DEVELOPING IMPROVED MATERIALS TO SUPPORT THE HYDROGEN ECONOMY

Michael Martin
Edison Materials Technology Center

May 16-19, 2006

Project ID# PDP18

Objectives

Edison Materials Technology Center (**EMTEC**) will use, “Hydrogen, Fuel Cells & Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan” goals to find and fund projects to stimulate near term manufacturing based commercialization potential.

Feasibility projects with job creation potential

Cross cutting breakthrough materials technology

Will use EMTEC Core Technology (CT) model

Target Technologies and Barriers

Target Technology	DOE Barrier Addressed
H_2 Generation from Renewable Liquid Feedstocks	Fuel Processor Capital Costs
H_2 Generation by Water Electrolysis	Renewable Integration
H_2 Generation by Photoelectrochemical Electrolysis	Materials Efficiency, Bulk Materials Synthesis, Device Configuration Designs
H_2 Separation Materials	Cost, Impurities
H_2 Generation from Biomass and Coal	Capital Cost and Efficiency
H_2 Storage by New Materials and Concepts	Efficiency, Cost, Weight and Volume
H_2 Processing: Sensors, Delivery, Purification	Durability, Cost

EMTEC

- EMTEC is one of 7 State of Ohio Edison Centers
  - Established in 1987 by Ohio Gov. Celeste
  - 501c(3) Not for Profit
- Membership Based with Over 140 Industry, University, and Government Members
- Virtual – We Own no Major Capital Equipment
- Access to Over $2B in State-Of-The-Art Facilities
- Significant Experience in Ceramics, Metals, Polymers, and many Material Processes

