# **Table of Contents**

 II.0		en Production Sub-Program Overview	
		ited Production from Bio-Derived Liquids	
II.A	Distribu	H <sub>2</sub> Gen Innovations, Inc: Low-Cost Hydrogen Distributed Production System	23
		Development	. 23
	II.A.2	Pacific Northwest National Laboratory: Distributed Hydrogen Production from	
	** * *	Biomass Reforming	
	II.A.3 II.A.4	Directed Technologies, Inc.: Analysis of Ethanol Reforming System Configurations Argonne National Laboratory: Pressurized Steam Reforming of Bio-Derived Liquids	. 31
	11.71.7	for Distributed Hydrogen Production	. 35
	II.A.5	Ohio State University: Investigation of Reaction Networks and Active Sites in	
		Bio-Ethanol Steam Reforming over Co-Based Catalysts.	. 39
	II.A.6	Virent Energy Systems, Inc.: Hydrogen Generation from Biomass-Derived Carbohydrates via the Aqueous-Phase Reforming (APR) Process	11
	II.A.7	Linde North America, Inc.: Integrated Hydrogen Production, Purification and	. 44
	11.21.7	Compression System	. 48
	II.A.8	Arizona State University: Zeolite Membrane Reactor for Water-Gas-Shift Reaction for	
	** 4 0	Hydrogen Production	. 51
	II.A.9	Pall Corporation: High Performance Palladium-Based Membrane for Hydrogen Separation and Purification	57
	II.A.10	Oak Ridge National Laboratory: Novel Low-Temperature Proton Transport	. 57
		Membranes	. 63
	II.A.11	Sandia National Laboratories: Ultra-Thin Proton Conduction Membranes for H <sub>2</sub>	
	II A 10	Stream Purification with Protective Getter Coatings	
		National Renewable Energy Laboratory: Distributed Bio-Oil Reforming	. /3
	11.A.13	(SCPO)	. 78
	II.A.14	Argonne National Laboratory: Distributed Reforming of Renewable Liquids via	
		Water Splitting Using Oxygen Transport Membrane (OTM)	. 85
II.B		ysis	
		Giner Electrochemical Systems, LLC: Low-Cost, High-Pressure Hydrogen Generator	. 90
	II.B.2	Proton Energy Systems: Hydrogen Generation from Electrolysis, 100 kgH <sub>2</sub> /day Trade Study	03
	II.B.3	Arizona State University: Development of Water Splitting Catalysts Using a Novel	. 93
	11.2.0	Molecular Evolution Approach	. 96
	II.B.4	National Renewable Energy Laboratory: Renewable Electrolysis Integrated System	
	II D 5	Development and Testing	.101
	II.B.5	Giner Electrochemical Systems, LLC: PEM Electrolyzer Incorporating an Advanced Low-Cost Membrane	105
	II.B.6	Avãlence LLC: High-Capacity, High Pressure Electrolysis System with Renewable	
		Power Sources	
	II.B.7	GE Global Research: Advanced Alkaline Electrolysis	
II.C		ions	.113
	II.C.1	Savannah River National Laboratory: Membrane Separation-Bulk Amorphous	117
	II.C.2	Hydrogen Purification/Separation Membranes	113
	11.0.2	Low-Temperature Membrane Reactor	.117

II.	Hydroge	n Produc	ction (Continued)	
	II.C	Separat	ions (Continued)	
		II.C.3	Materials and Systems Research, Inc.: Development of a Novel Efficient Solid-Oxide Hybrid for Co-Generation of Hydrogen and Electricity Using Nearby Resources for Local Application	121
	II.D	Biomass	s Gasification	.126
		II.D.1	National Renewable Energy Laboratory: Indirectly Heated Gasification of Biomass to Produce Hydrogen	126
		II.D.2	Gas Technology Institute: One Step Biomass Gas Reforming-Shift Separation Membrane Reactor	130
		II.D.3	United Technologies Research Center: A Novel Slurry-Based Biomass Reforming Process	133
		II.D.4	Los Alamos National Laboratory: Catalytic Solubilization and Conversion of Lignocellulosic Feedstocks to Hydrogen	137
	II.E	Photoel	ectrochemical	.140
		II.E.1	The University of Nevada, Las Vegas: Photoelectrochemical Hydrogen Production: UNLV-SHGR at UH Project Subtask	140
		II.E.2 II.E.3	National Renewable Energy Laboratory: Photoelectrochemical Water Splitting  Midwest Optoelectronics LLC: Critical Research for Cost-Effective	146
			Photoelectrochemical Production of Hydrogen	151
		II.E.4	University of Nevada, Reno: University of Nevada, Reno Photo-Electrochemical Project	155
		II.E.5	University of Toledo: Production of Hydrogen for Clean and Renewable Sources of Energy for Fuel Cell Vehicles	150
		II.E.6	National Renewable Energy Laboratory: Theory of Oxides for Photo-Electrochemical Hydrogen Production	
		II.E.7	University of California, Santa Barbara: Photoelectrochemical Hydrogen Production Using New Combinatorial Chemistry Derived Materials	
		II.E.8	University of Arkansas at Little Rock: Photoelectrochemical (PEC) Hydrogen Generation	173
		II.E.9	MVSystems, Incorporated: Photoelectrochemical Hydrogen Production: MVSystems Incorporated	177
	II.F	Biologic	cal Production	.182
		II.F.1	J. Craig Venter Institute: Hydrogen from Water in a Novel Recombinant O <sub>2</sub> -Tolerant Cyanobacterial System	182
		II.F.2	University of California, Berkeley: Maximizing Light Utilization Efficiency and Hydrogen Production in Microalgal Cultures	187
		II.F.3	Montana State University: Use of Biological Materials and Biologically Inspired Materials for $\mathbf{H}_2$ Catalysis	
		II.F.4	Florida International University: Photobiological Hydrogen Research	196
		II.F.5	National Renewable Energy Laboratory: Biological Systems for Hydrogen Photoproduction	200
		II.F.6	National Renewable Energy Laboratory: Fermentation and Electrohydrogenic Approaches to Hydrogen Production	
	II.G		en From Coal	.208
		II.G.1	Eltron Research & Development, Inc: Scale-Up of Hydrogen Transport Membranes for IGCC and FutureGen Plants.	208
		II.G.2	Southwest Research Institute <sup>®</sup> : Cost-Effective Method for Producing Self-Supporting Pd Alloy Membrane for Use in the Efficient Production of Coal-Derived Hydrogen	212
		II.G.3	United Technologies Research Center: Experimental Demonstration of Advanced Palladium Membrane Separators for Central High-Purity Hydrogen Production	215
		II.G.4	Western Research Institute: The Integration of a Structural Water-Gas Shift Catalyst with a Vanadium Alloy Hydrogen Transport Device	220

