Introduction

The fiscal year (FY) 2015 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 8–12, 2015, at the Crystal Gateway Marriott and Crystal City Marriott in Arlington, Virginia. 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 2015 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 2015 accomplishments and FY 2016 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 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	Abdel-Baset, Tarek	Fiat Chrysler Automobiles
2	Adzic, Radoslav	Brookhaven National Laboratory
3	Afzal, Kareem	PDC Machines, Inc.
4	Ahmed, Shabbir	Argonne National Laboratory
5	Ainscough, Chris	National Renewable Energy Laboratory
6	Antoni, Laurent	CEA (Alternative Energies and Atomic Energy Commission [France])
7	Ardo, Shane	University of California, Irvine
8	Autrey, Thomas	Pacific Northwest National Laboratory
9	Ayers, Katherine	Proton OnSite
10	Balema, Viktor	Sigma-Aldrich
11	Barbosa, Nicholas	National Institute of Standards and Technology
12	Barilo, Nick	Pacific Northwest National Laboratory
13	Baturina, Olga	U.S. Navy, Naval Research Laboratory
14	Benjamin, Thomas	Argonne National Laboratory
15	Boillot, Lionel	European Commission, Fuel Cells and Hydrogen Joint Undertaking
16	Bonhoff, Klaus	NOW GmbH
17	Bonner, Brian	Air Products and Chemicals, Inc.
18	Bordeaux, Christopher	Bordeaux International Energy Consulting LLC
19	Borup, Rod	Los Alamos National Laboratory
20	Bouwkamp, Nico	California Fuel Cell Partnership
21	Bowden, Mark	Pacific Northwest National Laboratory
22	Bowerson, Dan	Fiat Chrysler Automobiles

No.	Name	Organization
23	Bowman, Robert	Oak Ridge National Laboratory
24	Boyd, Robert	Boyd Hydrogen LLC
25	Brandon, Erik	National Aeronautics and Space Administration, Jet Propulsion Laboratory
26	Brown, Craig	National Institute of Standards and Technology
27	Bunnelle, Eric	Exxon Mobil Corporation
28	Burgunder, Albert	Praxair, Inc.
29	Cai, Mei	General Motors
30	Cairns, Julie	CSA Group
31	Centeck, Kevin	U.S. Army, TARDEC (Tank Automotive Research, Development and Engineering Center)
32	Chapman, Bryan	Exxon Mobil Corporation
33	Choudhury, Biswajit	DuPont Fuel Cells
34	Collins, William	Consultant
35	Contini, Vince	Battelle
36	Cullen, David	Oak Ridge National Laboratory
37	Curry-Nkansah, Maria	Argonne National Laboratory
38	Dale, Nilesh	Nissan Technical Center North America, Inc.
39	Dillich, Sara	U.S. Department of Energy
40	Dinh, Huyen	National Renewable Energy Laboratory
41	Dixon, David	University of Alabama
42	Dornheim, Martin	Helmholtz-Zentrum Geesthacht
43	Eckerle, Tyson	State of California
44	Eisman, Glenn	Rensselaer Polytechnic Institute
45	Erlebacher, Jonah	Johns Hopkins University
46	Esposito, Dan	Columbia University
47	Eudy, Leslie	National Renewable Energy Laboratory
48	Ewan, Mitch	University of Hawaii, Manoa
49	Fenske, George	Argonne National Laboratory
50	Fisher, Allison	Cella Energy US
51	Fritz, Katrina	KM Fritz LLC
52	Ganesan, Prabhu	University of South Carolina
53	Garzon, Fernando	University of New Mexico
54	Gennett, Thomas	National Renewable Energy Laboratory
55	George, Paul	Battelle
56	Gervasio, Don	University of Arizona
57	Gittleman, Craig	General Motors
58	Graetz, Jason	HRL Laboratories
59	Grassilli, Leo	Consultant
60	Greene, David	University of Tennessee, Knoxville
61	Gross, Tom	Energy Planning and Solutions
62	Grot, Stephen	Ion Power
63	Gupta, Ram	Virginia Commonwealth University
64	Haight, Andrea	Composite Technology Development, Inc.
65	Halevi, Barr	Pajarito Powder LLC
66	Hall, Karen	Fuel Cell and Hydrogen Energy Association
67	Hamdan, Monjid	Giner, Inc.
68	Hamilton, Jennifer	California Fuel Cell Partnership
69	Hanlin, Jason	Center for Transportation and the Environment
70	Hardis, Jonathan	National Institute of Standards and Technology
71	Harris, Aaron	Air Liquide Advanced Technologies US
72	Hartman, Brent	CSA Group