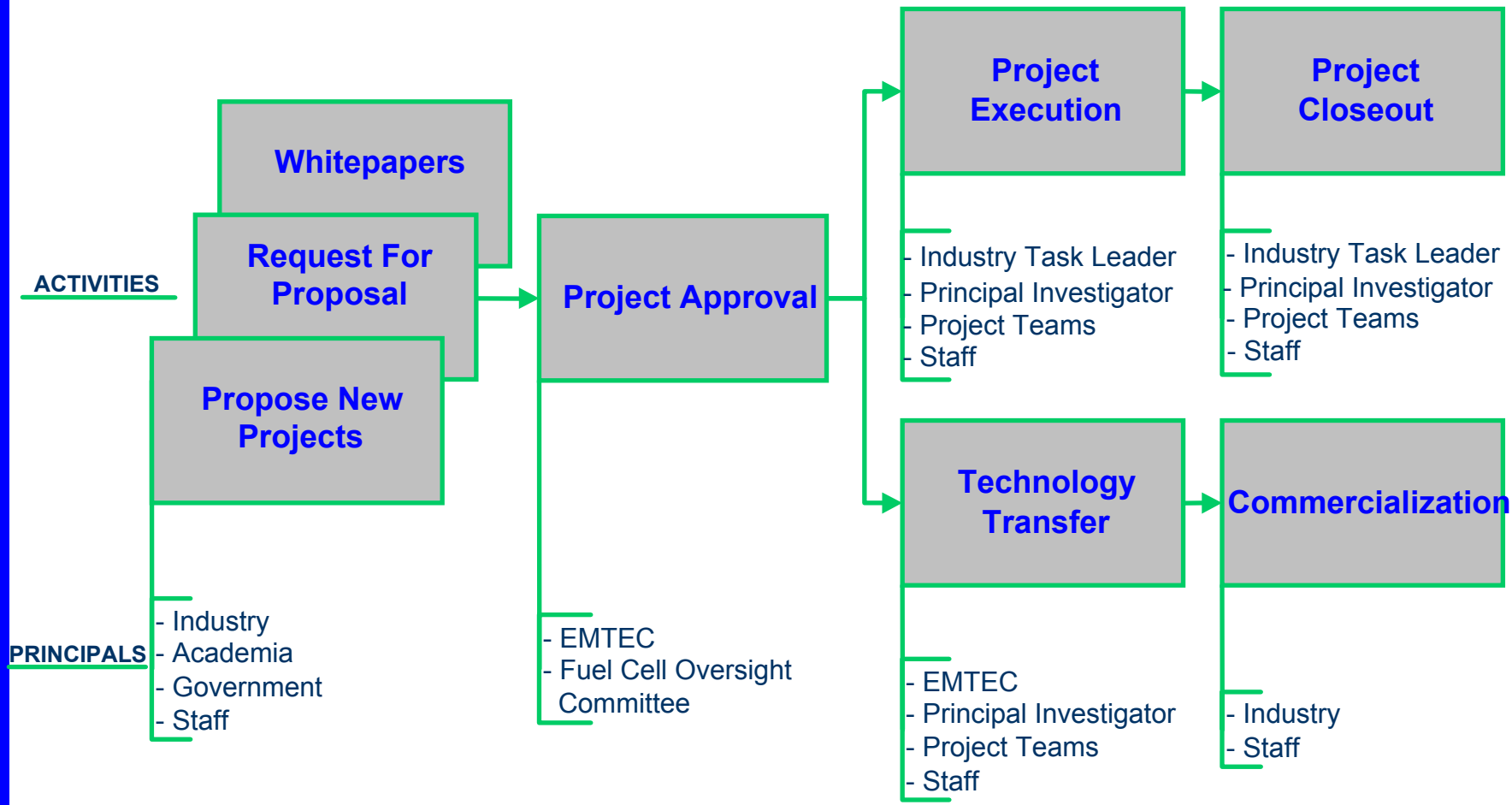
Approach

- EMTEC solicits and evaluates projects that:
  - Have Industry Relevance
  - Are Appropriately Resourced
  - Have EERE Hydrogen Goal Alignment
  - Addresses DOE Barriers
  - Have Commercialization Viability

- EMTEC has extensive experience managing collaborative technology projects

- EMTEC has developed a business model for selection and management of core technology

EMTEC Proposal Flow Chart



Status and Budget

Status

- 3 RFP Rounds
- 114 White Papers and Proposals Reviewed
- 42 Site visits performed
- 23 Projects funded

Budget

- FY04: $2.945 Million
- FY05: $2.961 Million
- FY06: ~$2.5 Million
- Contractor cost share > $7 million
- State of Ohio cost share: > $2 Million

Interactions - Collaborations

- State of Ohio – Department of Development – Technology Division
- State of Ohio – Department of Development – Third Frontier
- USAF – AFRL Technology Transfer program
- Procurement Technical Assistance Center (PTAC)
- Manufacturing Small Business Development Center (MSBDC)
- Materials Technology Liaison at AFRL
- Technical Steering Committee (TSC)

Key Accomplishments

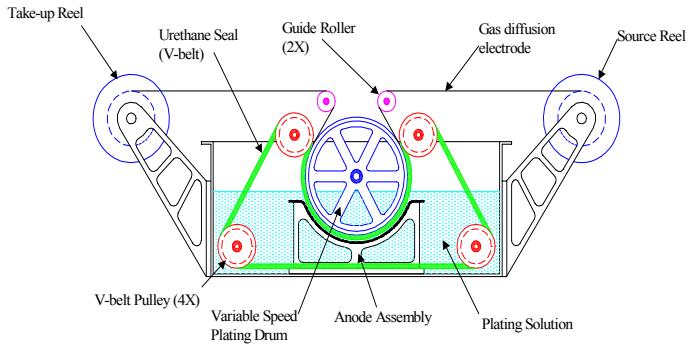
- Catacel – H_2 Reformation Product Developed
- Faraday – Tunable Catalytic Loading Process Developed
- Makel – Prototype H_2 Sensor Developed and Automotive Testing Initiated
- Participant with Argonne National Laboratory on R&D 100 Application
- MWOE – Pilot Scale PEC H_2 Production Operational
- Powdermet – Microballoon H_2 Storage Verified
- NexTech – H_2 Safety Sensor Performance Verified
- PET – Advanced Reel-to-Reel Electrolyzer Manufacturing Process Developed