II.	Hydroge	n Produ	ction (Continued)
	II.G	Hydrog	en From Coal (Continued)
		II.G.5	REB Research and Consulting: High Flux Metallic Membranes for Hydrogen Recovery and Membrane Reactors
	II.H	Nuclear	· Hydrogen Initiative
		II.H.1	Sandia National Laboratories: Sulfur-Iodine Thermochemical Cycle
		II.H.2	Savannah River National Laboratory: Hybrid Sulfur Thermochemical Process  Development
		II.H.3	Idaho National Laboratory: Laboratory-Scale High Temperature Electrolysis System 234
		II.H.4	Argonne National Laboratory: High Temperature Thermochemical Processes 240
	II.I	Hi-Tem	p Thermochemical
		II.I.1	The UNLV Research Foundation: Development of Solar-Powered Thermochemical Production of Hydrogen from Water
		II.I.2	University of Central Florida: Solar High-Temperature Water-Splitting Cycle with Quantum Boost
		II.I.3	University of Colorado at Boulder: Solar-Thermal Hydrogen Production Using a Metal-Oxide Based Thermochemical Water Splitting Cycle
		II.I.4	TIAX LLC: Solar Thermochemical Hydrogen (STCH) Production – H2A Analysis 264
	II.J	Cross-C	Cutting
		II.J.1	Edison Materials Technology Center: Developing Improved Materials to Support the
			Hydrogen Economy
	II.K	Basic E	nergy Sciences
		II.K.1	University of North Carolina: Metal-to-Ligand Charge Transfer Excited States
			on Surfaces and in Rigid Media Application to Energy Conversion
		II.K.2	University of Washington: Real-Time Atomistic Simulation Studies of Light
		11 17 7	Harvesting and Charge Transport for Solar Hydrogen Production
		II.K.3	National Renewable Energy Laboratory: Efficient H <sub>2</sub> Production via Novel Molecular Chromophores and Nanostructures
		II.K.4	National Renewable Energy Laboratory: Regulation of H <sub>2</sub> and CO <sub>2</sub> Metabolism:
			Factors Involved in Partitioning of Photosynthetic Reductant in Green Algae 285
		II.K.5	University of Georgia: Fundamental Studies of Recombinant Hydrogenases
		II.K.6	University of Colorado: Catalyst Discovery Using Biomolecule Evolution
		II.K.7	California Institute of Technology: Sunlight-Driven Hydrogen Formation by
		пкя	Membrane-Supported Photoelectrochemical Water Splitting
		11.14.0	Polycrystalline Photoelectrodes for Solar Hydrogen Production
		II.K.9	Colorado State University: A Combinatorial Approach to Realization of Efficient
			Water Photoelectrolysis
			Pacific Northwest National Laboratory: Fundamental Investigations of Water Splitting on Model ${\rm TiO_2}$ Photocatalysts Doped for Visible Light Absorption
			Brookhaven National Laboratory: Catalyzed Water Oxidation by Solar Irradiation of Band-Gap-Narrowed Semiconductors
			Ohio State University: Photoactive Inorganic Membranes for Charge Transport310
			University of Pennsylvania: Modular Designed Protein Constructions for Solar Generated H <sub>2</sub> from Water314
			Pennsylvania State University: A Hybrid Biological-Organic Photochemical Half-Cell for Generating Dihydrogen
		II.K.15	University of Washington: Hydrogenases of Methanococcus Maripaludis
		II.K.16	Princeton University: Theoretical Research Program on Bio-inspired Inorganic
			Hydrogen Generating Catalysts and Electrodes
		11.K.17	University of Oklahoma: Identification of Enzymes Involved in Syntrophic H <sub>2</sub> Production 328

