

---

## XVI. Project Listings by Organization

### 3M Company

II.B.2	High-Performance, Long-Lifetime Catalysts for Proton Exchange Membrane Electrolysis . . . . .	II-23
V.B.1	New Fuel Cell Membranes with Improved Durability and Performance . . . . .	V-64
V.B.2	Advanced Hybrid Membranes for Next Generation PEMFC Automotive Applications . . . . .	V-69
V.C.1	High Performance, Durable, Low Cost Membrane Electrode Assemblies for Transportation Applications . . . . .	V-73
V.C.4	Advanced Ionomers & MEAs for Alkaline Membrane Fuel Cells . . . . .	V-92
V.E.2	Fuel-Cell Fundamentals at Low and Subzero Temperatures . . . . .	V-108

### AccerlorMittal

III.8	Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . .	III-40
-------	---	--------

### Adherent Technologies, Inc.

IV.D.7	Optimizing the Cost and Performance of Composite Cylinders for H <sub>2</sub> Storage using a Graded Construction . . . . .	IV-138
--------	---	--------

### Air Liquide

III.8	Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . .	III-40
VIII.6	Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . .	VIII-31

### Air Products and Chemicals, Inc.

VII.9	Validation of an Advanced High Pressure PEM Electrolyzer and Composite Hydrogen Storage, with Data Reporting, for SunHydro Stations . . . . .	VII-44
VIII.6	Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . .	VIII-31

### Ames Laboratory

IV.C.4	High-Capacity Hydrogen Storage Systems via Mechanochemistry . . . . .	IV-81
IV.E.1	Complex Hydrides - A New Frontier for Future Energy Applications . . . . .	IV-143

### AOC, LLC

IV.D.3	Enhanced Materials and Design Parameters for Reducing the Cost of Hydrogen Storage Tanks . . . . .	IV-118
--------	--	--------

### Ardica Technologies

IV.C.6	Low-Cost $\alpha$ -Alane for Hydrogen Storage . . . . .	IV-88
--------	---	-------

### Argonne National Laboratory

III.1	Hydrogen Delivery Infrastructure Analysis . . . . .	III-9
III.11	Reference Station Design . . . . .	III-53
III.12	Hydrogen Fueling Station Pre-Cooling Analysis . . . . .	III-57
IV.A.1	System Analysis of Physical and Materials-Based Hydrogen Storage . . . . .	IV-11
V.A.2	Nanosegregated Cathode Alloy Catalysts with Ultra-Low Platinum Loading . . . . .	V-13
V.A.8	High-Throughput Synthesis, ORR Activity Modeling, and Testing of non-PGM PEMFC Cathode Catalysts . . . . .	V-51
V.C.1	High Performance, Durable, Low Cost Membrane Electrode Assemblies for Transportation Applications . . . . .	V-73
V.C.2	Rationally Designed Catalyst Layers for PEMFC Performance Optimization . . . . .	V-80
V.E.1	Durability Improvements Through Degradation Mechanism Studies . . . . .	V-101

## XVI. Project Listings by Organization

---

### Argonne National Laboratory (Continued)

V.F.2	Fuel Cells Systems Analysis .....	V-133
V.F.12	Novel Non-PGM Catalysts from Rationally Designed 3-D Precursors .....	V-184
IX.1	Impact of Fuel Cell System Peak Efficiency on Fuel Consumption and Cost. ....	IX-13
IX.4	Performance and Cost Analysis for a 300 kW Tri-generation Molten Carbonate Fuel Cell System .....	IX-29
IX.5	Employment Impacts of Infrastructure Development for Hydrogen and Fuel Cell Technologies .....	IX-34
IX.6	Life-Cycle Analysis of Water Consumption for Hydrogen Production. ....	IX-41
IX.10	Analysis of Incremental Fueling Pressure Cost .....	IX-54

### Arizona State University

II.C.1	High Efficiency Solar Thermochemical Reactor for Hydrogen Production .....	II-35
--------	--	-------

### Ashok Saxena

III.9	Low Cost Hydrogen Storage at 875 Bar Using Steel Liner and Steel Wire Wrap. ....	III-45
-------	--	--------

### Automotive Fuel Cell Corporation

VI.1	Fuel Cell Membrane Electrode Assembly Manufacturing R&D .....	VI-7
------	---	------

### Ballard Power Systems

V.D.1	Roots Air Management System with Integrated Expander. ....	V-96
V.E.4	The Effect of Airborne Contaminants on Fuel Cell Performance and Durability .....	V-119
V.E.5	Open Source Performance and Durability Model: Consideration of Membrane Properties on Cathode Degradation .....	V-125

### BASF SE

IV.B.2	Ford/BASF-SE/UM Activities in Support of the Hydrogen Storage Engineering Center of Excellence. ....	IV-27
--------	--	-------

### Battelle

V.F.6	Stationary and Emerging Market Fuel Cell System Cost Analysis—Primary Power and Combined Heat and Power Applications. ....	V-158
-------	--	-------

### Becht Engineering

VIII.6	Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources .....	VIII-31
--------	--	---------

### Bevilacqua Knight, Inc.

III.8	Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage .....	III-40
-------	---	--------

### BKi

VIII.6	Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources .....	VIII-31
--------	--	---------

### Boston College

IV.C.7	Novel Carbon(C)-Boron(B)-Nitrogen(N)-Containing H <sub>2</sub> Storage Materials .....	IV-92
--------	--	-------

### Branded by Media

VIII.7	Fuel Cell Technologies National Codes and Standards Deployment and Outreach .....	VIII-38
--------	---	---------

### Brookhaven National Laboratory

II.B.3	Low-Noble-Metal-Content Catalysts/Electrodes for Hydrogen Production by Water Electrolysis .....	II-28
V.A.3	Contiguous Platinum Monolayer Oxygen Reduction Electrocatalysts on High-Stability-Low-Cost Supports .....	V-20