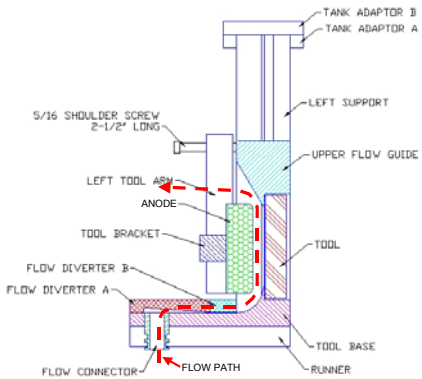
Novel Stackable Structural Reactor (SSR) for Low-cost Hydrogen Production - Catacel Corp

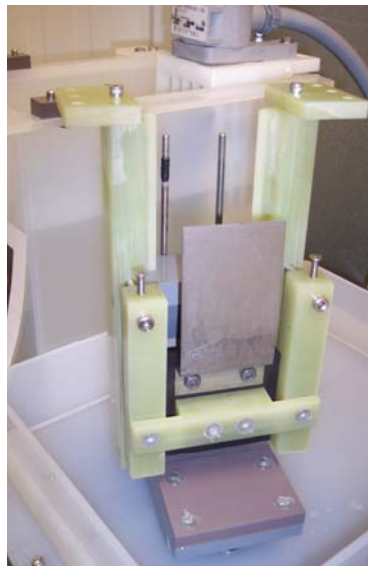
- DOE Barriers Addressed: Fuel Processor Manufacturing, Operation and Maintenance
- Total project value: $234,352
- Novel Stackable Structural Reactor (SSR) for low-cost stationary hydrogen production
- Intended to be a drop-in replacement for the loose ceramic catalyst media in the stationary steam reforming process
- Accomplishment: H_2 Reformation Product Developed
- Future Work: Installation and testing in steam reformer

Nanocatalyst Development Employing Electrically Mediated Processing for Hydrogen Generation – Faraday Technology

- DOE Barrier Addressed: Fuel processor manufacturing
- Total project value: $360,287
- A low-cost, mass production fabrication technology for catalyzation of membrane electrode assemblies (MEA) for PEM (Proton Exchange Membrane) electrolyzers and regenerative fuel cells
- Collaborators include Precision Energy Technologies (PET)
- Accomplishment: Tunable catalytic loading process developed
- Future work: Optimize catalytic loading