II. Hydroge	en Produ	ction (Cont	inued)	
II.K	Basic E	nergy Scier	nces (Continued)	
	II.K.18		of Hawaii: Production and Engineering of Hydrogenase as a Biocatalyst for Fuel	332
	II.K.19	University	of Arizona: "Electronically Wired" Semiconductor Nanoparticles: Toward Electron Transport in Hybrid Materials	
	II.K.20		of California, Santa Cruz: Hydrogen Generation Using Integrated iac and Photoelectrochemical Cells	338
	II.K.21	Pennsylva	nia State University: Tandem Hybrid Solar Energy System	342
	II.K.22		nia State University: Photoelectrochemistry of Semiconductor Nanowire	345
	II.K.23	Nanoptek	Corp: Strained ${\rm TiO}_2$ Photoanodes	348
		in Water I	nia State University: Highly Ordered Nanotube Arrays and their Use Photoelectrolysis	350
	II.K.25	in Mixed-	Polytechnic Institute and State University: Photoinitiated Electron Collection Metal Supramolecular Complexes: Development of Photocatalysts for Production	755
		v		
III. Hydrog		-		
	III.0		Delivery Sub-Program Overview	
	III.1		nc.: Hydrogen Delivery Infrastructure Options Analysis	
	III.2	-	National Laboratory: Hydrogen Delivery Infrastructure Analysis	368
	III.3		of Illinois at Urbana-Champaign: Hydrogen Embrittlement of Pipelines:	
			ntals, Experiments, Modeling	
	III.4	Secat, Inc	.: Materials Solutions for Hydrogen Delivery in Pipelines	381
	III.5	Oak Ridge	e National Laboratory: Composite Technology for Hydrogen Pipelines	386
	III.6	Savannah	River National Laboratory: FY 2008 SRNL Hydrogen Delivery Project-	
		Hydrogen	Permeability and Pipeline Integrity/Fiber Reinforced Composite Pipeline	390
	III.7	Gas Equip	oment Engineering Corp.: Innovative Hydrogen Liquefaction Cycle	395
	III.8		Livermore National Laboratory: Inexpensive Delivery of Cold Hydrogen erformance Glass Fiber Composite Pressure Vessels	400
	III.9	Air Produ	cts and Chemicals, Inc.: Reversible Liquid Carriers for an Integrated	
			n, Storage and Delivery of Hydrogen	404
	III.10	Argonne I	National Laboratory: Hydrogen Pipeline Compressors	408
	III.11		ational Laboratories: Enabling Hydrogen Embrittlement Modeling of	412
	III.12	FuelCell E	Energy, Inc.: Development of Highly Efficient Solid-State Electrochemical	
			Compressor	
	III.13	U	e National Laboratory: Hydrogen Permeability and Integrity of Steel Welds	
	III.14		ational Laboratories: Geologic Storage of Hydrogen	423
	III.15		nt Technologies Corporation: Hydrogen Regional Infrastructure Program lvania	427
IV. Hvdrog	en Storas	ge		435
IV.0			Sub-Program Overview	
		•	•	
IV.A	Metal F	•	nter of Excellence	
		IV.A.1a	Sandia National Laboratories: DOE Metal Hydride Center of Excellence	445
		IV.A.1b	HRL Laboratories, LLC: Thermodynamically Tuned Nanophase Materials for Reversible Hydrogen Storage	449
		IV.A.1c	University of Utah: Chemical Vapor Synthesis and Discovery of H <sub>2</sub> Storage Materials: Li-Al-Mg-N-H System	454
		IV.A.1d	University of Illinois at Urbana-Champaign: Reversible Hydrogen Storage Materials – Structure, Chemistry, and Electronic Structure	459

