

Table of Contents

Introduction	1
Hydrogen Production and Delivery	7
PD-014: Hydrogen Delivery Infrastructure Analysis	11
PD-025: Fatigue Performance of High-Strength Pipeline Steels and Their Welds in Hydrogen Gas Service	14
PD-031: Renewable Electrolysis Integrated System Development and Testing	17
PD-038: Biomass to Hydrogen (B2H2).....	20
PD-088: Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage	25
PD-096: Electrolyzer Component Development for the Hybrid Sulfur Thermochemical Cycle	28
PD-100: 700 bar Hydrogen Dispenser Hose Reliability Improvement.....	32
PD-101: Cryogenically Flexible, Low-Permeability Hydrogen Delivery Hose.....	35
PD-102: Analysis of Advanced Hydrogen Production Pathways.....	39
PD-103: High-Performance, Long-Lifetime Catalysts for Proton Exchange Membrane Electrolysis	43
PD-107: Hydrogen Fueling Station Pre-Cooling Analysis	46
PD-108: Hydrogen Compression Application of the Linear Motor Reciprocating Compressor	50
PD-109: Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage.....	54
PD-110: Low-Cost Hydrogen Storage at 875 bar Using Steel Liner and Steel Wire Wrap	57
PD-111: Monolithic Piston-Type Reactor for Hydrogen Production through Rapid Swing of Reforming/Combustion Reactions	60
PD-113: High-Efficiency Solar Thermochemical Reactor for Hydrogen Production.....	63
PD-114: Flowing Particle Bed Solarthermal Reduction–Oxidation Process to Split Water	67
PD-115: High-Efficiency Tandem Absorbers for Economical Solar Hydrogen Production.....	71
PD-116: Wide-Bandgap Chalcopyrite Photoelectrodes for Direct Solar Water Splitting	75
PD-123: High-Performance Platinum-Group-Metal-Free Membrane Electrode Assemblies through Control of Interfacial Processes	79
PD-124: Solid-Oxide-Based Electrolysis and Stack Technology with Ultra-High Electrolysis Current Density (>3A/cm ²) and Efficiency	82
PD-125: Tandem Particle Slurry Batch Reactors for Solar Water Splitting	85
PD-126: Compressorless Hydrogen Refueling Station Using Thermal Compression.....	89
PD-127: Sweet Hydrogen: High-Yield Production of Hydrogen from Biomass Sugars Catalyzed by In Vitro Synthetic Biosystems	94
PD-130: Improved Hydrogen Liquefaction through Heisenberg Vortex Separation of Para- and Orthohydrogen	97
PD-131: Magnetocaloric Hydrogen Liquefaction.....	101
PD-132: Advanced Barrier Coatings for Harsh Environments.....	106
PD-133: Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST) – Consolidation	109
PD-134: Cryo-Compressed Pathway Analysis	111

Hydrogen Storage	114
ST-001: System-Level Analysis of Hydrogen Storage Options.....	117
ST-004: Hydrogen Storage Engineering Center of Excellence.....	122
ST-008: Hydrogen Storage System Modeling: Public Access, Maintenance, and Enhancements.....	127
ST-063: Reversible Formation of Alane	132
ST-100: Hydrogen Storage Cost Analysis	136
ST-111: Thermomechanical Cycling of Thin-Liner, High-Fiber-Fraction Cryogenic Pressure Vessels Rapidly Refueled by Liquid Hydrogen Pump to 700 bar	140
ST-113: Innovative Development, Selection, and Testing to Reduce Cost and Weight of Materials for Balance-of-Plant Components	145
ST-114: Next-Generation Hydrogen Storage Vessels Enabled by Carbon Fiber Infusion with a Low-Viscosity, High-Toughness Resin System.....	149
ST-115: Achieving Hydrogen Storage Goals through High-Strength Fiberglass	153
ST-116: Low-Cost α -Alane for Hydrogen Storage	157
ST-118: Improving the Kinetics and Thermodynamics of $Mg(BH_4)_2$ for Hydrogen Storage	161
ST-119: High-Capacity Hydrogen Storage Systems via Mechanochemistry	165
ST-120: Design and Synthesis of Materials with High Capacities for Hydrogen Physisorption	169
ST-121: High-Capacity and Low-Cost Hydrogen-Storage Sorbents for Automotive Applications	173
ST-122: Hydrogen Adsorbents with High Volumetric Density: New Materials and System Projections	178
ST-126: Conformable Hydrogen Storage Coil Reservoir	181
ST-127: Hydrogen Materials–Advanced Research Consortium (HyMARC): A Consortium for Advancing Solid-State Hydrogen Storage Materials	185
ST-128: HyMARC: Sandia National Laboratories Effort	190
ST-129: HyMARC: Lawrence Livermore National Laboratory Effort.....	195
ST-130: HyMARC: Lawrence Berkeley National Laboratory Effort.....	199
ST-131: Hydrogen Storage Characterization and Optimization Research Efforts	204
ST-132: Hydrogen Storage Characterization Research Efforts	209
ST-133: Hydrogen Storage Characterization and Optimization Research Effort.....	213
Fuel Cells	218
FC-017: Fuel Cells Systems Analysis	221
FC-018: Fuel Cell Vehicle and Bus Cost Analysis	226
FC-020: New Fuel Cell Materials: Characterization and Method Development	230
FC-021: Neutron Imaging Study of the Water Transport in Operating Fuel Cells.....	235
FC-052: Technical Assistance to Developers	239
FC-081: Fuel Cell Technology Status: Degradation.....	241
FC-097: Stationary and Emerging Market Fuel Cell System Cost Analysis – Primary Power and Combined Heat and Power Applications.....	245
FC-098: A Total Cost of Ownership Model for Design and Manufacturing Optimization of Fuel Cells in Stationary and Emerging Market Applications	250
FC-104: High-Performance, Durable, Low-Cost Membrane Electrode Assemblies for Transportation Applications.....	254

