Introduction

The fiscal year (FY) 2016 U.S. Department of Energy (DOE) Hydrogen and Fuel Cells Program (the Program) Annual Merit Review and Peer Evaluation Meeting (AMR), in conjunction with DOE's Vehicle Technologies Office Annual Merit Review, was held June 6–10, 2016, 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 DOE offices (including the Office of Science [Basic Energy Sciences] and Advanced Research Projects Agency – Energy [ARPA-E]) in areas relevant to hydrogen and fuel cells were also presented at the FY 2016 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 2016 accomplishments and FY 2017 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 complete list of the meeting participants is presented as Appendix A.

Table 1: Peer Review Panel Members

No.	Name	Organization
1	Aceves, Salvador	Lawrence Livermore National Laboratory
2	Afzal, Kareem	PDC Machines, Inc.
3	Ahluwalia, Rajesh	Argonne National Laboratory
4	Ahn, Channing	California Institute of Technology
5	Ainscough, Chris	National Renewable Energy Laboratory
6	Allendorf, Mark	Sandia National Laboratories
7	Ardo, Shane	University of California, Irvine
8	Arif, Muhammad	National Institute of Standards and Technology
9	Autrey, Tom	Pacific Northwest National Laboratory
10	Benard, Pierre	Hydrogen Research Institute
11	Benjamin, Thomas	Argonne National Laboratory
12	Bonner, Brian	Air Products and Chemicals, Inc.
13	Bordeaux, Christopher	Bordeaux International Energy Consulting LLC
14	Borup, Rodney	Los Alamos National Laboratory
15	Bouwkamp, Nico	California Fuel Cell Partnership
16	Bowden, Mark	Pacific Northwest National Laboratory
17	Bowman, Robert	Oak Ridge National Laboratory
18	Boyd, Robert	Boyd Hydrogen LLC
19	Brooks, Kriston	Pacific Northwest National Laboratory
20	Brown, Craig	National Institute of Standards and Technology
21	Bunnelle, Eric	Exxon Mobil Corporation
22	Burgunder, Albert	Praxair, Inc.
23	Capauno, Chris	Proton OnSite
24	Cargnelli, Joseph	Hydrogenics Corporation

No.	Name	Organization
25	Centeck, Kevin	U.S. Army, TARDEC
26	Chapman, Bryan	Exxon Mobil Corporation
27	Chernicoff, William	Toyota Motor Corporation
28	Choudhury, Biswajit	DuPont
29	Collins, William	Consultant
30	Creager, Stephen	Clemson University
31	Cullen, David	Oak Ridge National Laboratory
32	Curry-Nkansah, Maria	Argonne National Laboratory
33	Dale, Nilesh	Nissan Technical Center North America, Inc.
34	DeSantis, Daniel	SAINC
35	Dillich, Sara	Retired, U.S. Department of Energy
36	Dinh, Huyen	National Renewable Energy Laboratory
37	Dismukes , Charles	Rutgers University
38	Dobbins, Tabbetha	Rowan University
39	Edwards, David	Air Liquide Advanced Business and Technologies
40	El-Awady, Jaafar	Johns Hopkins University
41	Elrick, William	California Fuel Cell Partnership
42	Eudy, Leslie	National Renewable Energy Laboratory
43	Ewan, Mitch	University of Hawaii, Manoa
44	Farese, David	Air Products and Chemicals, Inc.
45	Fenske, George	Argonne National Laboratory
46	Fitzgerald, Jay	U.S. Department of Energy
47	Francfort, Jim	Idaho National Laboratory
48	Funk, Stuart	LMI
49	Ganesan, Prabhu	Savannah River Consulting LLC
50	Garcia Hombrados, Alberto	Fuel Cells and Hydrogen Joint Undertaking (FCH JU)
51	Garzon, Fernando	University of New Mexico
52	Gennett, Thomas	National Renewable Energy Laboratory
53	George, Paul	Battelle
54	Gittleman, Craig	General Motors
55	Grassilli, Leo	Consultant
56	Grot, Stephen	Ion Power
57	Gupta, Ram	Virginia Commonwealth University
58	Haight, Andrea	Composite Technology Development, Inc.
59	Halevi, Barr	Pajarito Powder LLC
60	Hamilton, Jennifer	California Fuel Cell Partnership
61	Han, Taehee	Nissan Technical Center North America, Inc.
62	Hartman, Brent	CSA Group
63	Herbert, Thorsten	NOW GmbH
64	Herring, Andy	Colorado School of Mines
65	Hirano, Shinichi	Ford Motor Company
66	Holladay, Jamie	Pacific Northwest National Laboratory
67	Horacek, Phil	Powertech
68	Houchins, Cassidy	Strategic Analysis, Inc.
69	Hua, Thanh	Argonne National Laboratory
70	James, Brian	Strategic Analysis, Inc.
71	Jensen, Craig	University of Hawaii, Honolulu
72	Jerram, Lisa	Navigant
73	Josefik, Nicholas	U.S. Army Corps of Engineers
74	Keller, Jay	Consultant
75	Khalil, John	United Technologies Research Center (UTRC)