**Brookhaven National Laboratory (Continued)**

V.F.20 Semi-Automated MEA Fabrication with Ultra-Low Total PGM Loadings . . . . . V-223

**Bucknell University**

II.C.1 High Efficiency Solar Thermochemical Reactor for Hydrogen Production . . . . . II-35

**C P Industries**

III.9 Low Cost Hydrogen Storage at 875 Bar Using Steel Liner and Steel Wire Wrap. . . . . III-45

**California Fuel Cell Partnership**

VII.8 Station Operational Status System (SOSS) 3.0 Upgrade. . . . . VII-41

**California Institute of Technology**

IV.B.1 Hydrogen Storage Engineering Center of Excellence . . . . . IV-22

**California State University, Los Angeles**

VII.12 CSULA Hydrogen Refueling Facility Performance Evaluation and Optimization . . . . . VII-58

**Carnegie Mellon University**

V.A.7 Non-Precious Metal Fuel Cell Cathodes: Catalyst Development & Electrode Structure Design . . . . . V-43

**CellEra, Inc.**

V.C.4 Advanced Ionomers & MEAs for Alkaline Membrane Fuel Cells . . . . . V-92

**Center for Transportation and the Environment**

X.3 Fuel Cell Hybrid Electric Delivery Van Project . . . . . X-14

**City of Santa Fe Springs**

VIII.6 Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . . VIII-31

**Colorado School of Mines**

II.C.1 High Efficiency Solar Thermochemical Reactor for Hydrogen Production . . . . . II-35  
 V.A.1 Extended, Continuous Pt Nanostructures in Thick, Dispersed Electrodes. . . . . V-9  
 V.B.2 Advanced Hybrid Membranes for Next Generation PEMFC Automotive Applications . . . . . V-69  
 V.C.4 Advanced Ionomers & MEAs for Alkaline Membrane Fuel Cells . . . . . V-92  
 V.E.3 Effect of System Contaminants on PEMFC Performance and Durability . . . . . V-113  
 VI.1 Fuel Cell Membrane Electrode Assembly Manufacturing R&D . . . . . VI-7

**Composite Technology Development**

IV.D.7 Optimizing the Cost and Performance of Composite Cylinders for H<sub>2</sub> Storage using a Graded Construction. . . . . IV-138

**Cormetech, Inc.**

II.F.1 Monolithic Piston-Type Reactor for Hydrogen Production through Rapid Swing of Reforming/Combustion Reactions . . . . . II-84

**Custom Sensor Solutions**

VIII.11 Hydrogen Safety, Codes and Standards: Sensors . . . . . VIII-53

**Dason Technology, Inc.**

II.F.1 Monolithic Piston-Type Reactor for Hydrogen Production through Rapid Swing of Reforming/Combustion Reactions. . . . . II-84

## XVI. Project Listings by Organization

---

### **DJW Technologies**

VI.2 U.S. Clean Energy Hydrogen and Fuel Cell Technologies: A Competitiveness Analysis . . . . . VI-12

### **E4tech**

VI.2 U.S. Clean Energy Hydrogen and Fuel Cell Technologies: A Competitiveness Analysis . . . . . VI-12

### **Eaton Corporation**

V.D.1 Roots Air Management System with Integrated Expander . . . . . V-96

### **Electricore, Inc.**

V.D.1 Roots Air Management System with Integrated Expander . . . . . V-96

### **Element One**

VIII.5 NREL Hydrogen Sensor Testing Laboratory . . . . . VIII-26

### **Emerald Energy NW LLC**

III.14 Magnetocaloric Hydrogen Liquefaction . . . . . III-65

### **eon™ Consultants Ltd.**

VI.2 U.S. Clean Energy Hydrogen and Fuel Cell Technologies: A Competitiveness Analysis . . . . . VI-12

### **Excelsior Design, Inc.**

VIII.6 Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . . VIII-31

### **Firexplo**

VIII.6 Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . . VIII-31

### **Fluer, Inc.**

VIII.6 Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . . VIII-31

### **Ford Motor Company**

IV.B.1 Hydrogen Storage Engineering Center of Excellence . . . . . IV-22

IV.B.2 Ford/BASF-SE/UM Activities in Support of the Hydrogen Storage Engineering Center of Excellence . . . . . IV-27

IV.D.3 Enhanced Materials and Design Parameters for Reducing the Cost of Hydrogen Storage Tanks . . . . . IV-118

### **Fuel Cell & Hydrogen Energy Association**

VIII.8 Fuel Cell & Hydrogen Energy Association Codes and Standards Support . . . . . VIII-42

### **FuelCell Energy, Inc.**

II.F.2 Reformer-Electrolyzer-Purifier (REP) for Production of Hydrogen . . . . . II-90

III.10 Electrochemical Hydrogen Compressor . . . . . III-50

V.F.9 Smart Matrix Development for Direct Carbonate Fuel Cell . . . . . V-170

### **Gas Technology Institute**

VII.10 Performance Evaluation of Delivered Hydrogen Fueling Stations . . . . . VII-50

### **General Motors Company**

IV.B.1 Hydrogen Storage Engineering Center of Excellence . . . . . IV-22

IV.B.9 Testing, Modeling, and Evaluation of Innovative Hydrogen Storage System Designs . . . . . IV-59

IV.C.1 Hydrogen Storage in Metal-Organic Frameworks . . . . . IV-63

**General Motors Company (Continued)**

V.A.7 Non-Precious Metal Fuel Cell Cathodes: Catalyst Development & Electrode Structure Design . . . . . V-43  
 V.B.1 New Fuel Cell Membranes with Improved Durability and Performance . . . . . V-64  
 V.C.1 High Performance, Durable, Low Cost Membrane Electrode Assemblies for Transportation Applications . . . . . V-73  
 V.E.3 Effect of System Contaminants on PEMFC Performance and Durability . . . . . V-113  
 VI.1 Fuel Cell Membrane Electrode Assembly Manufacturing R&D . . . . . VI-7