# IV. Hydrogen Storage (Continued)

IV.A	Metal Hydride Center of Excellence (Continued)						
		IV.A.1e	University of Pittsburgh: First-Principles Modeling of Hydrogen Storage in Metal Hydride Systems	. 465			
		IV.A.1f	Sandia National Laboratories: Development of Metal Hydrides at Sandia National Laboratories	. 471			
		IV.A.1g	Oak Ridge National Laboratory: Preparation and Reactions of Complex Hydrides for Hydrogen Storage: Metal Borohydrides and Aluminum Hydrides	. 479			
		IV.A.1h	Jet Propulsion Laboratory: Development and Evaluation of Advanced Hydride Systems for Reversible Hydrogen Storage				
		IV.A.1i	University of Nevada, Reno: Effect of Gaseous Impurities on Durability of Complex Li-based Hydrides for Hydrogen Storage	. 487			
		IV.A.1j	University of Hawaii: Fundamental Studies of Advanced High-Capacity, Reversible Metal Hydrides	. 493			
		IV.A.1k	Brookhaven National Laboratory: Aluminum Hydride Regeneration	. 499			
		IV.A.1l	National Institute of Standards and Technology: National Institute of Standards and Technology (NIST)	. 504			
		IV.A.1m	United Technologies Research Center: Catalyzed Nano-Framework Stabilized High-Density Reversible Hydrogen Storage Systems	510			
		IV.A.1n	Internatix: High-Throughput Combinatorial Chemistry Development of Complex Hydrides	. 515			
		IV.A.10	Stanford University: Thermodynamically Tuned Nanophase Materials for Reversible Hydrogen Storage: Structure and Kinetics of Nanoparticle and Model System Materials	. 520			
		IV.A.1p	Savannah River National Laboratory: Electrochemical Reversible Formation of Alane	. 525			
		IV.A.1q	Savannah River National Laboratory: Li-Mg-N System Hydrogen Storage Materials and Metal Hydride System Engineering Analysis	. 528			
		IV.A.1r	California Institute of Technology: Synthesis of Nanophase Materials for Thermodynamically Tuned Reversible Hydrogen Storage	. 534			
		IV.A.1s	Ohio State University: Lightweight Intermetallics for Hydrogen Storage	. 539			
	IV.A.2		: Discovery of Novel Complex Metal Hydrides for Hydrogen Storage folecular Modeling and Combinatorial Methods	. 544			
	IV.A.3		State University: Center for Hydrogen Storage Research at Delaware State	. 546			
	IV.A.4	Hydrogen	of Connecticut: Effects and Mechanisms of Mechanical Activation on Sorption/Desorption of Nanoscale Lithium Nitrides and Lithium des	. 551			
IV.B	Chemic	•	n Storage Center of Excellence				
		IV.B.1a	Los Alamos National Laboratory: 2008 Overview - DOE Chemical Hydrogen Storage Center of Excellence (CHSCoE)				
		IV.B.1b	University of California, Davis: Chemical Hydrogen Storage using Ultra-High Surface Area Main Group Materials and The Development of Efficient Amine-Borane Regeneration Cycles	. 562			
		IV.B.1c	Pacific Northwest National Laboratory: Chemical Hydrogen Storage Research at PNNL	. 565			
		IV.B.1d	Pennsylvania State University: Electrochemical Hydrogen Storage Systems	. 570			
		IV.B.1e	University of Missouri: Chemical Hydrogen Storage Using Polyhedral  Borane Anions and Aluminum-Ammonia-Borane Complexes	574			

# IV. Hydrogen Storage (Continued)

IV.B	Chemic	al Hydroge	n Storage Center of Excellence (Continued)	
		IV.B.1f	Los Alamos National Laboratory: Chemical Hydrogen Storage R&D at Los Alamos National Laboratory	. 577
		IV.B.1g	University of Pennsylvania: Amineborane-Based Chemical Hydrogen Storage	. 583
		IV.B.1h	Rohm and Haas Company: Low-Cost Precursors to Novel Hydrogen Storage Materials	. 587
		IV.B.1i	University of Alabama: Main Group Element and Organic Chemistry for Hydrogen Storage and Activation	. 592
		IV.B.1j	University of Washington: Solutions for Chemical Hydrogen Storage: Dehydrogenation of B-N Bonds	. 598
	IV.B.2	of Liquid-	cts and Chemicals, Inc.: Hydrogen Storage by Reversible Hydrogenation Phase Hydrogen Carriers	. 602
	IV.B.3	and Storag	ogen, LLC: Chemical Hydride Slurry for Hydrogen Production	. 607
	IV.B.4	Hydrides a	national: Development of Regenerable High Capacity Boron Nitrogen as Hydrogen Storage Materials	
IV.C	Hydrog	en Sorptior IV.C.1a	National Renewable Energy Laboratory: Overview of the DOE Hydrogen Sorption Center of Excellence	
		IV.C.1b	Lawrence Livermore National Laboratory: Carbon Aerogels for Hydrogen Storage	. 624
		IV.C.1c	National Institute of Standards and Technology: NIST Center for Neutron Research in Support of the Hydrogen Sorption Center of Excellence	. 627
		IV.C.1d	Duke University: Optimizing the Binding Energy of Hydrogen on Nanostructured Carbon Materials through Structure Control and Chemical Doping	. 632
		IV.C.1e	Pennsylvania State University: Advanced Boron and Metal-Loaded High Porosity Carbons	. 635
		IV.C.1f	Rice University: Nanoengineering the Forces of Attraction in a Metal-Carbon Array for H <sub>2</sub> Uptake at Room Temperature	. 640
		IV.C.1g	Texas A&M University: A Biomimetic Approach to Metal-Organic Frameworks with High H <sub>2</sub> Uptake	. 644
		IV.C.1h	University of Michigan: Hydrogen Storage by Spillover	. 647
		IV.C.1i	Rice University: Optimization of Nano-Carbon Materials for Hydrogen Sorption	. 651
		IV.C.1j	National Renewable Energy Laboratory: NREL Research as Part of the Hydrogen Sorption Center of Excellence	. 655
		IV.C.1k	Oak Ridge National Laboratory: ORNL Progress within the DOE Center of Excellence for Hydrogen Sorption: Synthesis and Processing of Single-Walled Carbon Nanohorns for Hydrogen Storage and Catalyst	
		IV.C.1l	Supports	
		IV.C.1m	Air Products and Chemicals, Inc.: Enabling Discovery of Materials With a Practical Heat of Hydrogen Adsorption	
		IV.C.1n	California Institute of Technology: Enhanced Hydrogen Dipole Physisorption	
		IV.C.1o	University of North Carolina at Chapel Hill: Characterization of	. 019
			Hydrogen Adsorption by NMR	. 683

