Appendix A –Budgetary Information

The schedule for completing the milestones and achieving the targets and RD&D priorities outlined in this plan is based on expected funding levels, the current stage of development of different technologies, and the perceived difficulty in attaining the targets. Deviation from the expected funding levels may alter the schedule for completion of the tasks and milestones. For example, if funding falls short of expected levels, the target dates for completion of certain milestone may be extended to later dates. If additional funding is made available over the expected amount, the rate of technology development could be accelerated in key research areas.

Funding Profile:

The following table shows the funding profile (in millions) for the Fuel Cell Technologies Program (the EERE part of the DOE Hydrogen and Fuel Cells Program) from FY 2007 through FY 2011, with a breakdown by key activity. To reach its targets, the Fuel Cell Technologies Program expects funding to be provided at the level projected within internal DOE planning documents. If funding deviates from these projections, priorities have been established to reallocate funds.

Major Activity	FY 2007 Funding	FY 2008 Funding	FY 2009 Funding	FY 2010 Funding	FY 2011 Funding
Hydrogen Production & Delivery	33.7	38.6	10.0	14.6	17.5
Hydrogen Storage	33.7	42.4	57.8	31.1	14.6
Safety, Codes & Standards	13.5	15.4	12.2	8.7	6.9
Education	2.0	3.9	4.2	2.0	0.0
Systems Analysis	9.6	11.1	7.5	5.4	3.0
Market Transformation	0.0	0.0	4.8	15.0	0.0
Manufacturing	1.9	4.8	4.5	4.9	2.9
Fuel Cells	55.7	60.4	80.1	75.6	41.9
Technology Validation	39.4	29.6	14.8	13.0	9.0
TOTAL Hydrogen and Fuel Cells	**189.5**	**206.2**	**195.9**	**170.3**	**95.8**

Source: Congressional Budgets, Energy and Water Development Appropriations

Appendix C – Hydrogen Quality

The hydrogen fuel quality specification in Table C.1 below is based on the SAE International Surface Vehicle Standard *SAE-2719 - Hydrogen Fuel Quality Guideline for Fuel Cell Vehicles,* June 2011. This specification has been harmonized to the extent possible with the draft international standard, ISO/*DIS 14687-2, Hydrogen Fuel – Product Specification – Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles*, recently approved by the International Organization for Standardization (ISO).

The primary purpose of this specification is to ensure that the effects of possible fuel contaminants on fuel cell performance and durability in early commercial vehicles are acceptable. Modeling and analysis have shown that the impact on the cost of producing hydrogen fuel that complies with the specification is not significant. However, the costs of analyzing and verifying compliance with the specification are still under study. ASTM International has developed and is validating standardized methods to sample and analyze the presence of contaminants at the levels prescribed in the specification.

Additional fuel quality RD&D, fuel cell testing, operational data from fuel cell vehicles, improvements in the impurity tolerance of fuel cells, and advanced material storage options that are likely to introduce or impose different impurities may lead to revisions of these limits. Fuel Cell and Hydrogen Program RD&D planning will address hydrogen quality issues as they relate to cost and performance goals for each technology area— production, delivery, storage, fuel cells, and safety, codes and standards. Those issues and RD&D activities specific to each of these areas will be included in those sections of the RD&D Plan.