**Giner Electrochemical Systems, LLC**

II.B.4 High Temperature, High Pressure Electrolysis . . . . . II-31

**Giner, Inc.**

II.B.2 High-Performance, Long-Lifetime Catalysts for Proton Exchange Membrane Electrolysis . . . . . II-23  
 V.F.11 Ionomer Dispersion Impact on Advanced Fuel Cell and Electrolyzer Performance and Durability . . . . . V-179

**Global Engineering and Technology, LLC**

III.2 Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage . . . . . III-13  
 III.8 Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . . III-40

**GLWN – Westside Industrial Retention & Expansion Network**

VI.2 U.S. Clean Energy Hydrogen and Fuel Cell Technologies: A Competitiveness Analysis . . . . . VI-12

**GWS Solutions of Tolland, LLC**

VIII.6 Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . . VIII-31

**H2 Technology Consulting LLC**

IV.C.2 Hydrogen Sorbent Measurement Qualification and Characterization . . . . . IV-70

**Hanson Pressure Pipe**

III.2 Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage . . . . . III-13  
 III.8 Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . . III-40

**Harris Thermal Transfer Products**

III.2 Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage . . . . . III-13

**Hawaii Natural Energy Institute**

V.E.4 The Effect of Airborne Contaminants on Fuel Cell Performance and Durability . . . . . V-119  
 X.4 Hydrogen Energy Systems as a Grid Management Tool . . . . . X-18

**Hexagon Lincoln**

III.5 Development of High Pressure Hydrogen Storage Tank for Storage and Gaseous Truck Delivery . . . . . III-25  
 IV.B.1 Hydrogen Storage Engineering Center of Excellence . . . . . IV-22  
 IV.B.7 Development of Improved Composite Pressure Vessels for Hydrogen Storage . . . . . IV-53  
 IV.D.3 Enhanced Materials and Design Parameters for Reducing the Cost of Hydrogen Storage Tanks . . . . . IV-118  
 IV.D.6 Achieving Hydrogen Storage Goals through High-Strength Fiber Glass . . . . . IV-134

**HRL Laboratories, LLC**

IV.C.8 Boron-Based Hydrogen Storage: Ternary Borides and Beyond . . . . . IV-97  
 VIII.11 Hydrogen Safety, Codes and Standards: Sensors . . . . . VIII-53

## XVI. Project Listings by Organization

---

### Hydrogenics

VII.12	CSULA Hydrogen Refueling Facility Performance Evaluation and Optimization . . . . .	VII-58
X.2	Maritime Fuel Cell Generator Project . . . . .	X-10
X.3	Fuel Cell Hybrid Electric Delivery Van Project . . . . .	X-14

### Hy-Performance Materials Testing LLC

IV.D.1	Innovative Development, Selection and Testing to Reduce Cost and Weight of Materials for BOP Components . . . . .	IV-108
--------	---	--------

### Idaho National Laboratory

VII.14	Dynamic Modeling and Validation of Electrolyzers in Real Time Grid Simulation . . . . .	VII-65
--------	---	--------

### Illinois Institute of Technology

V.A.4	Synthesis and Characterization of Mixed-Conducting Corrosion Resistant Oxide Supports . . . . .	V-25
V.F.9	Smart Matrix Development for Direct Carbonate Fuel Cell . . . . .	V-170

### Indiana University Purdue University

V.C.2	Rationally Designed Catalyst Layers for PEMFC Performance Optimization . . . . .	V-80
-------	--	------

### Ion Power

V.E.1	Durability Improvements Through Degradation Mechanism Studies . . . . .	V-101
VI.1	Fuel Cell Membrane Electrode Assembly Manufacturing R&D . . . . .	VI-7

### IRD Fuel Cells

V.A.7	Non-Precious Metal Fuel Cell Cathodes: Catalyst Development & Electrode Structure Design . . . . .	V-43
-------	--	------

### Jet Propulsion Laboratory

IV.B.1	Hydrogen Storage Engineering Center of Excellence . . . . .	IV-22
--------	---	-------

### Johns Hopkins University

V.C.1	High Performance, Durable, Low Cost Membrane Electrode Assemblies for Transportation Applications . . .	V-73
-------	---	------

### Johnson Matthey Fuel Cells

V.C.2	Rationally Designed Catalyst Layers for PEMFC Performance Optimization . . . . .	V-80
-------	--	------

### Kalibrate

IX.14	Retail Marketing Analysis: Hydrogen Refueling Stations . . . . .	IX-67
-------	--	-------

### Kettering University

V.D.1	Roots Air Management System with Integrated Expander . . . . .	V-96
-------	--	------

### Kobe Steel, LTD

III.2	Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage . . . . .	III-13
-------	--	--------

### Lawrence Berkeley National Laboratory

IV.C.1	Hydrogen Storage in Metal-Organic Frameworks . . . . .	IV-63
V.C.1	High Performance, Durable, Low Cost Membrane Electrode Assemblies for Transportation Applications . . .	V-73
V.E.1	Durability Improvements Through Degradation Mechanism Studies . . . . .	V-101
V.E.2	Fuel-Cell Fundamentals at Low and Subzero Temperatures . . . . .	V-108

**Lawrence Berkeley National Laboratory (Continued)**

V.F.7	A Total Cost of Ownership Model for Design and Manufacturing Optimization of Fuel Cells in Stationary and Emerging Market Applications . . . . .	V-162
V.F.17	Advanced Hydroxide Conducting Membranes . . . . .	V-205
V.F.19	Engineered Low-Pt Catalyst Layers . . . . .	V-218
VI.1	Fuel Cell Membrane Electrode Assembly Manufacturing R&D . . . . .	VI-7