No.	Name	Organization
76	Kim, Yu Seung	Los Alamos National Laboratory
77	King, Joel	U.S. Army, TARDEC
78	Knights, Shanna	Ballard Power Systems
79	Kocha, Shyan	National Renewable Energy Laboratory
80	Kongkanand, Anusorn	General Motors
81	Kopasz, John	Argonne National Laboratory
82	Kraigsley, Alison	National Institute of Health
83	Krause, Theodore	Argonne National Laboratory
84	Kuppa, Shashi	U.S. Department of Transportation
85	Kurtz, Jennifer	National Renewable Energy Laboratory
86	Lakshmanan, Balsu	General Motors
87	Lee, Doohwan	University of Seoul
88	Linkous, Clovis	Youngstown State University
89	Lipman, Timothy	University of California, Berkeley
90	Liu, Di-Jia	Argonne National Laboratory
91	Ludlow, Daryl	Ludlow Electrochemical Hardware
92	Markovic, Nenad	Argonne National Laboratory
93	Martinez, Andrew	California Air Resources Board
94	Masten, David	General Motors
95	McWhorter, Scott	Savannah River National Laboratory
96	Melaina, Marc	National Renewable Energy Laboratory
97	Miller, James	Argonne National Laboratory
98	Minh, Nguyen	University of California, San Diego
99	Mittelsteadt, Cortney	Giner, Inc.
100	Mohtadi, Rana	Toyota Motor Corporation
101	Moretto, Pietro	European Commission, Joint Research Centre
102	Mukerjee, Sanjeev	Northeastern University
103	Mukundan, Rangachary	Los Alamos National Laboratory
104	Myers, Charlie	Trenergi Corporation
105	Notardonato, William	National Aeronautics and Space Administration
106	Nyberg, Eric	Washington State University
107	Odgaard, Madeleine	IRD Fuel Cells LLC
108	Oesterreich, Bob	Air Liquide
109	Olson, Gregory	Consultant
110	Ott, Kevin	Los Alamos National Laboratory
111	Parks, George	FuelScience LLC
112	Patel, Pinakin	Fuel Cell Energy, Inc.
113	Peden, Chuck	Pacific Northwest National Laboratory
114	Perry, Mike	United Technologies Research Center
115	Pivovar, Bryan	National Renewable Energy Laboratory
116	Polevaya, Olga	Nuvera Fuel Cells, Inc.
117	Prasad, Ajay	University of Delaware
118	Quackenbush, Karen	Fuel Cell and Hydrogen Energy Association
119	Ramirez-Cuesta, Timmy	Oak Ridge National Laboratory
120	Ramsden, Todd	National Renewable Energy Laboratory
121	Rice, Brian	University of Dayton Research Institute
122	Richards, Mark	Fuel Cell Energy, Inc.
123	Rinebold, Joel	Connecticut Center for Advanced Technology, Inc.
124	Rohatgi, Aashish	Pacific Northwest National Laboratory
125	Rousseau, Aymeric	Argonne National Laboratory
126	Rowe, Ian	U.S. Department of Energy
127	Rufael, Tecle	Chevron Corporation