Table C.1: Hydrogen Fuel Quality Specification				
Constituent	**Chemical Formula**	**Limits [e]**	**Laboratory Test Methods to Consider and Under Development [f]**	**Minimum Analytical Detection Limit**
Hydrogen fuel index	H_2	>99.97%		
Total allowable non-hydrogen, non-helium, non-particulate constituent		100 µmol/mol		
Acceptable limit of each individual constituent				
Water[a]	H_20	5 µmol/mol	ASTM D7653-10, ASTM D7649-10	0.12 µmol/mol
Total hydrocarbons[b] (C_1 basis)		2 µmol/mol	ASTM D7675-11	0.1 µmol/mol
Oxygen	O_2	5 µmol/mol	ASTM D7649-10	1 µmol/mol
Helium	He	300 µmol/mol	ASTM D1945-03	100 µmol/mol
Nitrogen, Argon	N_2, Ar	100 µmol/mol	ASTM D7649-10	5 µmol/mol
Carbon dioxide	CO_2	2 µmol/mol	ASTM D7649-10, ASTM D7653-10	0.1 µmol/mol
Carbon monoxide	CO	0.2 µmol/mol	ASTM D7653-10	0.01 µmol/mol
Total sulfur[c]		0.004 µmol/mol	ASTM D7652-11	0.00002 µmol/mol
Formaldehyde	HCHO	0.01 µmol/mol	ASTM D7653-10	0.01 µmol/mol
Formic acid	HCOOH	0.2 µmol/mol	ASTM D7550-09 , ASTM D7653-10	0.02 µmol/mol
Ammonia	NH_3	0.1 µmol/mol	ASTM D7653-10	0.02 µmol/mol
Total halogenates[d]		0.05 µmol/mol	ASTM WK23815, WK34574	0.01 µmol/mol
Particulate Concentration		1 mg/kg	ASTM D7650-10, ASTM D7651-10	0.005 mg/kg

[a] Due to water threshold level, the following constituents should not be found, however they should be tested for if there is a question on water content:
Sodium (Na+) @ <0.05 µmole/mole H_2 or <0.05 µg/liter
Potassium (K+) @ <0.05 µmole/mole H_2 or <0.08 µg/liter
or Potassium hydroxide (KOH) @ <0.05 µmole/mole H_2 or <0.12 µg/liter

[b] Includes, for example, ethylene, propylene, acetylene, benzene, phenol (paraffins, olefins, aromatic compounds, alcohols, aldehydes). THC may exceed 2 micromoles per mole due only to the presence of methane, in which case the summation of methane, nitrogen and argon is not to exceed 100 ppm.

[c] Includes, for example, hydrogen sulfide (H_2S), carbonyl sulfide (COS), carbon disulfide (CS_2) and mercaptans.
[d] Includes, for example, hydrogen bromide (HBr), hydrogen chloride (HCl), chlorine (Cl_2) and organic halides (R-X).
[e] Limits are upper limits except for the hydrogen which is a lower limit. All limits are subject to revision after additional testing under operational conditions and improved standardized analytical procedures.
[f] Gaseous sampling uses procedures in ASTM D7606-11

DOE Hydrogen Program
2011 Annual Merit Review
Project Evaluation Form

Project Number: _____ **Reviewer:** _____

Title of Project: _____

Presenter Name: _____

Provide **specific, concise** comments to support your evaluation.

1. **Relevance**
   To overall DOE objectives – the degree to which the project supports the Hydrogen and Fuel Cells Program and the goals and objectives in the Multi-Year RD&D Plan. (Weight = 20%)

	score	comments
4 - Outstanding. Project is critical to the Hydrogen and Fuel Cells Program and fully supports DOE RD&D objectives. **3 - Good.** Most project aspects align with the Hydrogen and Fuel Cells Program and DOE RD&D objectives. **2 - Fair.** Project partially supports the Hydrogen and Fuel Cells Program and DOE RD&D objectives. **1 - Poor.** Project provides little support to the Hydrogen and Fuel Cells Program and DOE RD&D objectives.		

2. **Approach**
   To performing the work – the degree to which barriers are addressed, the project is well designed, feasible, and integrated with other efforts. (Weight = 20%)

	score	comments
4 - Outstanding. Sharply focused on critical barriers; difficult to improve approach significantly. **3 - Good.** Generally effective but could be improved; contributes to overcoming some barriers. **2 - Fair.** Has significant weaknesses; may have some impact on overcoming barriers. **1 - Poor.** Not responsive to project objectives; unlikely to contribute to overcoming the barriers.		