١V.	Hydrog	en Storaș	ge (Continued)	
	IV.C	Sorbent	ts-Independent Projects	
		IV.C.2	Gas Technology Institute: Electron-Charged Graphite-Based Hydrogen Storage Material	. 687
		IV.C.3	State University of New York: Nanostructured Activated Carbon for Hydrogen Storage.	
		IV.C.4	University of Pennsylvania: Carbide-Derived Carbons with Tunable Porosity Optimized for Hydrogen Storage	
	IV D	New M	aterials–Independent Projects	
	14. D		University of California, Berkeley: A Synergistic Approach to the Development of New Hydrogen Storage Materials, Part I	
		IV.D.2	University of California, Santa Barbara: Hydrogen Storage Materials with Binding Intermediate between Physisorption and Chemisorption	
		IV.D.3	University of California, Los Angeles: Hydrogen Storage in Metal-Organic Frameworks	
		IV.D.4	Michigan Technological University: Novel Metal Perhydrides for Hydrogen Storage	
			New York State College of Ceramics at Alfred University: Glass Microspheres for Hydrogen Storage.	
	IV.E	Storage	Testing, Safety and Analysis	
	IV.L	IV.E.1	TIAX LLC: Analyses of Hydrogen Storage Materials and On-Board Systems	
			Argonne National Laboratory: System Level Analysis of Hydrogen Storage Options	
		IV.E.3		
		IV.E.4	Savannah River National Laboratory: Fundamental Environmental Reactivity Analysis of Hydrogen Storage Materials	
		IV.E.5	United Technologies Research Center: Quantifying and Addressing the DOE Material Reactivity Requirements with Analysis and Testing of Hydrogen Storage Materials and Systems	
		IV.E.6	Sandia National Laboratories: Chemical and Environmental Reactivity Properties of Hydrogen Storage Materials within the Context of Systems	
		IV.E.7	Southwest Research Institute®: Standardized Testing Program for Solid-State Hydrogen Storage Technologies	
	IV.F	Storage	Cross-Cutting	
	1 4.1	_	University of South Florida: Hydrogen Storage Research	
			Purdue University: Purdue Hydrogen Systems Laboratory	
			University of Arkansas at Little Rock: An Integrated Approach for Hydrogen Production and Storage in Complex Hydrides of Transitional Elements and	
			Carbon-based Nanostructural Materials	. 770
		IV.F.4	The UNLV Research Foundation: Hydrogen Fuel Cells and Storage	
			Technology Project.	. 776
V	Fuel Cell			
	V.0	Fuel Ce	lls Sub-Program Overview	789
	V.A	Analysi	s/Characterization	793
		V.A.1	Argonne National Laboratory: Fuel Cell Systems Analysis	. 793
		V.A.2	Directed Technologies, Inc.: Mass Production Cost Estimation for Direct H <sub>2</sub> PEM Fuel Cell System for Automotive Applications	. 798
		V.A.3	TIAX LLC: Cost Analyses of Fuel Cell Stack/Systems	. 803
		V.A.4	Oak Ridge National Laboratory: Microstructural Characterization of PEM Fuel Cell MEAs	. 811
		V.A.5	Los Alamos National Laboratory: Applied Science for Electrode Cost, Performance, and Durability	816