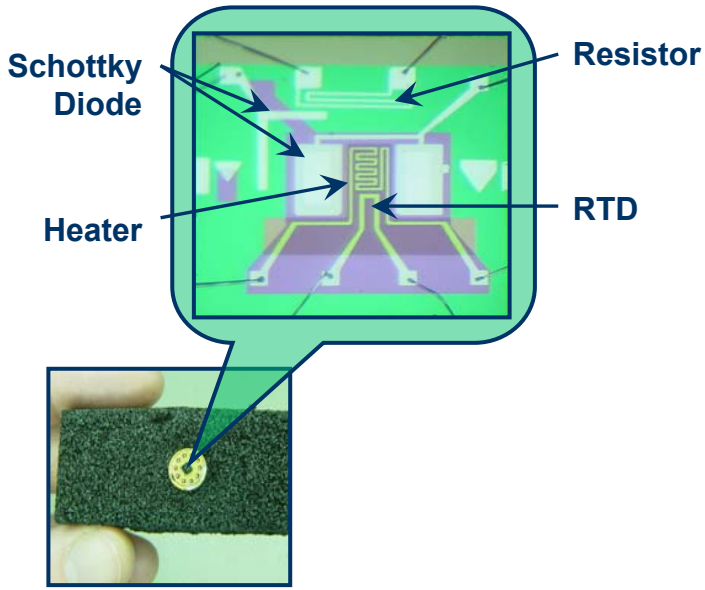


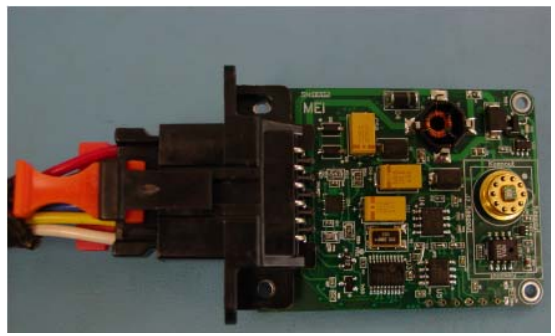




Low Cost MEMS Hydrogen Sensor for Transportation Safety – Makel Engineering

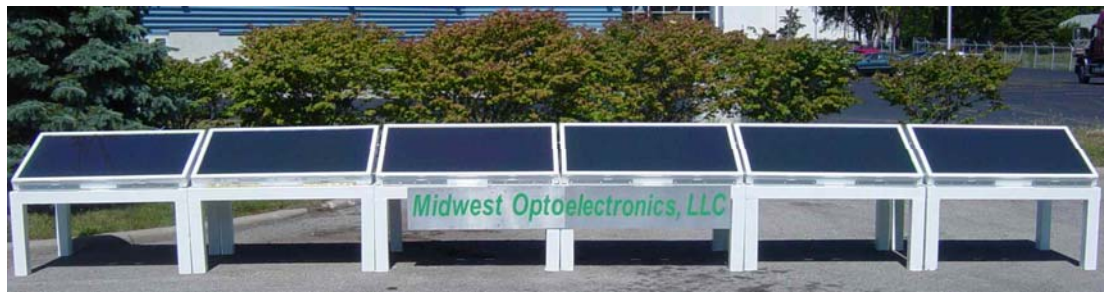
- DOE Barriers Addressed: Control and safety
- Total project value: $260,727
- Advanced hydrogen sensor system for hydrogen powered transportation applications
- Provides the means for low cost, compact, low power consumption, and miniaturized systems suitable for mass production
- Accomplishment: Prototype H_2 sensor developed and automotive testing initiated
- Future Work: Final product testing and market development





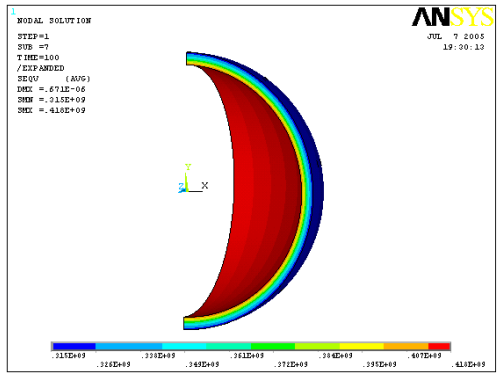
Development of Improved Materials for Integrated Photovoltaic - Electrolysis Hydrogen Generation Systems - MWOE

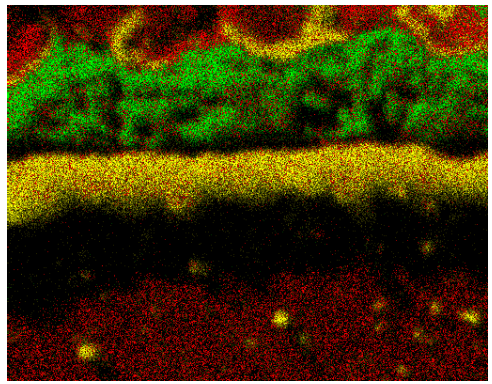
- DOE Barriers Addressed: Renewable integration, system efficiency
- Total project value: $674,875
- Small scale manufacturing process for Integrated Photovoltaic Electrolysis (IPE) panel
  - This technology produces hydrogen from water using sunlight
- Collaborators on project include the University of Toledo, Energy Photovoltaic, Inc, and National Renewable Energy Laboratory
- Accomplishment: Pilot scale IPE H_2 production operational
- Future Work: Improve solar-to-hydrogen efficiency