**Lawrence Livermore National Laboratory**

II.C.5	Wide Bandgap Chalcopyrite Photoelectrodes for Direct Solar Water Splitting . . . . .	II-56
IV.C.9	Improving the Kinetics and Thermodynamics of $Mg(BH_4)_2$ for Hydrogen Storage . . . . .	IV-101
IV.D.2	Thermomechanical Cycling of Thin Liner High Fiber Fraction Cryogenic Pressure Vessels Rapidly Refueled by $LH_2$ Pump to 700 Bar . . . . .	IV-113
VII.2	Performance and Durability Testing of Volumetrically Efficient Cryogenic Vessels and High Pressure Liquid Hydrogen Pump . . . . .	VII-13
VIII.11	Hydrogen Safety, Codes and Standards: Sensors . . . . .	VIII-53
VIII.12	Hands-on Hydrogen Safety Training . . . . .	VIII-60

**LightSail**

III.8	Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . .	III-40
-------	---	--------

**Linde Gas, LLC**

VII.10	Performance Evaluation of Delivered Hydrogen Fueling Stations . . . . .	VII-50
--------	---	--------

**Linde LLC**

IV.D.2	Thermomechanical Cycling of Thin Liner High Fiber Fraction Cryogenic Pressure Vessels Rapidly Refueled by $LH_2$ Pump to 700 Bar . . . . .	IV-113
VII.2	Performance and Durability Testing of Volumetrically Efficient Cryogenic Vessels and High Pressure Liquid Hydrogen Pump . . . . .	VII-13

**Los Alamos National Laboratory**

IV.B.1	Hydrogen Storage Engineering Center of Excellence . . . . .	IV-22
IV.B.8	Chemical Hydrogen Rate Modeling, Validation, and System Demonstration . . . . .	IV-56
IV.C.2	Hydrogen Sorbent Measurement Qualification and Characterization . . . . .	IV-70
V.A.7	Non-Precious Metal Fuel Cell Cathodes: Catalyst Development & Electrode Structure Design . . . . .	V-43
V.A.8	High-Throughput Synthesis, ORR Activity Modeling, and Testing of non-PGM PEMFC Cathode Catalysts . . . . .	V-51
V.C.1	High Performance, Durable, Low Cost Membrane Electrode Assemblies for Transportation Applications . . . . .	V-73
V.E.1	Durability Improvements Through Degradation Mechanism Studies . . . . .	V-101
V.E.2	Fuel-Cell Fundamentals at Low and Subzero Temperatures . . . . .	V-108
V.F.11	Ionomer Dispersion Impact on Advanced Fuel Cell and Electrolyzer Performance and Durability . . . . .	V-179
V.F.14	High Performance and Durable Low PGM Cathode Catalysts . . . . .	V-194
V.F.17	Advanced Hydroxide Conducting Membranes . . . . .	V-205
V.F.19	Engineered Low-Pt Catalyst Layers . . . . .	V-218
VIII.4	Hydrogen Fuel Quality . . . . .	VIII-21
VIII.11	Hydrogen Safety, Codes and Standards: Sensors . . . . .	VIII-53

**Materia**

IV.D.4	Next Generation Hydrogen Storage Vessels Enabled by Carbon Fiber Infusion with a Low Viscosity, High Toughness System . . . . .	IV-122
--------	---	--------



## XVI. Project Listings by Organization

---

### MegaStir Technologies, LLC

- III.2 Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage . . . . . III-13
- III.8 Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . . III-40

### Michigan State University

- V.A.5 Development of Novel Non-PGM Electrocatalysts for Proton Exchange Membrane Fuel Cell Applications . . . . . V-29

### Michigan Technological University

- V.C.1 High Performance, Durable, Low Cost Membrane Electrode Assemblies for Transportation Applications . . . V-73

### Montana State University

- IV.D.4 Next Generation Hydrogen Storage Vessels Enabled by Carbon Fiber Infusion with a Low Viscosity, High Toughness System . . . . . IV-122

### N & R Engineering

- III.9 Low Cost Hydrogen Storage at 875 Bar Using Steel Liner and Steel Wire Wrap . . . . . III-45

### Nanosonic

- III.6 Cryogenically Flexible, Low Permeability H<sub>2</sub> Delivery Hose . . . . . III-28

### National Institute of Standards and Technology

- IV.C.1 Hydrogen Storage in Metal-Organic Frameworks . . . . . IV-63
- IV.C.2 Hydrogen Sorbent Measurement Qualification and Characterization . . . . . IV-70
- IV.C.3 Neutron Characterization in Support of the DOE Hydrogen Storage Sub-Program . . . . . IV-76
- V.F.5 Neutron Imaging Study of the Water Transport in Operating Fuel Cells . . . . . V-152

