Introduction

The fiscal year (FY) 2018 U.S. Department of Energy (DOE) Hydrogen and Fuel Cells Program (the Program) Annual Merit Review and Peer Evaluation Meeting (AMR) was held June 13–15, 2018, at the Washington Marriott Wardman Park Hotel in Washington, DC. This report is a summary of comments by AMR peer reviewers about the hydrogen and fuel cell projects funded by DOE's Office of Energy Efficiency and Renewable Energy (EERE). Projects supported by other state agencies and DOE offices (including the Office of Fossil Energy Solid Oxide Fuel Cell Program [FE-SOFC)], Office of Science [Basic Energy Sciences], Advanced Research Projects Agency – Energy [ARPA-E], and EERE Advanced Manufacturing Office) in areas relevant to hydrogen and fuel cells were also presented at the FY 2018 AMR. DOE uses the results of this merit review and peer evaluation, along with additional review processes, to make funding decisions for upcoming fiscal years and help guide ongoing performance improvements to existing projects.

The objectives of this meeting include the following:

- Review and evaluate FY 2018 accomplishments and FY 2019 plans for DOE laboratory programs; industry/university cooperative agreements; and related research, development, and demonstration (RD&D) efforts.
- Provide an opportunity for stakeholders and participants (e.g., fuel cell and hydrogen system manufacturers, component developers, and others) to provide input to help shape the DOE-sponsored RD&D program in order to address the highest-priority technical barriers and facilitate technology transfer.
- Foster interactions among the national laboratories, industry, and universities conducting RD&D.

The peer review process followed the guidelines in the *Peer Review Guide* developed by EERE. The peer review panel members, listed in Table 1, provided comments about the projects presented. Panel members included experts from a variety of backgrounds related to hydrogen and fuel cells, and they represented national laboratories; universities; various government agencies; and manufacturers of hydrogen production, storage, delivery, and fuel cell technologies. Each reviewer was screened for conflicts of interest as prescribed by the *Peer Review Guide*. A subset of these reviewers was also asked to provide overall Program and sub-program review feedback. The results of this Program Review feedback are included in Appendix A. A complete list of the meeting participants is presented in Appendix B.

Table 1: Peer Review Panel Members

No.	Name	Organization
1	Kareem Afzal	PDC Machines, Inc.
2	Antonio Aguilo-Rullan	Fuel Cells And Hydrogen Joint Undertaking (FCH JU)
3	Rajesh Ahluwalia	Argonne National Laboratory
4	Paul Albertus	Advanced Research Projects Agency–Energy (ARPA-E)
5	Shaun Alia	National Renewable Energy Laboratory
6	Laurent Antoni	Commissariat à l'énergie atomique et aux énergies alternatives (CEA, French Atomic Energy Commission)
7	Katherine Ayers	Proton OnSite
8	Dustin Banham	Ballard Power Systems
9	Nick Barilo	Pacific Northwest National Laboratory
10	Jean Baronas	California Energy Commission
11	Olga Baturina	U.S. Naval Research Laboratory
12	Guido Bender	National Renewable Energy Laboratory
13	Matthew Bliekse	Shell Global New Energies
14	Richard Boardman	Idaho National Laboratory
15	Rodney Borup	Los Alamos National Laboratory
16	Nico Bouwkamp	California Fuel Cell Partnership/Frontier Energy
17	Peter Bouwman	Nedstack
18	Antonio Bouza	U.S. Department of Energy
19	Robert Bowman	Oak Ridge National Laboratory (retired)
20	Kenneth Boyce	UL