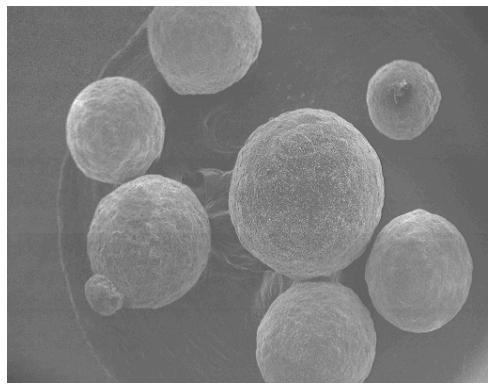


High Strength, Low-Cost Microballoons for Hydrogen Storage - Powdermet Inc.

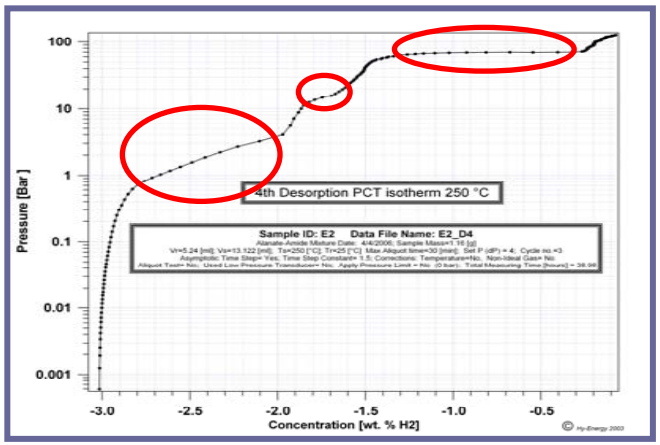
- DOE Barriers Addressed: Cost, weight and volume, energy efficiency
- Total project value: $218,267
- Nanocomposite high-strength coatings on light weight, low strength microballoons by chemical vapor deposition for high volume, low-cost hydrogen storage
- Collaborators on project include Air Force Research Laboratory and Hy-Energy LLC.
- Accomplishment: High strength microballoon H_2 storage verified
- Future Work: Design, build and test H_2 storage systems







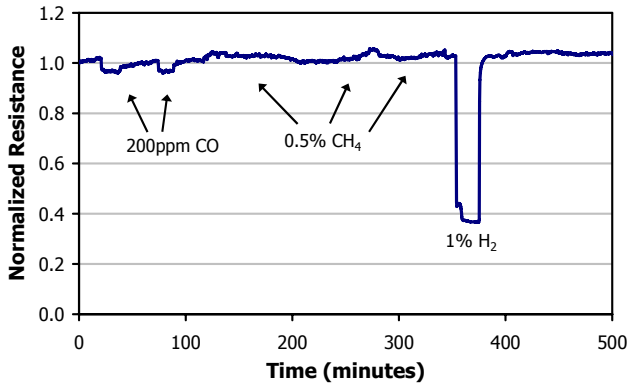
New Materials Offer Breakthrough for Hydrogen Storage – HyEnergy LLC

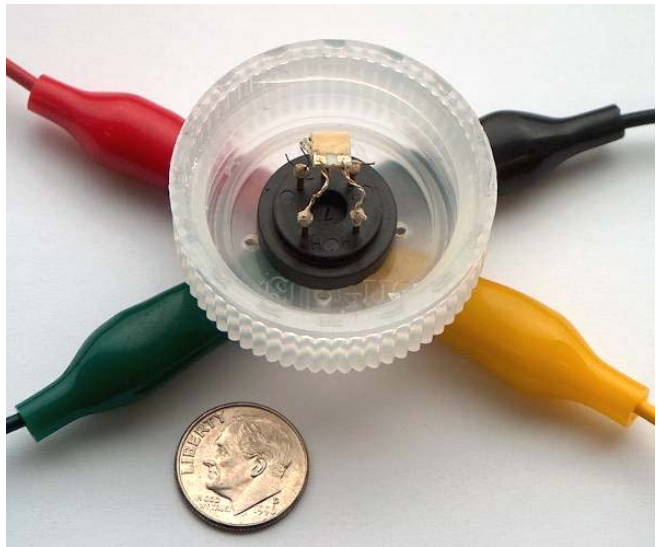


- DOE Barriers Addressed: Hydrogen Storage
- Total project value: $232,588
- PCT isotherm shows
  - Multiple phase transitions
  - Reversibility
  - Total capacity > 3%
  - Individual phases offer higher potential capacity
- Future Work: Phase identification, isolation and phase-specific PCT evaluation