3. **Accomplishments and progress**
   Toward overall project and DOE goals – the degree to which progress has been made and measured against performance indicators, and the degree to which the project has demonstrated progress toward DOE goals. (Weight = 40%)

	score	comments
4 - Outstanding. Excellent progress toward objectives; suggests that barrier(s) will be overcome. **3 - Good.** Significant progress toward objectives and overcoming one or more barriers. **2 - Fair.** Modest progress in overcoming barriers; rate of progress has been slow . **1 - Poor.** Little or no demonstrated progress towards objectives or any barriers.		

4. **Collaboration and coordination with other institutions**
The degree to which the project interacts with other entities and projects. (Weight = 10%)

	score	comments
4 - Outstanding. Close, appropriate collaboration with other institutions; partners are full participants and well coordinated. **3 - Good.** Some collaboration exists; partners are fairly well coordinated. **2 - Fair.** A little collaboration exists; coordination between partners could be significantly improved. **1 - Poor.** Most work is done at the sponsoring organization with little outside collaboration; little or no apparent coordination with partners.		

5. **Proposed future work**
The degree to which the project has effectively planned its future in a logical manner by incorporating appropriate decision points, considering barriers to its goals and, when sensible, mitigating risk by providing alternate pathways. (Weight = 10%)

	score	comments
4 - Outstanding. Plans clearly build on past progress and are sharply focused on barriers. **3 - Good.** Plans build on past progress and generally address overcoming barriers. **2 - Fair.** Plans may lead to improvements, but need better focus on overcoming barriers. **1 - Poor.** Plans have little relevance toward eliminating barriers or advancing the Program		

Project strengths:

Project weaknesses

Recommendations for additions/deletions to project scope

Project Number: **Reviewer:**

Appendix E — Acronyms

AEI	Advanced Energy Initiative
AEO	Annual Energy Outlook
AFC	Alkaline Fuel Cell
AHJ	Authorities Having Jurisdiction
AMFC	Alkaline Membrane Fuel Cells
AMR	Annual Merit Review
ANL	(DOE) Argonne National Laboratory
APU	Auxiliary Power Unit
ARRA	American Recovery and Reinvestment Act of 2009
ASES	American Solar Energy Society
ASME	American Society of Mechanical Engineers
AST	Accelerated Stress Test
ASTM	American Society for Testing and Materials
ATP	Adenosine-5'-Triphosphate
Bchl	Bacteriochlorophyll
BES	(DOE Office of) Basic Energy Sciences
BEV	Battery Electric Vehicle
BNL	(DOE) Brookhaven National Laboratory
BOP	Balance of Plant
BPVC	Boiler and Pressure Vessel Code
C/N	Ratio of Carbon to Nitrogen
CaFCP	California Fuel Cell Partnership
CARB	California Air Resource Board
CCB	Change Control Board
CcH2	Cryo-Compressed Hydrogen
CCM	Catalyst Coated Membrane
CDO	Code Development Organization
CDP	Composite Data Products
CEC	California Energy Commission
CERL	(U.S. Army's) Construction Engineering Research Laboratory
CFD	Computational Fluid Dynamics
CH2P	Combined Hydrogen and Power
CHG	Compressed Hydrogen Gas
CHHP	Combined Heat, Hydrogen and Power
CHP	Combined Heat and Power
CNG	Compressed Natural Gas
CoE	Center of Excellence
COP	Coefficient of Performance
CRADA	Cooperative Research and Development Agreement
CSA	Canadian Standards Association
CSD	Compression, Storage, and Dispensing
CSTT	Codes and Standards Technical Team

