Peter Rupnowski, National Renewable Energy Laboratory*	3.0	X		
TA-016	Fuel Cell Hybrid Electric Delivery Van *Jason Hanlin, Center for Transportation and the Environment*	3.6	X		
TA-017	Innovative Advanced Hydrogen Mobile Fueler *Sara Odom, Electricore Inc.*	2.9			X
TA-018	High-Temperature Electrolysis, Stack, and Systems Testing *Micah Casteel, Idaho National Laboratory*	3.4	X		
TA-028	Demonstration of Electrolyzer Operation at a Nuclear Plant to Allow for Dynamic Participation in an Organized Electricity Market and In-House Hydrogen Supply *Uuganbayar Otgonbaatar, Exelon Corporation*	3.4	X		
TA-035	Power Electronics for Electrolyzer Applications to Enable Grid Services *Robert Hovsapian, National Renewable Energy Laboratory*	3.4			X
TA-037	Demonstration and Framework for H2@Scale in Texas and Beyond *Rich Myhre, Frontier Energy, Inc.*	3.4	X		
TA-039	Solid Oxide Electrolysis System Demonstration *Hossein Ghezel-Ayagh, FuelCell Energy, Inc.*	3.4	X		
TA-042	Next-Generation Hydrogen Station Analysis *Genevieve Saur, National Renewable Energy Laboratory*	3.3	X		
TA-043	Solid Oxide Electrolysis Cell Stack Development and Manufacturing *Olga Marina, Pacific Northwest National Laboratory*	3.1	X		
TA-044	System Demonstration for Supplying Clean, Reliable, and Affordable Electric Power to Data Centers Using Hydrogen Fuel *Paul Wang, Caterpillar Inc.*	3.0	X		
TA-045	Waterfront Maritime Hydrogen Demonstration Project *Narendra Pal, Hornblower Group*	3.1	X		
TA-048	Advanced Research on Integrated Energy Systems (ARIES)/Flatirons Facility – Hydrogen System Capability Buildout *Daniel Leighton, National Renewable Energy Laboratory*	3.5			X
TA-052	Solid Oxide Electrolysis Cells Integrated with Direct Reduced Iron Plants for Producing Green Steel *Jack Brouwer, University of California, Irvine*	3.1	X		

Project Number	Project Title *Principal Investigator Name & Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
TA-053	Grid-Interactive Steelmaking with Hydrogen (GISH) *Ronald O'Malley, Missouri University of Science and Technology*	3.4	X		
TA-056	Ultra-Efficient Long-Haul Hydrogen Fuel Cell Tractor *Darek Villeneuve, Daimler Trucks North America*	3.5	X		
TA-057	High-Efficiency Fuel Cell Application for Medium-Duty Truck Vocations *Stan Bower, Ford Motor Company*	3.5	X		
TA-058	Freight Emissions Reduction via Medium-Duty Battery Electric and Hydrogen Fuel Cell Trucks with Green Hydrogen Production via a New Electrolyzer Design and Electrical Utility Grid Coupling *Jacob Lozier, General Motors LLC*	3.6	X		
TA-059	Medium-Duty Vehicle Total Cost of Ownership and Target Development *Ram Vijayagopal, Argonne National Laboratory*	3.4	X		
TA-060	Offshore Wind to Hydrogen – Modeling, Analysis, Testing, and International Collaboration Work *Genevieve Saur, National Renewable Energy Laboratory*	3.3	X		
TA-062	Validation of Interconnection and Interoperability of Grid-Forming Inverters Sourced by Hydrogen Technologies in View of 100% Renewable Microgrids *Kumaraguru Prabakar, National Renewable Energy Laboratory*	3.4	X		
TA-065	Total Cost of Ownership Analysis of Hydrogen Fuel Cells in Off-Road Heavy-Duty Applications – Preliminary Results *Rajesh Ahluwalia, Argonne National Laboratory*	3.4	X		

Analysis, Codes and Standards

Systems Analysis

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
SA-174	Life Cycle Analysis of Hydrogen Pathways *Amgad Elgowainy, Argonne National Laboratory*	3.4	X		
SA-178	Cradle-to-Grave Transportation Analysis *Amgad Elgowainy, Argonne National Laboratory*	3.7	X		

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
SA-181	Global Change Analysis Model Expansion – Hydrogen Pathways *Page Kyle, Pacific Northwest National Laboratory*	3.5	X		
SA-186	Updates to National Energy Modeling Systems To Include Hydrogen Module *Michael Schaal, OnLocation, Inc.*	3.4	X		

Safety, Codes and Standards

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
SCS-001	Component Failure Research and Development *Kevin Hartmann, National Renewable Energy Laboratory*	3.2	X		
SCS-005	Research and Development for Safety, Codes and Standards: Material and Component Compatibility *Joe Ronevich, Sandia National Laboratories*	3.7	X		
SCS-010	Research and Development for Safety, Codes and Standards: Hydrogen Behavior *Ethan Hecht, Sandia National Laboratories*	3.2	X		
SCS-011	Hydrogen Quantitative Risk Assessment *Ben Schroeder, Sandia National Laboratories*	3.6	X		
SCS-019	Hydrogen Safety Panel, Safety Knowledge Tools, and First Responder Training Resources *Nick Barilo, Pacific Northwest National Laboratory*	3.7	X		
SCS-021	National Renewable Energy Laboratory Hydrogen Sensor Testing Laboratory *William Buttner, National Renewable Energy Laboratory*	3.6	X		
SCS-022	Fuel Cell and Hydrogen Energy Association Codes and Standards Support *Karen Quackenbush, Fuel Cell and Hydrogen Energy Association*	3.2	X		
SCS-028	Hydrogen Education for a Decarbonized Global Economy (H2EDGE) *Eladio Knipping, Electric Power Research Institute*	3.2	X		
SCS-030	MC Formula Protocol for H35HF Fueling *Taichi Kuroki, National Renewable Energy Laboratory*	3.4	X		

Project Number	Project Title *Principal Investigator Name and Organization*	Final Score	Continue	Discontinue/ Further Review	Completed
SCS-031	Assessment of Heavy-Duty Fueling Methods and Components *Shaun Onorato, National Renewable Energy Laboratory*	3.5	X		
SCS-033	Risk Assessments of Design and Refueling for Hydrogen Locomotive and Tender *Brian Ehrhart, Sandia National Laboratories*	3.1	X		
SCS-H2042	Hydrogen Contaminant Detector *Matthew Post, National Renewable Energy Laboratory*	3.2	X		