No.	Name	Organization
128	Sandrock, Gary	Consultant
129	Serov, Alexey	University of New Mexico
130	Serre-Combe, Pierre	CEA (Alternative Energies and Atomic Energy Commission [France])
131	Siegel, Don	University of Michigan, Ann Arbor
132	Sievers, Robert	Teledyne Energy Systems
133	Sofronis, Petros	University of Illinois, Urbana-Champaign
134	Soto, Herie	Shell Oil Company
135	Spendelow, Jacob	Los Alamos National Laboratory
136	Stamenkovic, Vojislav	Argonne National Laboratory
137	Stavila, Vitalie	Sandia National Laboratories
138	Steinbach, Andy	3M
139	Steiner, Nadia	Universite de Franche-Comte
140	Stottler, Gary	General Motors
141	St-Pierre, Jean	University of Hawaii, Manoa
142	Swartz, Scott	NexTech Materials LTD
143	Swider-Lyons, Karen	U.S. Navy, Naval Research Laboratory
144	Tamhankar, Satish	Linde
145	Tchouvelev, Andrei	A.V.Tchouvelev & Associates Inc.
146	Thomas, Sandy	Clean Car Options
147	Toughiry, Mark	Department of Transportation
148	Tran, Thanh	U.S. Navy
149	Tsimis, Dionisis	Fuel Cells and Hydrogen Joint Undertaking (FCH JU)
150	Udovic, Terry	National Institute of Standards and Technology
151	Ulsh, Michael	National Renewable Energy Laboratory
152	Valdez, Thomas	National Aeronautics and Space Administration – Jet Propulsion Laboratory
153	Vanderborgh, Nicholas	Los Alamos National Laboratory
154	Veenstra, Mike	Ford Motor Company
155	Verduzco, Laura	Chevron Corporation
156	Vogel, John	Combined Energies LLC
157	Wagner, Frederick T.	General Motors
158	Waldecker, James	Ford Motor Company
159	Wang, Conghua	TreadStone Technologies, Inc.
160	Weber, Adam	Lawrence Berkeley National Laboratory
161	Wei, Max	Lawrence Berkeley National Laboratory
162	Wheeler, Douglas	DJW Technology LLC
163	Williams, Mark	National Energy Technology Laboratory
164	Woods, Stephen	National Aeronautics and Space Administration
165	Xu, Hui	Giner, Inc.
166	Yan, Yushan	University of Delaware
167	Yandrasits, Michael	3M
168	Zelenay, Piotr	Los Alamos National Laboratory

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 program. Comments about program management are provided in Appendix B.

Analysis Methodology

A total of **131** Fuel Cell Technologies Office (FCTO) projects were reviewed at the meeting. As shown in Table 1, **168** review panel members participated in the AMR process, providing a total of **716** 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 an online, private 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 Production and Delivery; Hydrogen Storage; Fuel Cells; Manufacturing R&D; Safety, Codes and Standards; and Systems Analysis programs, scores were based on the following five criteria and weights:

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.

For the Market Transformation and Technology Validation programs, scores were based on the following five criteria and weights:

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

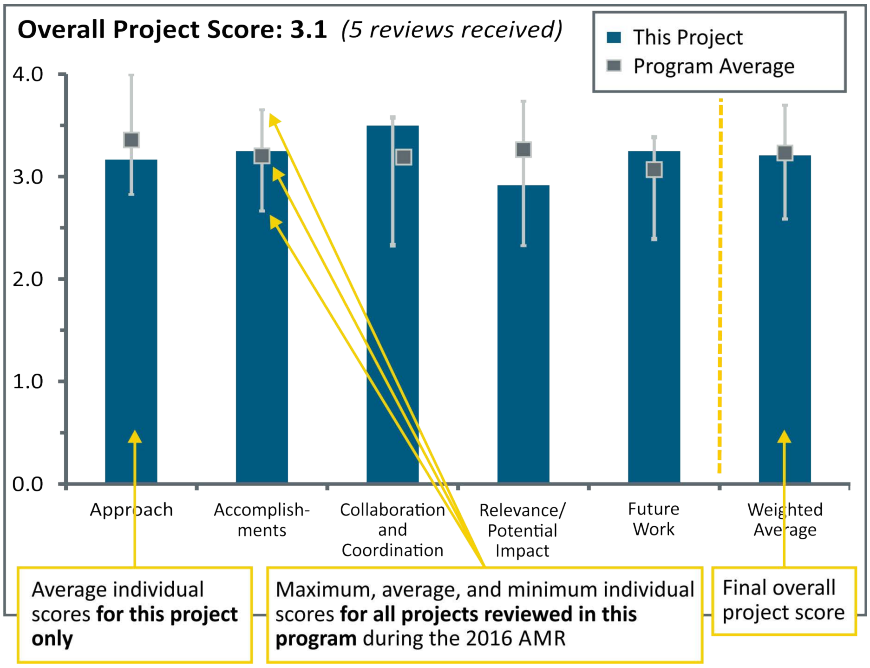
For all programs, reviewers were also asked to provide qualitative comments regarding the five criteria, specific strengths and weaknesses of the project, and any recommendations relating to the work scope. These comments were also entered into the online, private database for easy retrieval and analysis.

Organization of the Report

The project comments and scores are grouped by program (Hydrogen Production and Delivery; Hydrogen Storage; Fuel Cells; Manufacturing R&D; Technology Validation; Safety, Codes and Standards; Market Transformation; and Systems Analysis) in order 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 2016 AMR. The report also includes a summary of the qualitative comments for each project, as well as a graph showing the overall project score and a comparison of how each project aligns with all of the other projects in its program. A sample graph is provided in Figure 1.

Projects are compared based on a consistent set of criteria. 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 program.

Figure 1: Sample Project Score Graph with Explanation



For clarification, consider a hypothetical review in which only five projects were presented and reviewed in a 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 this 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 program (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