No.	Name	Organization
21	Jack Brouwer	University of California, Irvine
22	Susan Burke	U.S. Environmental Protection Agency
23	James Burns	University of Virginia
24	Scott Calabrese Barton	Michigan State University
25	Pietro Caloprisco	Fuel Cells and Hydrogen Joint Undertaking (FCH JU)
26	Kevin Centeck	U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC)
27	Bryan Chapman	ExxonMobil
28	Santanu Chaudhuri	Argonne National Laboratory
29	Praveen Cheekatamarla	Atrex Energy, Inc.
30	Dejun Chen	Georgetown University
31	Biswajit Choudhury	E. I. du Pont de Nemours and Company (DuPont)
32	Eric Coker	Sandia National Laboratories
33	William Collins	WPCSOL, LLC (consultant)
34	Hector Colon-Mercado	Savannah River National Laboratory
35	David Cullen	Oak Ridge National Laboratory
36	Nilesh Dale	Nissan Technical Center North America, Inc.
37	Nemanja Danilovic	Lawrence Berkeley National Laboratory
38	Daniel DeSantis	Strategic Analysis, Inc.
39	Todd Deutsch	National Renewable Energy Laboratory
40	Huyen Dinh	National Renewable Energy Laboratory
41	Tabbetha Dobbins	Rowan University
42	Martin Dornheim	Helmholtz–Zentrum Geesthacht Centre for Materials and Coastal Research
43	Tyson Eckerle	California Governor's Office of Business and Economic Development
44	David Edwards	Air Liquide
45	Glenn Eisman	Eisman Technology Consultants, LLC
46	S. Elongo Elangovan	OxEon Energy, LLC
47	Leslie Eudy	National Renewable Energy Laboratory
48	Mitch Ewan	University of Hawaii, Manoa/Hawaii Natural Energy Institute
49	Gary Flood	GSF Consulting, LLC
50	Prabhu Ganesan	Greenway Energy, LLC
51	Monterey Gardiner	BMW Group
52	Dominic Francis (Don) Gervasio	University of Arizona
53	Hossein Ghezel-Ayagh	FuelCell Energy, Inc.
54	William Gibbons	University of Maryland
55	Craig Gittleman	General Motors
56	Colin Gore	RedOx Power Systems
57	Leo Grassilli	U.S. Department of the Navy, Office of Naval Research (retired)
58	Markus Gross	BMW Group
59	Tom Gross	Energy Planning and Solutions
60	Stephen Grot	Ion Power
61	Katrina Groth	University of Maryland
62	Jennifer Hamilton	Frontier Energy/California Fuel Cell Partnership
63	Aaron Harris	Air Liquide
64	Kevin Harrison	National Renewable Energy Laboratory
65	Jason Hattrick-Simpers	National Institute of Standards and Technology
66	Andrew Haug	3M
67	James Hinkley	Commonwealth Scientific and Industrial Research

No.	Name	Organization
		Organization (CSIRO)
68	Shinichi Hirano	Ford Motor Company
69	Jamie Holladay	Pacific Northwest National Laboratory
70	Nick Irvin	Southern Company
71	Levi Irwin	ManTech International Corporation/U.S. Department of Energy, Solar Energy Technologies Office
72	Ian Jakupca	NASA
73	Brian James	Strategic Analysis, Inc.
74	Lisa Jerram	American Public Transportation Association
75	Nicholas Josefik	U.S. Army Corps of Engineers
76	Richard Kallman	City of Santa Fe Springs, Department of Fire – Rescue
77	Tim Karlsson	International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)
78	Joerg Karstedt	Zentrum für BrennstoffzellenTechnik (ZBT) GmbH
79	Douglass Kauffman	National Energy Technology Laboratory
80	Jay Keller	Zero Carbon Energy Solutions (consultant)
81	Ronald Kent	Southern California Gas Company/Sempra Energy
82	Yu Seung Kim	Los Alamos National Laboratory
83	Benjamin Klahr	CNA Corporation
84	Shanna Knights	Ballard Power Systems
85	Brian Koeppel	Pacific Northwest National Laboratory
86	Anusorn Kongkanand	General Motors
87	Michael Koonce	Luxfer-GTM Technologies, LLC
88	John Kopasz	Argonne National Laboratory
89	Theodore Krause	Argonne National Laboratory
90	Ahmet Kusoglu	Lawrence Berkeley National Laboratory
91	Stephan Lany	National Renewable Energy Laboratory
92	Mark Lausten	Allegheny Science & Technology, supporting U.S. Department of Energy, Solar Energy Technologies Office
93	Mark Leavitt	General Motors
94	Ludwig Lipp	T2M Global
95	Di-Jia Liu	Argonne National Laboratory
96	Meilin Liu	Georgia Institute of Technology
97	Daryl Ludlow	Ludlow Electrochemical Hardware Corporation
98	Miguel Maes	NASA White Sands Test Facility
99	Zq Mao	Tsinghua University
100	Radenka Maric	University of Connecticut
101	Andrew Martinez	California Air Resources Board
102	Sara Marxen	CSA Group
103	David Masten	General Motors
104	Christopher Matranga	National Energy Technology Laboratory
105	Paul Matter	pH Matter, LLC
106	Anthony McDaniel	Sandia National Laboratories
107	Stephen McDougle	MEI Technologies, Inc. (consultant to NASA White Sands Test Facility)
108	Kyle McKeown	The Linde Group
109	Noah Meeks	Southern Company
110	Nguyen Minh	University of California, San Diego
111	Cortney Mittelsteadt	Giner, Inc.
112	Miguel Modestino	New York University
113	Pietro Moretto	European Commission Joint Research Centre (JRC)
114	Syed Mubeen	University of Iowa

