

2004 DOE Hydrogen, Fuel Cell and
Infrastructure Technologies Program Review

***Low-Cost, High-Pressure
Hydrogen Generator***

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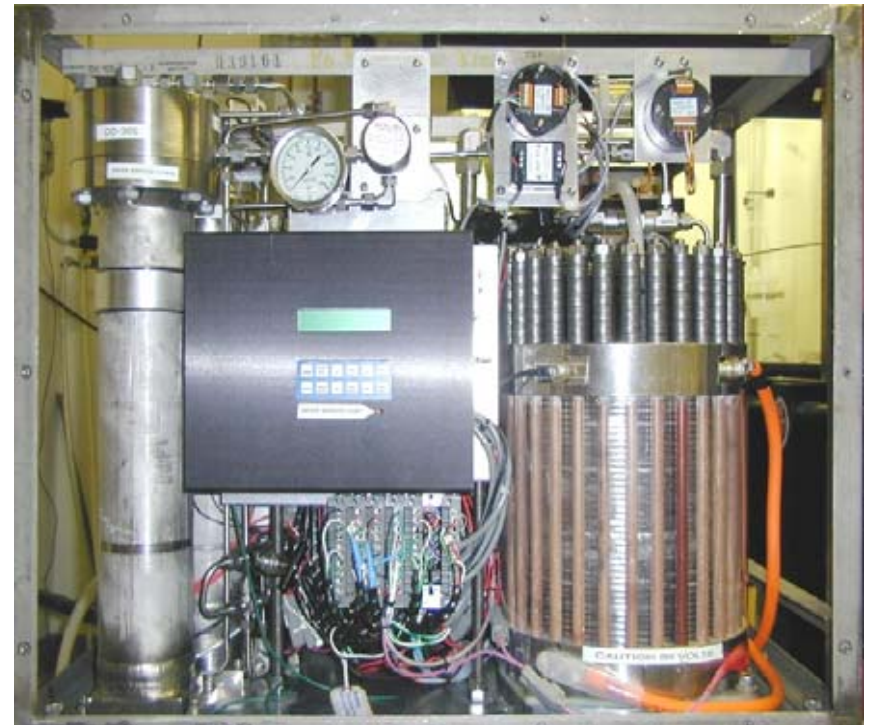
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Project Objectives

Overall Project

- Develop and demonstrate a low-cost, high-pressure water electrolyzer system
 - Eliminate need for mechanical hydrogen compressor
 - Increase electrolyzer hydrogen discharge pressure to 5,000 psig
 - Reduce capital costs to meet DOE targets
 - Demonstrate a 3,300 scfd high-pressure electrolyzer operating on a renewable energy source
 - Public outreach and education





Project Objectives

Past Year (Jan 03- Mar 04)

- Develop lower cost materials and fabrication processes for stack components
- Develop, fabricate and demonstrate an electrolyzer stack and system producing hydrogen at 2,000 psig
- Design, fabricate and test a prototype electrolyzer system that delivers hydrogen at 2,000 psig
- Design and fabricate a test stand for 5,000 psig operation

Budget

- Total Project Budget: \$3.026M
 - DOE Share: \$1.499M
 - Cost Share: \$1.527M
- FY04 Funding
 - DOE: \$245K
 - Contract awarded April 04
- Cost Share Funding to Date: \$819K
 - Jan 03- Mar 04

Technical Barriers

DOE Technical Barriers for Hydrogen Generation by Water Electrolysis

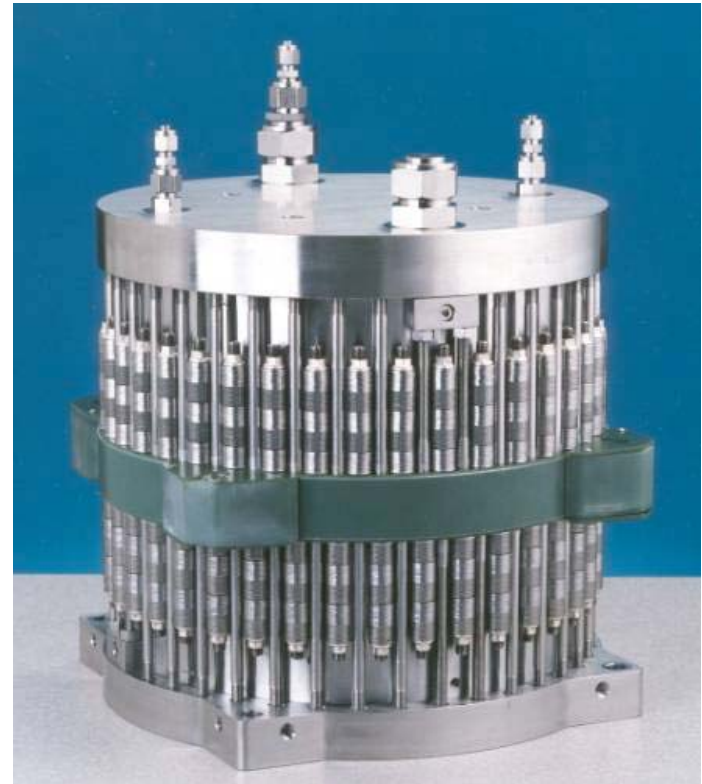
- Q. Cost- capital cost, O&M
- R. System Efficiency- replace mechanical compressor with electrochemical compression
- S. Grid Electricity Emissions
- T. Renewable Integration
- U. Electricity Costs