### National Renewable Energy Laboratory

- II.B.1 Renewable Electrolysis Integrated System Development and Testing . . . . . II-18
- II.B.2 High-Performance, Long-Lifetime Catalysts for Proton Exchange Membrane Electrolysis . . . . . II-23
- II.C.2 Flowing Particle Bed Solarthermal Redox Process to Split Water . . . . . II-41
- II.C.4 High-Efficiency Tandem Absorbers for Economical Solar Hydrogen Production . . . . . II-50
- II.C.5 Wide Bandgap Chalcopyrite Photoelectrodes for Direct Solar Water Splitting . . . . . II-56
- II.E.1 Fermentation and Electrohydrogenic Approaches to Hydrogen Production . . . . . II-76
- II.E.2 Improving Cyanobacterial O<sub>2</sub>-Tolerance using CBS Hydrogenase for H<sub>2</sub> Production . . . . . II-81
- III.6 Cryogenically Flexible, Low Permeability H<sub>2</sub> Delivery Hose . . . . . III-28
- III.11 Reference Station Design . . . . . III-53
- III.13 700-Bar Hydrogen Dispenser Hose Reliability Improvement . . . . . III-60
- IV.B.1 Hydrogen Storage Engineering Center of Excellence . . . . . IV-22
- IV.B.6 System Design, Analysis, and Modeling for Hydrogen Storage Systems . . . . . IV-49
- IV.C.2 Hydrogen Sorbent Measurement Qualification and Characterization . . . . . IV-7
- V.A.1 Extended, Continuous Pt Nanostructures in Thick, Dispersed Electrodes . . . . . V-9
- V.B.2 Advanced Hybrid Membranes for Next Generation PEMFC Automotive Applications . . . . . V-69
- V.C.4 Advanced Ionomers & MEAs for Alkaline Membrane Fuel Cells . . . . . V-92
- V.E.3 Effect of System Contaminants on PEMFC Performance and Durability . . . . . V-113
- V.F.1 Optimal Stationary Fuel Cell Integration and Control . . . . . V-130
- V.F.10 Fuel Cell Technology Status—Degradation . . . . . V-174
- V.F.15 Magnetic Annealing of Pt-Alloy Nanostructured Thin Film Catalysts for Enhanced Activity . . . . . V-198



**National Renewable Energy Laboratory (Continued)**

VI.1	Fuel Cell Membrane Electrode Assembly Manufacturing R&D	VI-7
VII.1	Hydrogen Component Validation	VII-9
VII.3	FCTO INTEGRATE Stack Test Bed & Grid Interoperability	VII-17
VII.4	Fuel Cell Electric Vehicle Evaluation	VII-21
VII.5	Technology Validation: Fuel Cell Bus Evaluations	VII-26
VII.6	Material Handling Equipment Data Collection and Analysis	VII-31
VII.11	Hydrogen Station Data Collection and Analysis	VII-53
VII.13	Stationary Fuel Cell Evaluation	VII-61
VIII.2	Component Standard Research & Development	VIII-13
VIII.5	NREL Hydrogen Sensor Testing Laboratory	VIII-26
VIII.7	Fuel Cell Technologies National Codes and Standards Deployment and Outreach	VIII-38
VIII.9	Hydrogen Contaminant Detector	VIII-46
IX.3	Pathway Analysis: Projected Cost, Lifecycle Energy Use and Emissions of Emerging Hydrogen Technologies	IX-24
IX.12	Infrastructure Investment and Finance Scenario Analysis	IX-61

**New England Wire Technologies**

III.6	Cryogenically Flexible, Low Permeability H <sub>2</sub> Delivery Hose	III-28
-------	---	--------

**New Jersey Institute of Technology**

VI.1	Fuel Cell Membrane Electrode Assembly Manufacturing R&D	VI-7
------	---	------

**Nissan Technical Center, North America**

V.A.4	Synthesis and Characterization of Mixed-Conducting Corrosion Resistant Oxide Supports	V-25
V.A.5	Development of Novel Non-PGM Electrocatalysts for Proton Exchange Membrane Fuel Cell Applications	V-29
V.B.2	Advanced Hybrid Membranes for Next Generation PEMFC Automotive Applications	V-69

**Norm Shade**

III.7	Hydrogen Compression Application of the Linear Motor Reciprocating Compressor (LMRC)	III-33
-------	--	--------

**Northeastern University**

V.A.5	Development of Novel Non-PGM Electrocatalysts for Proton Exchange Membrane Fuel Cell Applications	V-29
-------	---	------

**Northwestern University**

II.C.1	High Efficiency Solar Thermochemical Reactor for Hydrogen Production	II-35
IX.5	Employment Impacts of Infrastructure Development for Hydrogen and Fuel Cell Technologies	IX-34

**Oak Ridge National Laboratory**

III.2	Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage	III-13
III.8	Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage	III-40
III.9	Low Cost Hydrogen Storage at 875 Bar Using Steel Liner and Steel Wire Wrap	III-45
IV.D.5	Melt Processable PAN Precursor for High Strength, Low-Cost Carbon Fibers (Phase II)	IV-126
V.A.2	Nanosegregated Cathode Alloy Catalysts with Ultra-Low Platinum Loading	V-13
V.A.7	Non-Precious Metal Fuel Cell Cathodes: Catalyst Development & Electrode Structure Design	V-43
V.E.1	Durability Improvements Through Degradation Mechanism Studies	V-101

## XVI. Project Listings by Organization

---

### Oak Ridge National Laboratory (Continued)

V.F.4	Characterization of Fuel Cell Materials. . . . .	V-147
V.F.15	Magnetic Annealing of Pt-Alloy Nanostructured Thin Film Catalysts for Enhanced Activity. . . . .	V-198
V.F.16	High Conductivity Durable Anion Conducting Membranes. . . . .	V-203
V.F.18	DOE's High Acid Content Diels Alder Poly(Phenylene)s for High Temperature and Low Humidity Applications . . . . .	V-211
V.F.19	Engineered Low-Pt Catalyst Layers . . . . .	V-218
IX.2	GPRA Analysis: Impact of Program Targets on Vehicle Penetration and Benefits . . . . .	IX-19
IX.11	Analysis of Optimal On-Board Storage Pressure for Hydrogen Fuel Cell Vehicles. . . . .	IX-58

### Oregon State University

IV.B.1	Hydrogen Storage Engineering Center of Excellence . . . . .	IV-22
IV.B.3	Microscale Enhancement of Heat and Mass Transfer for Hydrogen Energy Storage. . . . .	IV-32