No.	Name	Organization
115	Christopher Muhich	Arizona State University
116	Rangachary Mukundan	Los Alamos National Laboratory
117	Deborah Myers	Argonne National Laboratory
118	Tien Nguyen	Independent
119	William Notardonato	NASA Kennedy Space Center
120	James O'Brien	Idaho National Laboratory
121	Robert Oesterreich	Air Liquide
122	Tadashi Ogitsu	Lawrence Livermore National Laboratory
123	Gregory Olson	CSRA Inc. (consultant)
124	Pinakin Patel	T2M Global
125	Matthew Pellow	Electric Power Research Institute (EPRI)
126	Michael Penev	National Renewable Energy Laboratory
127	Mike Perry	United Technologies Research Center (UTRC)
128	Michael Peters	National Renewable Energy Laboratory
129	Guillaume Petitpas	Lawrence Livermore National Laboratory
130	Joseph Pierre	KeyLogic Systems, Inc.
131	Peter Pintauro	Vanderbilt University
132	Bryan Pivovar	National Renewable Energy Laboratory
133	Karen Quackenbush	Fuel Cell and Hydrogen Energy Association
134	Glenn Rambach	California State University, Bakersfield/Third Orbit Power Systems, Inc.
135	Jeffrey G. Reed	University of California, Irvine
136	Joel Rinebold	Connecticut Center for Advanced Technology, Inc.
137	Tommy Rockward	Los Alamos National Laboratory
138	Ian Rowe	U.S. Department of Energy
139	Tecle Rufael	Chevron Energy Technology Company
140	Mark Ruth	National Renewable Energy Laboratory
141	Christian Sattler	German Aerospace Center (DLR)
142	Troy Semelsberger	Los Alamos National Laboratory
143	Alexey Serov	University of New Mexico, Center for Emerging Energy Technologies/Pajarito Powder, LLC
144	Kevin Simmons	Pacific Northwest National Laboratory
145	Joshua Snyder	Drexel University
146	Petros Sofronis	University of Illinois at Urbana-Champaign/International Institute for Carbon-Neutral Energy Research (I^2CNER)
147	Herie Soto	Shell Oil Company
148	Jacob Spendelow	Los Alamos National Laboratory
149	Vojislav Stamenkovic	Argonne National Laboratory
150	Andy Steinbach	3M
151	Nadia Steiner	Université de Franche-Comté
152	Jeff Stevenson	Pacific Northwest National Laboratory
153	Gary Stottler	General Motors
154	Jean St-Pierre	University of Hawaii, Manoa/Hawaii Natural Energy Institute
155	Scott Swartz	Nexceris, LLC
156	Karen Swider-Lyons	U.S. Naval Research Laboratory
157	Sandy Thomas	Clean Car Options (retired)
158	Mark Toughiry	U.S. Department of Transportation
159	Hiroshi Tsuchiya	New Energy and Industrial Technology Development Organization (NEDO)
160	Michael Ulsh	National Renewable Energy Laboratory
161	Hiroyuki Usuda	New Energy and Industrial Technology Development Organization (NEDO)