No.	Name	Organization
73	Harvey, David	Ballard Power Systems
74	Hennessey, Barbara	U.S. Department of Transportation
75	Herring, Andy	Colorado School of Mines
76	Hirano, Shinichi	Ford Motor Company
77	Holladay, Jamie	Pacific Northwest National Laboratory
78	Hua, Thanh	Argonne National Laboratory
79	Huang, Xinyu	University of South Carolina
80	Jacobson, David	National Institute of Standards and Technology
81	James, Brian	Strategic Analysis, Inc.
82	Jaramillo, Thomas	Stanford University
83	Jensen, Craig	University of Hawaii, Honolulu
84	Jensen, Torben Rene	Aarhus University
85	Jerram, Lisa	Navigant
86	Keller, Jay	Consultant
87	Khalil, Y. (John)	United Technologies Research Center
88	Kienitz, Brian	Consultant
89	Klebanoff, Lennie	Sandia National Laboratories
90	Knights, Shanna	Ballard Power Systems
91	Kocha, Shyam	National Renewable Energy Laboratory
92	Kongkanand, Anusorn	General Motors
93	Kopasz, John	Argonne National Laboratory
94	Krause, Theodore	Argonne National Laboratory
95	Kreller, Cortney	Los Alamos National Laboratory
96	Kurtz, Jennifer	National Renewable Energy Laboratory
97	Lakshmanan, Balsu	General Motors
98	Levy, Michael	Aaqius
99	Liu, Di-Jia	Argonne National Laboratory
100	Ludlow, Daryl	Ludlow Electrochemical Hardware
101	Lymperopoulos, Nikolaos (Nikos)	European Commission, Fuel Cells and Hydrogen Joint Undertaking
102	Markovic, Nenad	Argonne National Laboratory
103	Martinez, Andrew	California Air Resources Board
104	Masten, David	General Motors
105	McDonald, Rob	Energetics Incorporated
106	McWhorter, Scott	Savannah River National Laboratory
107	Melaina, Marc	National Renewable Energy Laboratory
108	Mergel, Jurgen	Forschungszentrum Julich GmbH
109	Miller, James	Argonne National Laboratory
110	Minh, Nguyen	University of California, San Diego
111	Mittelsteadt, Cortney	Giner, Inc.
112	Mohtadi, Rana	Toyota Motor Corporation
113	More, Karren	Oak Ridge National Laboratory
114	Moretto, Pietro	European Commission, Joint Research Centre
115	Motyka, Ted	Savannah River National Laboratory
116	Mukerjee, Sanjeev	Northeastern University
117	Myers, Charlie	Trenergi Corporation
118	Myers, Deborah	Argonne National Laboratory
119	Nguyen, Nha	U.S. Department of Transportation
120	Niangar, Ellazar	Nissan Technical Center North America, Inc.
121	Nicholas, Mike	University of California, Davis
122	O'Brien, James	Idaho National Laboratory
123	Odgaard, Madeleine	IRD Fuel Cells LLC