### Pacific Northwest National Laboratory

II.F.1	Monolithic Piston-Type Reactor for Hydrogen Production through Rapid Swing of Reforming/Combustion Reactions. . . . .	II-84
III.14	Magnetocaloric Hydrogen Liquefaction . . . . .	III-65
IV.B.1	Hydrogen Storage Engineering Center of Excellence . . . . .	IV-22
IV.B.5	Systems Engineering of Chemical Hydrogen Storage and Cryo-Sorbent Storage, Pressure Vessel, and Balance of Plant for Onboard Hydrogen Storage. . . . .	IV-44
IV.C.7	Novel Carbon(C)-Boron(B)-Nitrogen(N)-Containing H <sub>2</sub> Storage Materials . . . . .	IV-92
IV.D.3	Enhanced Materials and Design Parameters for Reducing the Cost of Hydrogen Storage Tanks . . . . .	IV-118
IV.D.6	Achieving Hydrogen Storage Goals through High-Strength Fiber Glass. . . . .	IV-134
V.F.14	High Performance and Durable Low PGM Cathode Catalysts . . . . .	V-194
VIII.6	Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . .	VIII-31

### Pajarito Powder, LLC

V.A.5	Development of Novel Non-PGM Electrocatalysts for Proton Exchange Membrane Fuel Cell Applications . . . . .	V-29
-------	---	------

### Pennsylvania State University

II.E.1	Fermentation and Electrohydrogenic Approaches to Hydrogen Production. . . . .	II-76
--------	---	-------

### pH Matter, LLC

V.A.10	Non-Precious Metal Bi-Functional Catalysts . . . . .	V-60
--------	--	------

### Plug Power

X.1	Ground Support Equipment Demonstration . . . . .	X-7
-----	--	-----

### POSCO

III.8	Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . .	III-40
-------	---	--------

### Powertech Labs, Inc.

VII.7	Development of the Hydrogen Station Equipment Performance (HyStEP) Device . . . . .	VII-36
-------	---	--------

### PPG Industries, Inc.

IV.D.6	Achieving Hydrogen Storage Goals through High-Strength Fiber Glass. . . . .	IV-134
--------	---	--------

**Pressure Science, Inc.**

- III.9 Low Cost Hydrogen Storage at 875 Bar Using Steel Liner and Steel Wire Wrap . . . . . III-45

**Proton Energy Systems d/b/a Proton OnSite**

- II.B.3 Low-Noble-Metal-Content Catalysts/Electrodes for Hydrogen Production by Water Electrolysis . . . . . II-28  
 V.A.9 Non-Platinum Group Metal OER/ORR Catalysts for Alkaline Membrane Fuel Cells and Electrolyzers . . . . . V-56  
 VII.9 Validation of an Advanced High Pressure PEM Electrolyzer and Composite Hydrogen Storage,  
 with Data Reporting, for SunHydro Stations. . . . . VII-44  
 VIII.6 Hydrogen Safety Panel, Safety Knowledge Tools and First Responder Training Resources . . . . . VIII-31

**Protonex Technology Corporation**

- IV.C.7 Novel Carbon(C)-Boron(B)-Nitrogen(N)-Containing H<sub>2</sub> Storage Materials . . . . . IV-92

**RCF Economic & Financial Consulting**

- IX.5 Employment Impacts of Infrastructure Development for Hydrogen and Fuel Cell Technologies . . . . . IX-34

**Redox Fuel Cells, Inc.**

- V.F.8 Affordable, High Performance, Intermediate Temperature Solid Oxide Fuel Cells . . . . . V-167

**Rensselaer Polytechnic University**

- V.F.17 Advanced Hydroxide Conducting Membranes . . . . . V-205

**Rutgers, the State University of New Jersey**

- II.D.2 Tunable Photoanode-Photocathode-Catalyst Interface Systems for Efficient Solar Water Splitting . . . . . II-72  
 V.A.9 Non-Platinum Group Metal OER/ORR Catalysts for Alkaline Membrane Fuel Cells and Electrolyzers . . . . . V-56

**Sandia National Laboratories**

- II.C.1 High Efficiency Solar Thermochemical Reactor for Hydrogen Production . . . . . II-35  
 III.3 Hydrogen Embrittlement of Structural Steels . . . . . III-18  
 III.11 Reference Station Design . . . . . III-53  
 IV.C.8 Boron-Based Hydrogen Storage: Ternary Borides and Beyond . . . . . IV-97  
 IV.C.9 Improving the Kinetics and Thermodynamics of Mg(BH<sub>4</sub>)<sub>2</sub> for Hydrogen Storage . . . . . IV-101  
 IV.D.1 Innovative Development, Selection and Testing to Reduce Cost and Weight of Materials for BOP  
 Components . . . . . IV-108  
 V.F.17 Advanced Hydroxide Conducting Membranes . . . . . V-205  
 V.F.18 DOE's High Acid Content Diels Alder Poly(Phenylene)s for High Temperature and Low Humidity  
 Applications . . . . . V-211  
 VII.7 Development of the Hydrogen Station Equipment Performance (HyStEP) Device . . . . . VII-36  
 VIII.1 Hydrogen behavior and Quantitative Risk Assessment. . . . . VIII-1  
 VIII.3 R&D for Safety, Codes and Standards: Materials and Components Compatibility . . . . . VIII-17  
 VIII.10 Enabling Hydrogen Infrastructure Through Science-based Codes and Standards . . . . . VIII-49  
 IX.7 Hydrogen Analysis with the Sandia ParaChoice Model . . . . . IX-44  
 X.2 Maritime Fuel Cell Generator Project . . . . . X-10

**Savannah River Consultants**

- II.C.3 Electrolyzer Component Development for the HyS Thermochemical Cycle . . . . . II-46

**Savannah River National Laboratory**

- II.C.3 Electrolyzer Component Development for the HyS Thermochemical Cycle . . . . . II-46  
 III.4 Fiber Reinforced Composite Pipelines. . . . . III-22