No.	Name	Organization
162	Nicholas Vanderborgh	Los Alamos National Laboratory (retired)
163	Mike Veenstra	Ford Motor Company
164	Laura Verduzco	Chevron Corporation
165	George Walchuk	ExxonMobil Research and Engineering Company
166	James Waldecker	Ford Motor Company
167	Adam Weber	Lawrence Berkeley National Laboratory
168	Jan Wegener	NOW GmbH
169	Douglas Wheeler	DJW Technology, LLC
170	Mark Williams	AECOM/National Energy Technology Laboratory
171	Stephen Woods	NASA
172	Hui Xu	Argonne National Laboratory
173	Piotr Zelenay	Los Alamos National Laboratory
174	Junliang Zhang	Shanghai Jiao Tong University (SITU)
175	Jonathan Zimmerman	Sandia National Laboratories
176	Barr Zulevi	Pajarito Powder, LLC

Summary of Peer Review Panel's Crosscutting Comments and Recommendations

AMR panel members provided comments and recommendations regarding selected DOE hydrogen and fuel cell projects, overall management of the Hydrogen and Fuel Cells Program, and the AMR peer evaluation process. The project comments, recommendations, and scores are provided in the following sections of this report, grouped by sub-program. Comments about Program and sub-program management are provided in Appendix A.

Analysis Methodology

A total of **116** Fuel Cell Technologies Office (FCTO) projects were reviewed at the meeting. As shown in the table above, **176** review panel members participated in the AMR process, providing a total of **665** project evaluations. These reviewers were asked to provide numeric scores (on a scale of 1–4, including half-point intervals, with 4 being the highest) for five aspects of the work presented. Sample evaluation forms are provided in Appendix C. Scores and comments were submitted using laptops (provided on-site) to a private online database, allowing for real-time tracking of the review process. A list of projects that were presented at the AMR but not reviewed is provided in Appendix D.

For the Hydrogen Fuel R&D; Fuel Cell R&D; Technology Acceleration and Hydrogen Infrastructure R&D; Safety, Codes and Standards; and Systems Analysis sub-programs, scores were based on the five criteria and weights provided below. The Hydrogen Fuel R&D sub-program includes two project categories: Hydrogen Production and Delivery R&D and Hydrogen Storage R&D; these were similarly evaluated.

Score 1: Approach to performing the work (20%)
Score 2: Accomplishments and progress toward overall project and DOE goals (45%)
Score 3: Collaboration and coordination with other institutions (10%)
Score 4: Relevance/potential impact on DOE Program goals and RD&D objectives (15%)
Score 5: Proposed future work (10%)

For each project, individual reviewer scores for each of the five criteria were weighted using the formula in the box below to create a final score for each reviewer for that project. The average score for each project was then calculated by averaging the final scores for individual reviewers. The individual reviewer scores for each question were also averaged to provide information on the project's question-by-question scoring. In this manner, a project's final overall score can be meaningfully compared to that of another project.

Final Overall Score = [Score 1 x 0.20] + [Score 2 x 0.45] + [Score 3 x 0.10] + [Score 4 x 0.15] + [Score 5 x 0.10]

A perfect overall score of "4" indicates that a project satisfied the five criteria to the fullest possible extent; the lowest possible overall score of "1" indicates that a project did not satisfactorily meet any of the requirements of the five criteria.

This year, the Hydrogen Production and Delivery R&D category included a sub-category for HydroGEN seedling projects. The evaluation form for these projects (included in Appendix C) was modified to address their unique features; the scores for these projects were based on the following five criteria and weights:

Score 1: Approach to performing the work (20%)
Score 2: Relevance/potential impact on DOE Program goals and RD&D objectives and the HydroGEN Consortium mission (15%)
Score 3: Accomplishments and progress toward overall project and DOE goals and the HydroGEN Consortium mission (30%)
Score 4: Collaboration effectiveness with HydroGEN and, as appropriate, other institutions (25%)
Score 5: Proposed future work (10%)