No.	Name	Organization
124	Olson, Gregory	Consultant
125	Ott, Kevin	Los Alamos National Laboratory
126	Owejan, Jon	Alfred State, SUNY College of Technology
127	Parks, George	FuelScience LLC
128	Patel, Pinakin	Fuel Cell Energy, Inc.
129	Pecharsky, Vitalij	Iowa State University
130	Penev, Michael	National Renewable Energy Laboratory
131	Perret, Robert	Nevada Technical Services LLC
132	Perry, Mike	United Technologies Research Center
133	Pietrasz, Patrick	Ford Motor Company
134	Pivovar, Bryan	National Renewable Energy Laboratory
135	Ramsden, Todd	National Renewable Energy Laboratory
136	Resende, William	BMW
137	Rhodes, Bill	National Nuclear Security Administration
138	Richards, Mark	FuelCell Energy, Inc.
139	Rinebold, Joel	Connecticut Center for Advanced Technology, Inc.
140	Rose, Bob	Breakthrough Technologies Institute
141	Rufael, Tecle	Chevron Corporation
142	Sandrock, Gary	Oak Ridge National Laboratory
143	Schneider, Jesse	BMW
144	Serre-Combe, Pierre	CEA (Alternative Energies and Atomic Energy Commission [France])
145	Siegel, Don	University of Michigan, Ann Arbor
146	Snyder, Joshua	Drexel University
147	Sofronis, Petros	University of Illinois, Urbana-Champaign
148	Song, Min-Kyu	Washington State University
149	Soto, Herie	Shell Oil Company
150	Spitler, Mark	U.S. Department of Energy
151	Stamenkovic, Vojislav	Argonne National Laboratory
152	Steinbach, Andy	3M
153	Stolten, Detlef	Forschungszentrum Julich GmbH
154	St-Pierre, Jean	University of Hawaii, Manoa
155	Swartz, Scott	NexTech Materials, LTD
156	Thomas, C.E. (Sandy)	Clean Car Options
157	Toughiry, Mark	U.S. Department of Transportation
158	Trabold, Tom	Rochester Institute of Technology
159	Trocciola, John	SRA International, Inc.
160	van der Vliet, Dennis	3M
161	van Hassel, Bart	United Technologies Research Center
162	Vanderborgh, Nicholas	Los Alamos National Laboratory (retired)
163	Veenstra, Mike	Ford Motor Company
164	Verduzco, Laura	Chevron Corporation
165	Wagner, Frederick T.	General Motors
166	Waldecker, James	Ford Motor Company
167	Walk, Alex	SGL Group
168	Wang, Conghua	TreadStone Technologies, Inc.
169	Warren, Dave	Oak Ridge National Laboratory
170	Weber, Adam	Lawrence Berkeley National Laboratory
171	Wei, Max	Lawrence Berkeley National Laboratory
172	Wheeler, Douglas	DJW Technology LLC
173	Williams, Mark	National Energy Technology Laboratory
174	Wilson, Mahlon	Los Alamos National Laboratory

No.	Name	Organization
175	Woods, Stephen	National Aeronautics and Space Administration
176	Xu, Hui	Giner, Inc.
177	Yandrasits, Michael	3M
178	Zelenay, Piotr	Los Alamos National Laboratory
179	Zhu, Yimin	OneD Material, 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 sub-program management are provided in Appendix B.

Analysis Methodology

A total of **117** Fuel Cell Technologies Office (FCTO) projects were reviewed at the meeting. As shown in Table 1, **179** review panel members participated in the AMR process, providing a total of **704** 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 sub-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 sub-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%)

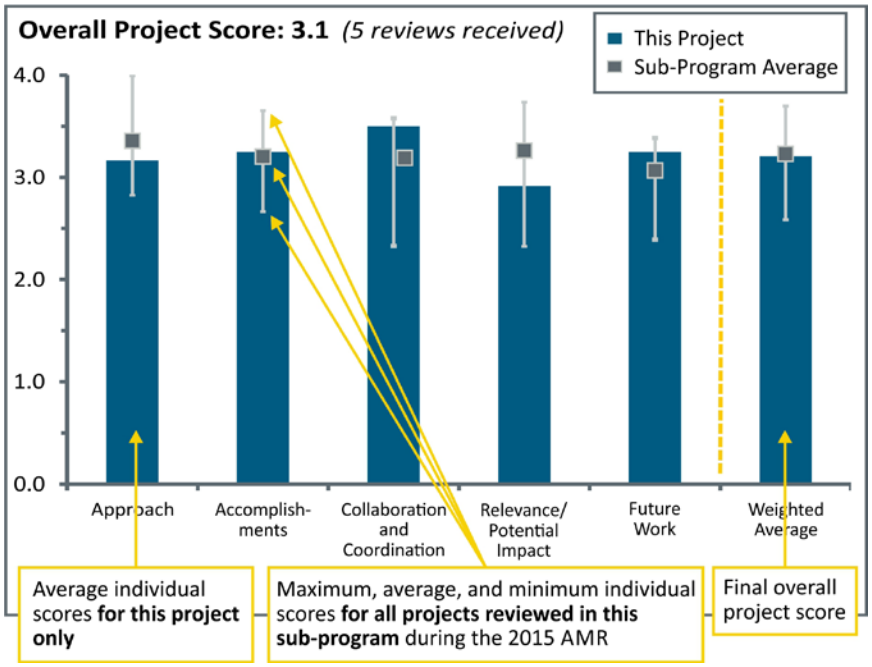
For all sub-programs, reviewers were also asked to provide qualitative comments regarding the five criteria, specific strengths and weaknesses of the project, and any recommendations relating to the work scope. These comments were also entered into the online, private database for easy retrieval and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

Organization of the Report

The project comments and scores are grouped by sub-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 2015 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 sub-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 sub-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 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 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 sub-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