DDP	Detailed Data Products
DFMA	Design for Manufacture and Assembly
DG	Distributed Generation
DLA	Defense Logistics Agency
DMFC	Direct Methanol Fuel Cell
DNGR	Distributed Natural Gas Reforming
DOC	U.S. Department of Commerce
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EERE	(DOE) Office of Energy Efficiency and Renewable Energy
EIA	U.S. Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA	U.S. Environmental Protection Agency
EPAct	Energy Policy Act of 2005
EPRI	Electric Power Research Institute
ER	Emergency Response
ESG	Executive Steering Group
EWD	Energy and Water Development
FAA	(DOT) Federal Aviation Administration
FACA	Federal Advisory Committee Act
FCB	Fuel Cell Bus
FCEV	Fuel Cell Electric Vehicle
FCHEA	U.S. Fuel Cells and Hydrogen Energy Association
FCH JU	Fuel Cell and Hydrogen Joint Undertaking
FCT	(DOE) Fuel Cell Technologies (Office)
FCV	Fuel Cell Vehicles
FE	(DOE) Office of Fossil Energy
FOM	Federated Object Model
FPITT	Fuel Pathway Integration Technical Team
FRB	Fiber-Reinforced Polymer
FTE	Full-Time Equivalent
GDE	Gas Diffusion Electrode
GDL	Gas Diffusion Layer
GGE	Gallon of Gasoline Equivalent
GHG	Greenhouse Gases
GIS	Geographical Information System
GPRA	Government Performance and Results Act
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (Model)
GSE	Ground Support Equipment
GTI	Gas Technology Institute
GTR	Global Technical Regulations
H2A	Hydrogen Analysis Tool (computer model)
HAMMER	Hazardous Materials Management and Emergency Response
HCSTT	Hydrogen Codes and Standards Technical Team

HDPE	High-Density Polyethylene
HDSAM	Hydrogen Delivery Scenario Analysis Model
H-E-B	Here Everything's Better (supermarkets)
HEV	Hybrid Electric Vehicle
HFCEV	Hydrogen Fuel Cell Electric Vehicle
HFCIT	(DOE) Hydrogen, Fuel Cells and Infrastructure Technologies (Program)
HFCV	Hydrogen and Fuel Cell Vehicle
HFI	Hydrogen Fuel Initiative
HHV	Higher Heating Value
HIPOC	Hydrogen Industry Panel on Codes
HLA	High Level Architecture
HNEI	Hawaii Natural Energy Institute
HSDC	Hydrogen Secure Data Center
HSECoE	Hydrogen Storage Engineering Center of Excellence
HSP	Hydrogen Safety Panel
HTAC	The Hydrogen and Fuel Cell Technical Advisory Committee
HyARC	Hydrogen Analysis Resource Center
HyPRO	Hydrogen Production Simulation Tool
HyTEC	Hydrogen Technology and Energy Curriculum
HyTrans	Hydrogen Transition Model
IB	Integrated Baseline
ICAO	International Civil Aviation Organization
ICC	International Code Council
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IPEC	Incident Photon-to-Electron Conversion
IPHE	International Partnership for Hydrogen and Fuel Cells in the Economy
IRES	Integrated Renewable Energy Station
ISO	International Organization for Standardization
ITER	International Thermonuclear Experimental Reactor
LCA	Life Cycle Assessment
LCOE	Levelized Cost of Energy
LH2	Liquid Hydrogen
LHC	Light Harvesting Complex
LHV	Lower Heating Value
LLNL	(DOE) Lawrence Livermore National Laboratory
LPG	Liquefied Petroleum Gas (also called Liquid Propane Gas)
M&O	Management and Operations
MACRS	Modified Accelerated Cost-Recovery System
MARKAL	Market Allocation Model
MCFC	Molten Carbonate Fuel Cell
MEA	Membrane Electrode Assembly
MEC	Microbial Electrolysis Cell