# V. Fuel Cells (Continued)

V.A	Analysi	s/Characterization (Continued)	
	V.A.6	National Institute of Standards and Technology: Neutron Imaging Study of the Water Transport in Operating Fuel Cells	. 821
	V.A.7	Los Alamos National Laboratory: Component Benchmarking Subtask Reported: USFCC Durability Protocol Development and Technical-Assisted Industrial and University Partners	826
	V.A.8	Argonne National Laboratory: Fuel Cell Testing at Argonne National Laboratory	
	V.A.9	Montana State University-Billings: Montana Palladium Research Initiative: Detection of Trace Platinum Group Element Particulates with Laser Spectroscopy	
	V.A.10	Battelle Memorial Institute: Market Opportunity Assessment of Direct Hydrogen PEM Fuel Cells in Federal and Portable Markets	
V.B	Bipolar	Plates/Hardware	. 844
	V.B.1	Oak Ridge National Laboratory: Nitrided Metallic Bipolar Plates	. 844
	V.B.2	GrafTech International Ltd.: Next Generation Bipolar Plates for Automotive PEM Fuel Cells	. 849
	V.B.3	UTC Power: Low-Cost Durable Seals for PEMFCs	855
	V.B.4	Honeywell Engineering & Technology: Cost and Performance Enhancements for a PEM Fuel Cell Turbocompressor	. 858
V.C	Catalys	ts/Supports	.861
	V.C.1 V.C.2	3M Company: Advanced Cathode Catalysts and Supports for PEM Fuel Cells Pacific Northwest National Laboratory: Development of Alternative and Durable	. 861
	v.c.z	High Performance Cathode Supports for PEM Fuel Cells	
	V.C.3	UTC Power Corporation: Highly Dispersed Alloy Cathode Catalyst for Durability	. 874
	V.C.4	Argonne National Laboratory: PEMFC using Aligned Carbon Nanotubes as Electrodes in MEAs	. 878
	V.C.5	University of South Carolina: Novel Non-Precious Metal Catalysts for PEMFC: Catalyst Selection through Molecular Modeling and Durability Studies	. 881
	V.C.6	Argonne National Laboratory: Non-Platinum Bimetallic Cathode Electrocatalysts	
	V.C.7	Los Alamos National Laboratory: Advanced Cathode Catalysts	
V.D	Distrib	uted Energy	
٧	V.D.1	UTC Power: PEM Fuel Cell Powerplant Development and Verification	
	V.D.2	Nuvera Fuel Cells: Cost-Effective High-Efficiency Advanced Reforming  Module (CHARM)	
	V.D.3	Intelligent Energy: Development and Demonstration of a New-Generation High	
	VD 4	Efficiency 1-10 kW Stationary Fuel Cell System.	
	V.D.4 V.D.5	Plug Power: FC40 International Stationary Fuel Cell Demonstration	
	V.D.5 V.D.6	Plug Power: Intergovernmental Stationary Fuel Cell System Demonstration	
***		· · · · · · · · · · · · · · · · · · ·	
V.E	Impurit V.E.1	ties	922
	VE 0	Cell Performance	. 922
	V.E.2	Clemson University: Fundamental Effects of Impurities on Fuel Cell Performance and Durability	. 926
	V.E.3	University of Connecticut: Effects of Impurities on Fuel Cell Performance and Durability	. 930
V.F	Recycli	ng	935
	V.F.1	BASF Catalysts LLC: Platinum Group Metal Recycling Technology Development	
	V.F.2	Ion Power, Inc.: Platinum Recycling Technology Development	. 939
V.G	Membr	anes	943
	V.G.1	Kettering University: Development of a Novel Proton Conducting Membrane and a CFD Multi-Phase Porous Flow Model for PEM Fuel Cells	

# V. Fuel Cells (Continued)

V.G	Membranes (Continued)					
	V.G.2	University of Central Florida: Lead Research and Development Activity for DOE's High Temperature, Low Relative Humidity Membrane Program	949			
	V.G.3	Chemsultants International, Inc.: Microstructural Design and Development of High Performance Polymer Electrolyte Membranes	953			
	V.G.4	Los Alamos National Laboratory: PEM Fuel Cell Durability	957			
	V.G.5	3M Company: Membranes and MEAs for Dry, Hot Operating Conditions	962			
	V.G.6	Lawrence Berkeley National Laboratory: New Polyelectrolyte Materials for High Temperature Fuel Cells				
	V.G.7	Arkema Inc.: Improved, Low-Cost, Durable Fuel Cell Membranes				
	V.G.8	Colorado School of Mines: Novel Approaches to Immobilized Heteropoly Acid (HPA)  Systems for High Temperature, Low Relative Humidity Polymer-Type Membranes				
	V.G.9	Virginia Polytechnic Institute and State University: High-Temperature, Low Relative Humidity, Polymer-type Membranes Based on Disulfonated Poly(arylene ether) Block and Random Copolymers Optionally Incorporating Protonic Conducting Layered Water Insoluble Zirconium Fillers	982			
	VG 10	Arizona State University: Protic Salt Polymer Membranes: High-Temperature	902			
	V.G.10	Water-Free Proton-Conducting Membranes.	987			
	VG 11	Clemson University: Fluoroalkylphosphonic-Acid-Based Proton Conductors				
		Case Western Reserve University: Poly(p-Phenylene Sulfonic Acids): PEMs with Frozen-In Free Volume				
	V.G.13	Case Western Reserve University: NanoCapillary Network Proton Conducting Membranes for High-Temperature Hydrogen/Air Fuel Cells				
	V.G.14	Pennsylvania State University: New Proton Conductive Composite Materials with Co-Continuous Phases Using Functionalized and Crosslinkable VDF/CTFE				
	V.G.15	Fluoropolymers				
	V.G.16	Giner Electrochemical Systems, LLC: Dimensionally Stable Membranes				
		University of Tennessee: Poly(cyclohexadiene)-Base Polymer Electrolyte Membranes for Fuel Cell Applications				
	V.G.18	Giner Electrochemical Systems, LLC: Dimensionally Stable High Performance Membrane				
	V.G.19	University of Southern Mississippi: Improved Membrane Materials for PEM Fuel Cell Applications				
****	***	••				
V.H	Water 1 V.H.1	Transport CFD Research Corporation: Water Transport in PEM Fuel Cells: Advanced Modeling,				
		Material Selection, Testing, and Design Optimization	. 1033			
	V.H.2	Rochester Institute of Technology: Visualization of Fuel Cell Water Transport and Performance Characterization under Freezing Conditions	. 1037			
	V.H.3	Los Alamos National Laboratory: Water Transport Exploratory Studies	. 1042			
V.I	Auxilar	ry/Off-Road/Portable	.1048			
	V.I.1	Cummins Power Generation: Diesel-Fueled SOFC System for Class 7/Class 8 On-Highway Truck Auxiliary Power				
	V.I.2	MTI Micro Fuel Cells: Direct Methanol Fuel Cell Prototype Demonstration for Consumer Electronics Applications.				
	V.I.3	Delphi Corporation: Solid Oxide Fuel Cell Development for Auxiliary Power in Heavy Duty Vehicle Applications				
	V.I.4	PolyFuel, Inc.: Direct Methanol Fuel Cell Power Supply for All-Day True Wireless Mobile Computing				
	VI5	IdaTech LLC: Research & Development for Off-Road Fuel Cell Applications				