Novel Ceramic Hydrogen Sensors for Fuel Cell Applications – NexTech Materials

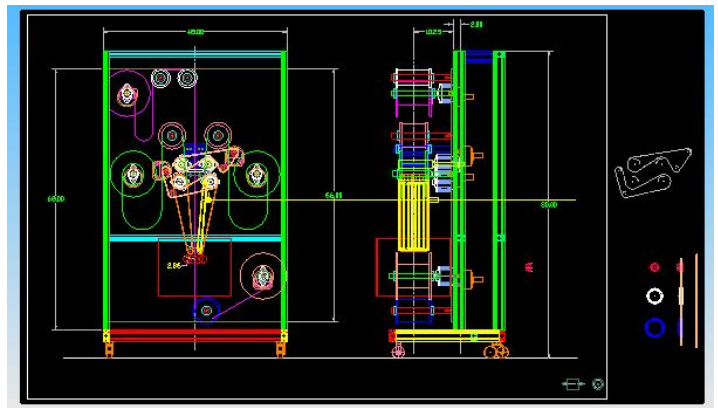
- DOE Barriers Addressed: Control and safety
- Total project value: $215,073
- Novel ceramic sensor for hydrogen safety; low-cost sensor technology with improved gas sensitivity, selectivity, and response time
- Safe practices in the production, storage, distribution and use of hydrogen are essential for a hydrogen economy
- Accomplishment: H_2 safety sensor performance verified
- Future Work: Completion of prototype assembly and testing





Reel-to-Reel Electrolyzer MEA Processing – Precision Energy & Technology

- DOE Barriers Addressed: Fuel processor manufacturing
- Total project value: $216,897
- Develop continuous reel-to-reel manufacturing equipment and and control processes to bring lower cost commercialization for hydrogen producing membranes
- Thermal, pressure and speed control for catalyst application and MEA assembly
- Accomplishment: Advanced reel-to-reel electrolyzer manufacturing process developed
- Future Work: Equipment and process optimization and testing



Program Summary

Hydrogen Program Performance

EFC #	Project Title	Applicant	Project Funding	Match Ratio	On Schedule	On Cost	Meeting Objective	Comm. Potential	Reinvest. Position	Prtnr/Chmpn
H1-01	Nanocatalyst Development Employing Electrically Mediated Processing for Hydrogen Generation (I)	Faraday	$ 360,287	2.89	●	●	●	○	○	○
H1-09-2A	Novel Spiral Stackable Reactor (SSR) for Low-Cost Hydrogen Production (II)	Catacel Corp	$ 528,737	2.17	●	●	●	●	○	○
H1-11	Commercialization of EM Solid State Welding for High Pressure Hydrogen Storage (I)	IAP Research Inc.	$ 324,769	3.25	●	●	●	○	○	○
H1-15	Low Cost MEMS Hydrogen Sensor for Transportation Safety (I)	Makel Engineering	$ 260,727	1.99	●	●	●	●	○	○
H1-16-2A	Development of Improved Materials for Integrated Photovoltaic-Electrolysis Hydrogen Generation Systems (I-II)	MWOE	$ 674,875	2.08	●	●	●	○	○	○
H2-20-2A	Regenerative Solid Oxide Fuel Cell (II)	UDRI	$ 390,000	1.95	●	●	●	○	○	○
H2-15	High Temperature Electrochemical Cells for Hydrogen Production and Regenerative Fuel Cell Systems (I)	NexTech	$ 215,000	2.15	●	●	●	○	○	○
H2-21	Novel Ceramic Hydrogen Sensors for Fuel Cell Applications (I)	NexTech	$ 215,073	2.15	●	●	●	○	○	○
H2-12	High Strength, Low Cost Microballoons for Hydrogen Storage (I)	Powdermet	$ 218,267	2.23	●	●	●	●	○	○
H2-3	Hydrogen Storage Using Porous Silicon (I)	Dephi	$ 216,742	2.46	●	●	●	○	○	○