MHE	Material Handling Equipment
MiniCAM	Mini-Climate Assessment Model
MMBtu	Million (Thousand Thousand) Btu
MOF	Metal Organic Framework
MPL	Micro-Porous Layer
MSM	Macro-System Model
MTBF	Mean Time Between Failures
MYPP	Multi-Year Program Plan
MYRD&D	Multi-Year Research, Development, and Demonstration (Plan)
NA	Not Available
NAE	National Academy of Engineering
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NDE	Nondestructive Evaluation
NE	(DOE) Office of Nuclear Energy
NEMS	National Energy Modeling System
NETL	(DOE) National Energy Technology Laboratory
NFCBP	National Fuel Cell Bus Program
NFPA	National Fire Protection Association
NHA	National Hydrogen Association
NHTSA	National Highway Transportation Safety Administration
NIST	National Institute for Standards and Technology
NO_X	Nitrogen Oxide
NPS	U.S. National Park Service
NRC	National Research Council
NREL	(DOE) National Renewable Energy Laboratory
O&M	Operations and Maintenance
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturers
OMB	(White House) Office of Management and Budget
ORNL	(DOE) Oak Ridge National Laboratory
OSTP	(White House) Office of Science and Technology Policy
OTR	Over the Road
PAN	Polyacrylonitrile
P/R	Photosynthesis/Respiration Capacity Ratio
PAE	Planning, Analysis and Evaluation
PAFC	Phosphoric Acid Fuel Cell
PAR	Photosynthetically Active Radiation
PART	(OMB) Program Assessment Rating Tool
PB	Programmatic Baseline
PBA	(EERE Office of) Planning, Budget and Analysis
PBI-type	Polybenzimidazole-type (Fuel Cell)
PDA	Personal Digital Assistant
PEC	Photoelectrochemical
PEM	Polymer Electrolyte Membrane

PEMFC	Polymer Electrolyte Membrane Fuel Cell
PHEV	Plug-In Hybrid Electric Vehicle
PM	Particulate Matter
PM	Program Manager
PMC	Project Management Center
PMOP	Program Management and Operations Plan
PNNL	(DOE) Pacific Northwest National Laboratory
PNS	Purple Non-Sulfur (Bacteria)
POF	Polymeric Organic Framework
PPA	Power Purchase Agreement
PROX	Preferential Oxidation
PSA	Pressure Swing Adsorption
PSAT	Powertrain Systems Analysis Toolkit
PTC	Production Tax Credit
R&D	Research and Development
RCS	Regulations, Codes and Standards
RCSWG	Regulations, Codes and Standards Working Group
RD&D	Research, Development and Demonstration
RDD&D	Research, Development, Demonstration and Deployment
RFP	Request for Proposal
RH	Relative Humidity
RLP	Resource Loaded Plan
RMP	Risk Management Plan
SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SAP	Systems Analysis Plan
SBIR	Small Business Innovation Research (Program)
SC	(DOE) Office of Science
SCRA	South Carolina Research Authority
SCS	Safety, Codes and Standards
SDO	Standards Development Organizations
SECA	Solid State Energy Conversion Alliance
SERA	Scenario Evaluation and Regionalization Analysis
SIP	Systems Integration Plan
SMR	Steam Methane Reforming
SNL	(DOE) Sandia National Laboratories
SOFC	Solid Oxide Fuel Cell
SOW	Statement of Work
SRA	SRA International, Inc.
SRNL	(DOE) Savannah River National Laboratory
STCH	Solar Thermochemical Hydrogen (Production)
STH	Solar to Hydrogen
TAG	U.S. Technical Advisory Groups
TARDEC	(U.S. Army's) Tank Automotive, Research, Development, and Engineering Center
TB	Technical Baseline

TBD	To Be Determined
TDM	Technology Development Manager
TEA	Techo-Economic Analysis
TIR	Technical Information Report
TRL	Technology Readiness Level
U.S. DRIVE	Driving Research and Innovation for Vehicle efficiency and Energy sustainability (Partnership)
UL	Underwriters Laboratories
UN	United Nations
UNECE	United Nations Economic Commission for Europe
USCAR	U.S. Council for Automotive Research
USDA	U.S. Department of Agriculture
VSATT	Vehicle Systems Analysis Technical Team
VT	(EERE) Vehicle Technologies (Office)
VTP	Vehicle Technologies Program
WBS	Work Breakdown Structure
ZBus	Zero-Emission Bus
ZIF	Zeolitic Imidazolate Framework