FC-106:	Rationally Designed Catalyst Layers for Polymer Electrolyte Membrane Fuel Cell Performance Optimization	259
FC-107:	Non-Precious-Metal Fuel Cell Cathodes: Catalyst Development and Electrode Structure Design	263
FC-109:	New Fuel Cell Membranes with Improved Durability and Performance	269
FC-110:	Advanced Hybrid Membranes for Next-Generation Polymer Electrolyte Membrane Fuel Cell Automotive Applications.....	274
FC-116:	Smart Matrix Development for Direct Carbonate Fuel Cell	279
FC-128:	Facilitated Direct Liquid Fuel Cells with High-Temperature Membrane Electrode Assemblies.....	283
FC-129:	Advanced Catalysts and Membrane Electrode Assemblies for Reversible Alkaline Membrane Fuel Cells	286
FC-130:	Development of Platinum-Group-Metal-Free Catalysts for Hydrogen Oxidation Reaction in Alkaline Media	291
FC-131:	Highly Stable Anion-Exchange Membranes for High-Voltage Redox-Flow Batteries	295
FC-132:	Innovative Non-Platinum-Group-Metal Catalysts for High-Temperature Polymer Electrolyte Membrane Fuel Cells	300
FC-135:	Fuel Cell Consortium for Performance and Durability – Consortium Overview.....	305
FC-136:	Fuel Cell Consortium for Performance and Durability – Electrocatalysts and Supports	311
FC-137:	Fuel Cell Consortium for Performance and Durability – Electrode Layer Integration.....	316
FC-138:	Fuel Cell Consortium for Performance and Durability – Ionomers, Gas Diffusion Layers, Interfaces	321
FC-139:	Fuel Cell Consortium for Performance and Durability – Modeling, Evaluation, Characterization	326
FC-140:	Tailored High-Performance Low-Platinum-Group-Metal Alloy Cathode Catalysts	331
FC-141:	Platinum Monolayer Electrocatalysts	336
FC-142:	Extended Surface Electrocatalyst Development	341
FC-143:	Highly Active, Durable, and Ultra-Low-Platinum-Group-Metal Nanostructured Thin Film Oxygen Reduction Reaction Catalysts and Supports	346
FC-144:	Highly Accessible Catalysts for Durable High-Power Performance	351
FC-145:	Corrosion-Resistant Non-Carbon Electrocatalyst Supports for Proton Exchange Fuel Cells	355
FC-146:	Advanced Materials for Fully Integrated Membrane Electrode Assemblies in Anion Exchange Membrane Fuel Cells	359
FC-147:	Advanced Ionomers and Membrane Electrode Assemblies for Alkaline Membrane Fuel Cells	363
FC-149:	Multiscale Modeling of Fuel Cell Membranes.....	366
Manufacturing R&D.....		369
MN-001:	Fuel Cell Membrane Electrode Assembly Manufacturing Research and Development.....	371
MN-012:	Clean Energy Supply Chain and Manufacturing Competitiveness Analysis for Hydrogen and Fuel Cell Technologies	374
MN-013:	Fuel Cell and Hydrogen Opportunity Center	378
MN-014:	U.S. Clean Energy Hydrogen and Fuel Cell Technologies: A Competitiveness Analysis.....	381
MN-017:	Manufacturing Competitiveness Analysis for Hydrogen Refueling Stations.....	385