I - Phase I
II - Phase II
III = Phase III

LEGEND

- ● Excellent / Outstanding
- ● OK / Good
- ● Caution / Watch / Needs Improvement
- ● Problems / Unacceptable
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EFC #	Project Title	Applicant	Project Funding	Match Ratio	On Schedule	On Cost	Meeting Objective	Comm. Potential	Reinvest. Position	Prtnr/Chmpn
H2-08	Electrochemical Coal Gasification with Novel Electrodes (I)	Ohio Univ.	$ 70,070	2.00	●	●	●	○	○	○
H2-22	Fabrication of Metal-Carbon Nanostructure Composites (I)	Univ. of Toledo	$ 73,334	1.55	●	●	●	○	○	○
H2-18	Novel Materials for Reversible Hydrogen Storage (I)	Hy-Energy	$ 232,588	2.09	●	●	●	○	○	○
H2-11	Development of Complex Metal Hydrides for Hydrogen Storage Applications (I)	GFS Chemicals	$ 197,092	2.18	●	●	●	○	○	○
H2-16	Novel Intermediate-Temperature Reversible SOFC for a Renewable Energy System that can Co-produce Power and Hydrogen (I)	NFCRC	$ 224,085	2.24	●	●	●	○	○	○
H2-23	Reel to Reel Processing for Continuous Thermal Pressing of the Catalyst Film onto a Membrane for High Volume, Low Cost Commercialization of Hydrogen Generating MEAs (I)	PET	$ 201,897	2.21	●	●	●	○	○	○
H3-14	Electrochemical Conversion of Biomass to Hydrogen (I)	TMI	$ 162,000	1.62	●	●	●	○	○	○
H2-2	Improved Liquifaction Process (I)	Praxair	$ 200,804	2.01	●	●	●	○	○	○

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H3-19	Methanol Reformed Hydrogen For Portable PEM Fuel Cell Systems (I)	Protonex	$ 264,573	2.65	●	●	●	○	○	○
H3-3	Development of High Pressure Electrolyzers for Backup Power Systems (I)	Proton Energy	$ 207,526	2.10	●	●	●	○	○	○
H3-7	Scalable Steam Methane Reformer System for Distributed Hydrogen Production (I)	Catacel Corp	$ 209,998	2.10	●	●	●	○	○	○
H3-13	Low-Cost Manufacturing of Multi-Fuel Reactors for an Innovative High-Efficiency Planar Reformer (I)	Delphi	$ 219,084	2.19	●	●	●	○	○	○
H3-5	Innovative and Cost-Effective Micro-Process for Roll-to-Roll Solution Casting of Multi-Layer PEMS (I)	Chemsultants	$ 203,657	2.11	●	●	●	○	○	○
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					○	○	○	○	○	○

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Summary

- EMTEC manages an ongoing program with a DOE cooperative agreement in Hydrogen, Fuel Cells & Infrastructure Technologies
- Every project targets at least one DOE technical barrier
- Successful projects will generate jobs and marketable products or processes

Future Plans

- Select at least four projects for Phase II near-term commercialization development
- Aggressively participate in R&D 100 applications relevant to Phase II projects
- Release Round 4 RFP that stresses product development and near term job creation
- Watch for RFP: ~ August 2006

Response to Comments

Key Reviewer Comments	EMTEC Response
Projects do not share DOE's research goals	This program focuses on commercialization of near-term technologies aligned with DOE hydrogen goals
Projects not well aligned with DOE barriers	Project alignment with barriers are now better described
Why not fund fewer projects at higher levels	$200k for commercial feasibility + $400k for product development spreads risk and magnifies opportunities