V. Fuel Cel	ls (Conti	nued)
V.J	Cross-C	Cutting
	V.J.1	Case Western Reserve University: Light-Weight, Low-Cost PEM Fuel Cell Stacks 1065
	V.J.2	University of South Carolina: Fuel Cell Research at the University of South Carolina 1068
V.K	Water N	Management
	V.K.1	Honeywell Engineering & Technology: Development of Thermal and Water
		Management System for PEM Fuel Cells
	V.K.2	Pacific Northwest National Laboratory: Low-Cost Manufacturable Microchannel
		Systems for Passive PEM Water Management
	V.K.3	Nuvera Fuel Cells, Inc.: CIRRUS: Cell Ice Regulation and Removal Upon Start-Up 1079
VI. Manuf	acturing	R&D
	VI.0	Manufacturing R&D Sub-Program Overview
	VI.1	National Renewable Energy Laboratory: Fuel Cell Membrane Electrode Assembly
		Manufacturing R&D
	VI.2	National Center for Manufacturing Sciences: Advanced Manufacturing Technologies for Renewable Energy Applications - a DOE/NCMS Partnership
	VI.3	National Institute of Standards and Technology: Metrology for Fuel Cell
		Manufacturing
VII. Techn	ology Val	lidation
	VII.0	Technology Validation Sub-Program Overview
	VII.1	Chrysler LLC: Hydrogen to the Highways - Controlled Hydrogen Fleet and
		Infrastructure Demonstration and Validation Project
	VII.2	Ford Motor Company: Ford and BP Hydrogen Fuel Cell Vehicle and Infrastructure
		Demonstration Program Review 2008
	VII.3	Chevron Technology Ventures LLC: Controlled Hydrogen Fleet and Infrastructure
	3711.4	Demonstration and Validation Project
	VII.4 VII.5	General Motors: Hydrogen Vehicle and Infrastructure Demonstration and Validation 1124 Air Products and Chemicals, Inc.: California Hydrogen Infrastructure Project 1128
	VII.5 VII.6	Lawrence Livermore National Laboratory: Automotive Cryogenic Capable Pressure
	V 11.0	Vessels for Compact, High Dormancy (L)H <sub>2</sub> Storage
	VII.7	Florida Hydrogen Initiative, Inc.: Florida Hydrogen Initiative
	VII.8	University of Nevada, Las Vegas: Hydrogen Filling Station
	VII.9	City of Las Vegas: Southern Nevada Alternative Fuels Demonstration Project
	VII.10	Air Products and Chemicals, Inc.: Validation of an Integrated Hydrogen
		Energy Station
	VII.11	University of Hawaii at Manoa: Hawaii Hydrogen Center for Development and
		Deployment of Distributed Energy Systems
	VII.12	National Renewable Energy Laboratory: Controlled Hydrogen Fleet and Infrastructure Analysis
	VII.13	National Renewable Energy Laboratory: Technology Validation: Fuel Cell Bus
	V 11.13	Evaluations
VIII. Safet	-	& Standards
	VIII.0	Safety, Codes & Standards Sub-Program Overview
	VIII.1	National Renewable Energy Laboratory: Hydrogen Safety Codes and Standards 1183
	VIII.2	Sandia National Laboratories: Hydrogen Safety, Codes and Standards R&D:  Materials Compatibility
	VIII.3	Pacific Northwest National Laboratory: Hydrogen Safety Tools: Software and
	v 111.3	Hardware
	VIII.4	Los Alamos National Laboratory: Hydrogen Fuel Quality: The Year In Review
	VIII.5	Sandia National Laboratories: Hydrogen Safety, Codes and Standards R&D –
		Release Behavior