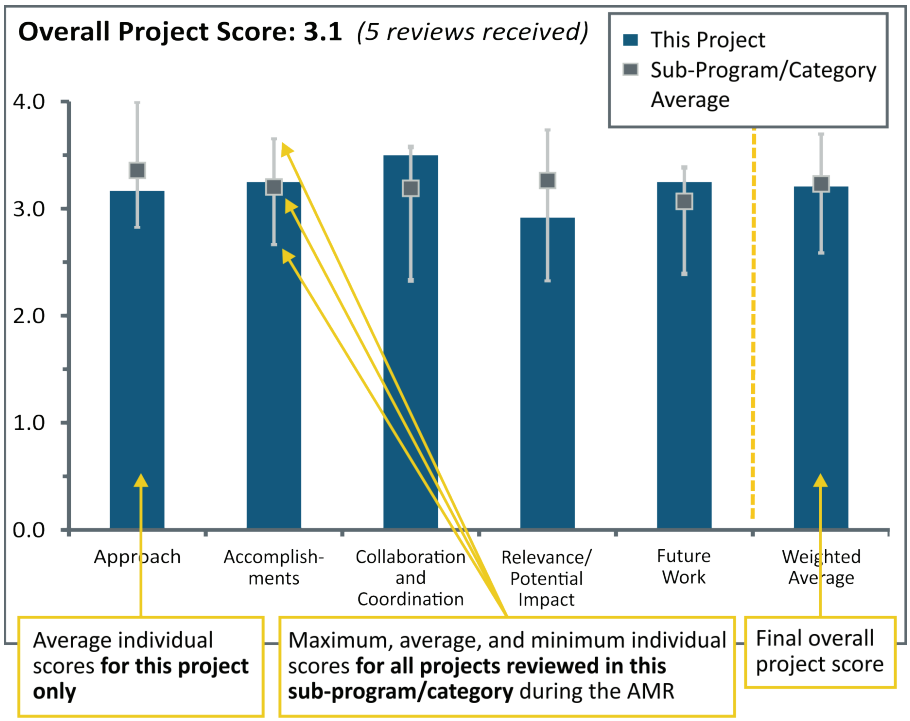
For all projects, reviewers were also asked to provide qualitative comments regarding the five criteria, specific strengths and weaknesses of the project, and any recommendations relating to the work scope. These comments were also entered into the private online database for easy retrieval and analysis.

Organization of the Report

The project comments and scores are grouped by sub-program (Hydrogen Fuel R&D; Fuel Cell R&D; Technology Acceleration and Hydrogen Infrastructure R&D; Safety, Codes and Standards; and Systems Analysis) and, in the case of Hydrogen Fuel R&D, by (sub)category (Hydrogen Production and Delivery R&D, HydroGEN Seedling, and Hydrogen Storage R&D) to align with FCTO's planning scheme. Each of these sections begins with a brief description of the general type of research and development or other activity being conducted. Next are the results of the reviews of each project presented at the 2018 AMR, with a summary of the qualitative comments for each project.

Each individual project summary also includes a graph showing the overall project score and a comparison of how each project aligns with all of the other projects in its sub-program or (sub)category. Projects are compared based on the consistent set of criteria listed above. Each project report includes a chart with bars representing that project's average scores for each of the five designated criteria. The gray vertical hash marks that overlay the blue bars represent the corresponding maximum, average, and minimum scores for all of the projects in the same sub-program. A sample graph is provided.

Sample Project Score Graph with Explanation



For clarification, consider a hypothetical review in which only five projects were presented and reviewed in a sub-program. Table 2 displays the average scores for each project according to the five rated criteria.

Table 2: Sample Project Scores

	Approach (20%)	Accomplishments (45%)	Collaboration and Coordination (10%)	Relevance/ Potential Impact (15%)	Future Work (10%)
Project A	3.4	3.3	3.3	3.2	3.1
Project B	3.1	2.8	2.7	2.7	2.9
Project C	3.0	2.6	2.7	2.8	2.9
Project D	3.4	3.5	3.4	3.2	3.3
Project E	3.6	3.7	3.5	3.4	3.4
Maximum	3.6	3.7	3.5	3.4	3.4
Average	3.3	3.2	3.1	3.0	3.1
Minimum	3.0	2.6	2.7	2.7	2.9

Using these data, the chart for Project A would contain five bars representing the values listed for that project in Table 2. A gray hash mark indicating the related maximum, average, and minimum values for all of the projects in Project A's sub-program or (sub)category (the last three lines in Table 2) would overlay each corresponding bar to facilitate comparison. In addition, each project's criteria scores would be weighted and combined to produce a final, overall project score that would permit meaningful comparisons to other projects. Below is a sample calculation for the Project A weighted score.

Final Score for Project A = [3.4 x 0.20] + [3.3 x 0.45] + [3.3 x 0.10] + [3.2 x 0.15] + [3.1 x 0.10] = 3.3