## XVI. Project Listings by Organization

---

### Savannah River National Laboratory (Continued)

IV.B.1	Hydrogen Storage Engineering Center of Excellence . . . . .	IV-22
IV.C.5	Electrochemical Reversible Formation of $\alpha$ -Alane . . . . .	IV-84
IV.E.2	Elucidation of Hydrogen Interaction Mechanisms with Metal-Doped Carbon Nanostructures. . . . .	IV-144
V.F.13	PGM Free Catalysts for PEMFC . . . . .	V-189

### Southwest Research Institute®

III.7	Hydrogen Compression Application of the Linear Motor Reciprocating Compressor (LMRC) . . . . .	III-33
-------	--	--------

### Spectrum Automation Controls

II.B.1	Renewable Electrolysis Integrated System Development and Testing . . . . .	II-18
III.13	700-Bar Hydrogen Dispenser Hose Reliability Improvement. . . . .	III-60
VII.1	Hydrogen Component Validation. . . . .	VII-9
VII.3	FCTO INTEGRATE Stack Test Bed & Grid Interoperability . . . . .	VII-17
VIII.2	Component Standard Research & Development . . . . .	VIII-13

### Spencer Composites Corporation

IV.D.2	Thermomechanical Cycling of Thin Liner High Fiber Fraction Cryogenic Pressure Vessels Rapidly Refueled by LH <sub>2</sub> Pump to 700 Bar. . . . .	IV-113
IV.D.4	Next Generation Hydrogen Storage Vessels Enabled by Carbon Fiber Infusion with a Low Viscosity, High Toughness System. . . . .	IV-122
VII.2	Performance and Durability Testing of Volumetrically Efficient Cryogenic Vessels and High Pressure Liquid Hydrogen Pump . . . . .	VII-13

### SRI International

IV.C.6	Low-Cost $\alpha$ -Alane for Hydrogen Storage . . . . .	IV-88
--------	---	-------

### Stanford University

II.C.1	High Efficiency Solar Thermochemical Reactor for Hydrogen Production . . . . .	II-35
II.C.5	Wide Bandgap Chalcopyrite Photoelectrodes for Direct Solar Water Splitting . . . . .	II-56

### Strategic Analysis, Inc.

II.A.1	Hydrogen Pathways Analysis for Solid Oxide Fuel Cell (SOFC) and Dark Fermentation. . . . .	II-11
IV.A.2	Hydrogen Storage Cost Analysis . . . . .	IV-17
V.F.3	Fuel Cell Vehicle and Bus Cost Analysis. . . . .	V-141
V.F.7	A Total Cost of Ownership Model for Design and Manufacturing Optimization of Fuel Cells in Stationary and Emerging Market Applications . . . . .	V-162
VI.2	U.S. Clean Energy Hydrogen and Fuel Cell Technologies: A Competitiveness Analysis . . . . .	VI-12

### SunHydro LLC

VII.9	Validation of an Advanced High Pressure PEM Electrolyzer and Composite Hydrogen Storage, with Data Reporting, for SunHydro Stations. . . . .	VII-44
-------	--	--------

### Sustainable Innovations, LLC

III.10	Electrochemical Hydrogen Compressor . . . . .	III-50
--------	---	--------

### SustainX

III.8	Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . .	III-40
-------	---	--------

**Swagelok**

- III.6 Cryogenically Flexible, Low Permeability H<sub>2</sub> Delivery Hose . . . . . III-28

**Temple University**

- III.2 Vessel Design and Fabrication Technology for Stationary High-Pressure Hydrogen Storage . . . . . III-13  
 III.8 Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . . III-40

**Texas A&M University**

- IV.C.2 Hydrogen Sorbent Measurement Qualification and Characterization . . . . . IV-70

**The University of Alabama**

- IV.C.7 Novel Carbon(C)-Boron(B)-Nitrogen(N)-Containing H<sub>2</sub> Storage Materials . . . . . IV-92

**Toray Composites America**

- IV.D.3 Enhanced Materials and Design Parameters for Reducing the Cost of Hydrogen Storage Tanks . . . . . IV-118

**TreadStone Technologies, Inc.**

- V.C.3 Novel Structured Metal Bipolar Plates for Low Cost Manufacturing. . . . . V-86

**Unique Electric Solutions**

- X.3 Fuel Cell Hybrid Electric Delivery Van Project . . . . . X-14

**United Parcel Service**

- X.3 Fuel Cell Hybrid Electric Delivery Van Project . . . . . X-14

**United Technologies Research Center**

- IV.B.1 Hydrogen Storage Engineering Center of Excellence . . . . . IV-22  
 IV.B.4 Advancement of Systems Designs and Key Engineering Technologies for Materials Based Hydrogen Storage . . . . . IV-36  
 V.C.2 Rationally Designed Catalyst Layers for PEMFC Performance Optimization. . . . . V-80  
 V.E.2 Fuel-Cell Fundamentals at Low and Subzero Temperatures. . . . . V-108

**University of Connecticut**

- V.E.4 The Effect of Airborne Contaminants on Fuel Cell Performance and Durability . . . . . V-119

**University of Texas at Austin**

- V.C.2 Rationally Designed Catalyst Layers for PEMFC Performance Optimization. . . . . V-80

**Université du Québec à Trois-Rivières**

- IV.B.1 Hydrogen Storage Engineering Center of Excellence . . . . . IV-22

**University of Calgary**

- V.E.5 Open Source Performance and Durability Model: Consideration of Membrane Properties on Cathode Degradation . . . . . V-125

**University of California, Berkeley**

- IV.C.2 Hydrogen Sorbent Measurement Qualification and Characterization . . . . . IV-70  
 V.F.7 A Total Cost of Ownership Model for Design and Manufacturing Optimization of Fuel Cells in Stationary and Emerging Market Applications . . . . . V-162