Technology Validation	388
TV-001: Fuel Cell Electric Vehicle Evaluation.....	391
TV-008: Fuel Cell Bus Evaluations	394
TV-017: Hydrogen Station Data Collection and Analysis.....	397
TV-019: Hydrogen Component Validation	401
TV-025: Performance Evaluation of Delivered Hydrogen Fueling Stations	404
TV-026: Development of the Hydrogen Station Equipment Performance (HyStEP) Device.....	406
TV-027: Station Operational Status System (SOSS) 3.0 Implementation, SOSS 3.1 Upgrade, and Station Map Upgrade Project	409
TV-028: Advanced Hydrogen Fueling Station Supply: Tube Trailers.....	412
TV-029: Performance and Durability Testing of Volumetrically Efficient Cryogenic Vessels and High-Pressure Liquid Hydrogen Pump.....	414
TV-031: Dynamic Modeling and Validation of Electrolyzers in Real-Time Grid Simulation	418
TV-032: Fuel Cell Electric Truck Component Sizing	421
TV-033: Brentwood Case Study.....	424
TV-034: Fuel Cell Hybrid Electric Delivery Van Project	428
TV-037: Hydrogen Meter Benchmark Testing.....	432
 Safety, Codes and Standards	 439
SCS-001: National Codes and Standards Deployment and Outreach	441
SCS-002: Hydrogen Component Research and Development.....	445
SCS-005: Research and Development for Safety, Codes and Standards: Material and Component Compatibility	448
SCS-007: Hydrogen Fuel Quality.....	451
SCS-011: Hydrogen Quantitative Risk Assessment.....	454
SCS-019: Hydrogen Safety Panel, Safety Knowledge Tools, and First Responder Training Resources	457
SCS-021: National Renewable Energy Laboratory Hydrogen Sensor Testing Laboratory.....	461
SCS-022: Fuel Cell & Hydrogen Energy Association Codes and Standards Support	465
SCS-025: Enabling Hydrogen Infrastructure through Science-Based Codes and Standards	468
SCS-026: Compatibility of Polymeric Materials Used in the Hydrogen Infrastructure	471
 Market Transformation	 474
MT-008: Hydrogen Energy Systems as a Grid Management Tool.....	476
MT-011: Ground Support Equipment Demonstration	480
MT-013: Maritime Fuel Cell Generator Project	483
MT-014: Demonstration of Fuel Cell Auxiliary Power Unit to Power Truck Refrigeration Units in Refrigerated Trucks.....	487
MT-017: Medium-Duty Parcel Delivery Truck.....	490
MT-020: Fuel Cell-Battery Electric Hybrid for Utility or Municipal Medium- or Heavy-Duty Bucket Trucks – Fuel-Cell-Powered Auxiliary Power Module	493

Systems Analysis	496
SA-035: Employment Impacts of Hydrogen and Fuel Cell Technologies.....	500
SA-039: Life-Cycle Analysis of Water Consumption for Hydrogen Production	504
SA-044: Impact of Fuel Cell and Hydrogen Storage Improvements on Fuel Cell Electric Vehicles.....	507
SA-052: The Business Case for Hydrogen-Powered Passenger Cars: Competition and Solving the Infrastructure Puzzle	511
SA-055: Hydrogen Analysis with the Sandia ParaChoice Model.....	514
SA-057: Life-Cycle Analysis of Emerging Hydrogen Production Technologies	518
SA-058: Analysis of Incentives and Policy Impacts on the Market for Alternative Fuels and Vehicles.....	522
SA-059: Sustainability Analysis.....	525
SA-060: Evaluation of Technology Status Compared to Program Targets	528
SA-061: National Fuel Cell Electric Vehicle and Hydrogen Fueling Station Scenarios.....	532
SA-062: Expanded Capabilities for the Hydrogen Financial Analysis Scenario Tool.....	535
Appendix A: Attendee List	538
Appendix B: Program Comments	557
Appendix C: Evaluation Forms	598
Appendix D: Projects Not Reviewed	606
Appendix E: AMR Questionnaire Results Summary	612