VIII. Sa	fety, Codes	& Standards (Continued)	
	VIII.6	Pacific Northwest National Laboratory: Hydrogen Safety Panel	. 1202
	VIII.7	Regulatory Logic LLC: Supporting the Consensus-Based Process for Hydrogen Codes and Standards	
	VIII.8	Longitude 122 West, Inc.: IEA Hydrogen Task 18: Evaluation of Integrated	. 1200
	V 111.0	Demonstration Systems.	. 1207
IX. Edu	cation		. 1211
	IX.0	Education Sub-Program Overview	. 1213
	IX.1 IX.2	Oak Ridge National Laboratory: Hydrogen Knowledge and Opinions Assessment Pacific Northwest National Laboratory: Hydrogen Safety: First Responder	. 1219
		Education	. 1222
	IX.3	National Renewable Energy Laboratory: Hydrogen Education for Code Officials	
	IX.4	The Media Network: Increasing "H2IQ": A Public Information Program	
	IX.5	Hydrogen Education Foundation: H2 and You: A Public Education Initiative	
	IX.6	University of California, Berkeley: Hydrogen Technology and Energy Curriculum (HyTEC)	
	IX.7	The National Energy Education Development (NEED) Project: H <sub>2</sub> Educate –	
		Middle School Hydrogen Education Project.	. 1238
X. Syste	ems Analysis	5	. 1241
J	X.0	Systems Analysis Sub-Program Overview	
	X.1	Oak Ridge National Laboratory: Development of HyTrans Model and Integrated Scenario Analysis.	
	X.2	Argonne National Laboratory: Fuel-Cycle Analysis of Hydrogen-Powered Fuel-Cell Systems with the GREET Model	
	X.3	National Renewable Energy Laboratory: Discrete Choice Analysis of Consumer Preferences for Refueling Availability	
	X.4	National Renewable Energy Laboratory: Macro-System Model	
	X.5	RCF Economic and Financial Consulting, Inc.: Analysis of the Hydrogen Production and Delivery Infrastructure as a Complex Adaptive System	
	X.6	National Renewable Energy Laboratory: Updates to the H2A Hydrogen Production Discounted Cash Flow Model (H2A Version 2.0)	
	X.7	Lawrence Livermore National Laboratory: Water Needs and Constraints for Hydrogen Pathways	
	X.8	National Renewable Energy Laboratory: HyDRA: Hydrogen Demand and Resource Analysis Tool	
	X.9	National Renewable Energy Laboratory: Lessons Learned for Refueling Infrastructure	
	X.10	Missouri University of Science and Technology: Hydrogen and Fuel Cell Analysis:  Lessons Learned from Stationary Power Generation	
	X.11	Argonne National Laboratory: Hydrogen Quality Issues for Fuel Cell Vehicles	
	X.11 X.12	TIAX LLC: Assessment of Platinum Leasing Strategies for Fuel-Cell Vehicles and Platinum Availability Update	
	X.13	University of Illinois at Urbana-Champaign: Evaluation of the Potential Environmental Impacts from Large-Scale Use and Production of Hydrogen in Energy and Transportation Applications	
	X.14	Tetra Tech, Inc.: Potential Environmental Impacts of Hydrogen-Based Transportation and Power Systems	
	X.15	National Renewable Energy Laboratory: Adapting the H2A Hydrogen Production Cost Analysis Model to Stationary Applications	
	X.16	National Renewable Energy Laboratory: DOE Hydrogen Program Risk Analysis in Support of EERE's Portfolio Analysis	1305

X. S	ystems Analysi	s (Continued)	
	X.17	Sandia National Laboratories: Analysis of Energy Infrastructures and Potential Impacts from an Emergent Hydrogen Fueling Infrastructure	1307
XI.	Small Business	Innovation Research Projects	1311
	XI.0	Small Business Innovation Research (SBIR) Hydrogen Program New Projects Awarded in FY 2008	1313
	Phase l	[ Projects	1314
	XI.1	Directed Technologies, Inc.: Aqueous Phase Base-Facilitated-Reforming of Renewable Fuel	1314
	XI.2	Faraday Technology, Inc.: Faradayic ElectroEtching of Stainless Steel Bipolar Plates	1314
	XI.3	Giner Electrochemical Systems, LLC: Anode Concepts for SO2 Crossover Reduction in the HyS Electrolyzer	1315
	XI.4	InnovaTek, Inc.: Power Generation from an Integrated Biofuel Reformer and Solid Oxide Fuel Cell.	1315
	XI.5	Precision Energy and Technology, LLC: Utilizing Metal Injection Molding to Meet High Volume, Cost Effective Manufacturing of Bipolar Plates	1316
	XI.6	T3 Scientific, LLC: Sulfur-Resistant, Ultrathin Dense Membrane for Production of High Purity Hydrogen (STTR Project)	
	Phase 1	II Projects	1317
	XI.7	FuelCell Energy, Inc.: Development of Highly Efficient Solid State Electrochemical Hydrogen Compressor	
	XI.8	Mohawk Innovative Technology, Inc.: Advanced Sealing Technology for Hydrogen Compressors	
	XI.9	Physical Optics Corporation: Photoelectrochemical System for Hydrogen Generation	
	XI.10	Synkera Technologies, Inc.: Nanotube Array Photoelectrochemical Hydrogen Production	1317
	XI.11	Eltron Research & Development, Inc.: Perovskite Adsorbents for Warm-Gas Removal of Sulfur	1318
	XI.12	Inorganic Specialists, Inc.: Nanofiber Paper for Fuel Cells and Catalyst Supports	1318
XII.	Acronyms and	d Abbreviations	1319
XIII.	Primary Cont	acts Index	1337
	•	gram Contacts	
XV.	Project Listing	gs by State	1345
XVI.	Project Listing	gs by Organization	1367