## XVI. Project Listings by Organization

---

### University of California, Davis

IV.E.3 Activation of Hydrogen Under Ambient Conditions by Main Group Molecules . . . . . IV-145

### University of California, Irvine

II.F.2 Reformer-Electrolyzer-Purifier (REP) for Production of Hydrogen . . . . . II-90

IX.9 Tri-Generation Fuel Cell Technologies for Location-Specific Applications (FY 2015) . . . . . IX-54

### University of California, San Diego

IV.C.2 Hydrogen Sorbent Measurement Qualification and Characterization . . . . . IV-70

### University of Chicago

IX.13 The Business Case for Hydrogen-powered Passenger Cars: Competition and Solving the Infrastructure  
Puzzle . . . . . IX-65

### University of Colorado Boulder

II.C.2 Flowing Particle Bed Solarthermal Redox Process to Split Water . . . . . II-41

II.C.6 Accelerated Discovery of Advanced RedOX Materials for Solar Thermal Water Splitting to Produce  
Renewable Hydrogen . . . . . II-60

### University of Connecticut

V.F.9 Smart Matrix Development for Direct Carbonate Fuel Cell . . . . . V-170

### University of Delaware

V.A.1 Extended, Continuous Pt Nanostructures in Thick, Dispersed Electrodes. . . . . V-9

### University of Hawaii

II.C.4 High-Efficiency Tandem Absorbers for Economical Solar Hydrogen Production . . . . . II-50

II.C.5 Wide Bandgap Chalcopyrite Photoelectrodes for Direct Solar Water Splitting . . . . . II-56

V.C.3 Novel Structured Metal Bipolar Plates for Low Cost Manufacturing. . . . . V-86

### University of Maryland

V.F.8 Affordable, High Performance, Intermediate Temperature Solid Oxide Fuel Cells. . . . . V-167

### University of Michigan

IV.B.1 Hydrogen Storage Engineering Center of Excellence . . . . . IV-22

IV.B.2 Ford/BASF-SE/UM Activities in Support of the Hydrogen Storage Engineering Center of Excellence. . . . . IV-27

IV.C.9 Improving the Kinetics and Thermodynamics of  $Mg(BH_4)_2$  for Hydrogen Storage. . . . . IV-101

### University of Missouri

IV.C.4 High-Capacity Hydrogen Storage Systems via Mechanochemistry . . . . . IV-81

IV.C.8 Boron-Based Hydrogen Storage: Ternary Borides and Beyond . . . . . IV-97

### University of Nevada, Las Vegas

II.C.4 High-Efficiency Tandem Absorbers for Economical Solar Hydrogen Production . . . . . II-50

II.C.5 Wide Bandgap Chalcopyrite Photoelectrodes for Direct Solar Water Splitting . . . . . II-56

### University of New Mexico

V.A.5 Development of Novel Non-PGM Electrocatalysts for Proton Exchange Membrane Fuel Cell Applications . . . . . V-29

V.E.5 Open Source Performance and Durability Model: Consideration of Membrane Properties on Cathode  
Degradation . . . . . V-125

**University of Rochester**

- V.A.7 Non-Precious Metal Fuel Cell Cathodes: Catalyst Development & Electrode Structure Design . . . . . V-43

**University of South Carolina**

- V.A.6 Development of Ultra-Low Doped-Pt Cathode Catalysts for PEM Fuel Cells . . . . . V-37  
 V.E.3 Effect of System Contaminants on PEMFC Performance and Durability . . . . . V-113

**University of Tennessee**

- IX.8 Status and Prospects of the N.A. Non-Automotive Fuel Cell Industry: 2014 Update. . . . . IX-48

**University of Texas**

- X.3 Fuel Cell Hybrid Electric Delivery Van Project . . . . . X-14

**University of Toledo**

- II.D.1 New Metal Oxides for Efficient Hydrogen Production via Solar Water Splitting. . . . . II-67

**University of Waterloo**

- V.A.7 Non-Precious Metal Fuel Cell Cathodes: Catalyst Development & Electrode Structure Design . . . . . V-43

**US Hybrid Corporation**

- X.5 Demonstration and Deployment of a Fuel Cell-Electric Refuse Truck for Waste Transportation . . . . . X-21

**Valence**

- X.3 Fuel Cell Hybrid Electric Delivery Van Project . . . . . X-14

**Vanderbilt University**

- V.B.1 New Fuel Cell Membranes with Improved Durability and Performance . . . . . V-64

**Virginia Commonwealth University**

- IV.E.4 Elucidation of Hydride Interaction Mechanisms with Carbon Nanostructures and the Formation of Novel Nanocomposites. . . . . IV-146

**Virginia Polytechnic Institute**

- II.B.4 High Temperature, High Pressure Electrolysis . . . . . II-31  
 IV.D.5 Melt Processable PAN Precursor for High Strength, Low-Cost Carbon Fibers (Phase II) . . . . . IV-126

**W.L. Gore & Associates**

- VI.1 Fuel Cell Membrane Electrode Assembly Manufacturing R&D . . . . . VI-7

**Washington State University**

- II.F.1 Monolithic Piston-Type Reactor for Hydrogen Production through Rapid Swing of Reforming/Combustion Reactions . . . . . II-84

**WireTough Cylinders**

- III.8 Steel Concrete Composite Vessel for 875 bar Stationary Hydrogen Storage . . . . . III-40  
 III.9 Low Cost Hydrogen Storage at 875 Bar Using Steel Liner and Steel Wire Wrap. . . . . III-45

**WPCSOL**

- V.E.4 The Effect of Airborne Contaminants on Fuel Cell Performance and Durability . . . . . V-119