DOE Technical Targets for Water Electrolysis for 2010 (for 250 kg/day system)

	Energy Efficiency (%LHV)	Cost \$/kg
Cell Stack	81	0.25
Balance of Plant	98	0.07
Compression	95	0.16

Approach

- Incrementally increase the operating pressure of the GES differential pressure electrolyzer, through improved seal and endplate design
 - 1,000 psid in 2002; 2,000 psid in 2003
 - Planned further increases to 3,500 and 5000 psid
- Replace high-cost metal components with lower-cost materials
- System innovations to replace high-cost, high maintenance components



Project Safety

- GES has initiated a failure mode and effects analysis (FMEA) for our laboratory operations and prototype electrolyzer systems
- GES is developing a management of change (MOC) process for the project
 - Changes in stack and system components, control systems or algorithms, and operating procedures must be approved by project safety committee

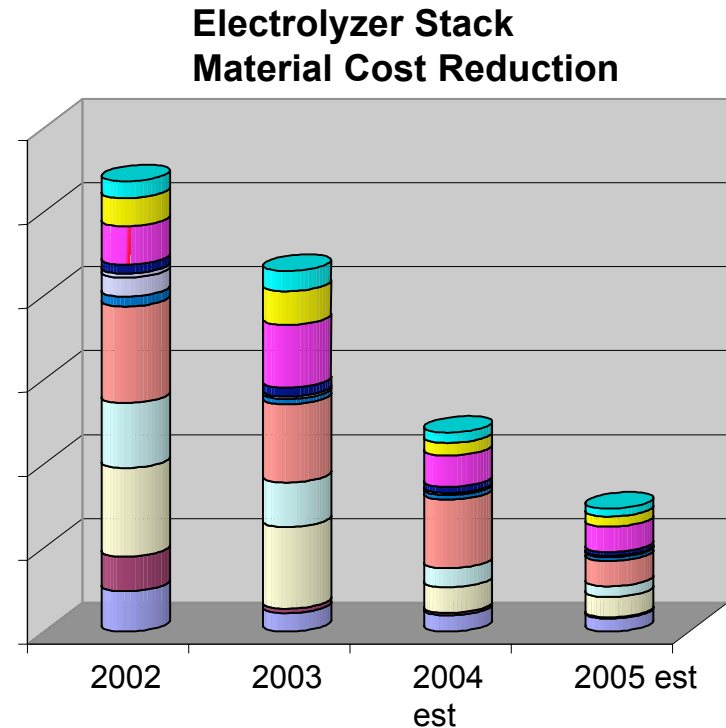
Project Timeline

Task	2003				2004				2005			
	1	2	3	4	1	2	3	4	1	2	3	4
<i>TASK 1. Stack Cost Reduction</i>												
DEMONSTRATED LOW -COST CATHODE SUPPORT		X										
REDUCED STACK PARTS COUNT		X										
<i>TASK 2. BOP Cost Reduction</i>												
<i>TASK 3. High Pressure Stack Design</i>												
<i>TASK 4 2,000 psi Prototype COMPLETED STACK&SYSTEM</i>												
Extended testing of Prototype System			X									
<i>TASK 5. 5,000 psi Test Stand COMPLETED STAND FABRICATION</i>												
<i>TASK 6. 3,500 psi Short Stack Stack Complete</i>												
<i>TASK 7. High Pressure System System Complete</i>												
<i>TASK 8. 5,000 psi Short Stack Stack Complete</i>												
<i>TASK 7. Public Outreach/Education</i>												

Technical Accomplishments

■ Stack Cost Reduction

- Developed and demonstrated a low-cost cathode support
- Reduced electrolyzer stack parts count by >50%
- 30% reduction in stack materials cost, 40% reduction in fabrication labor
- Demonstrated operation of lab-scale hardware at 10,000 Amps/ft²

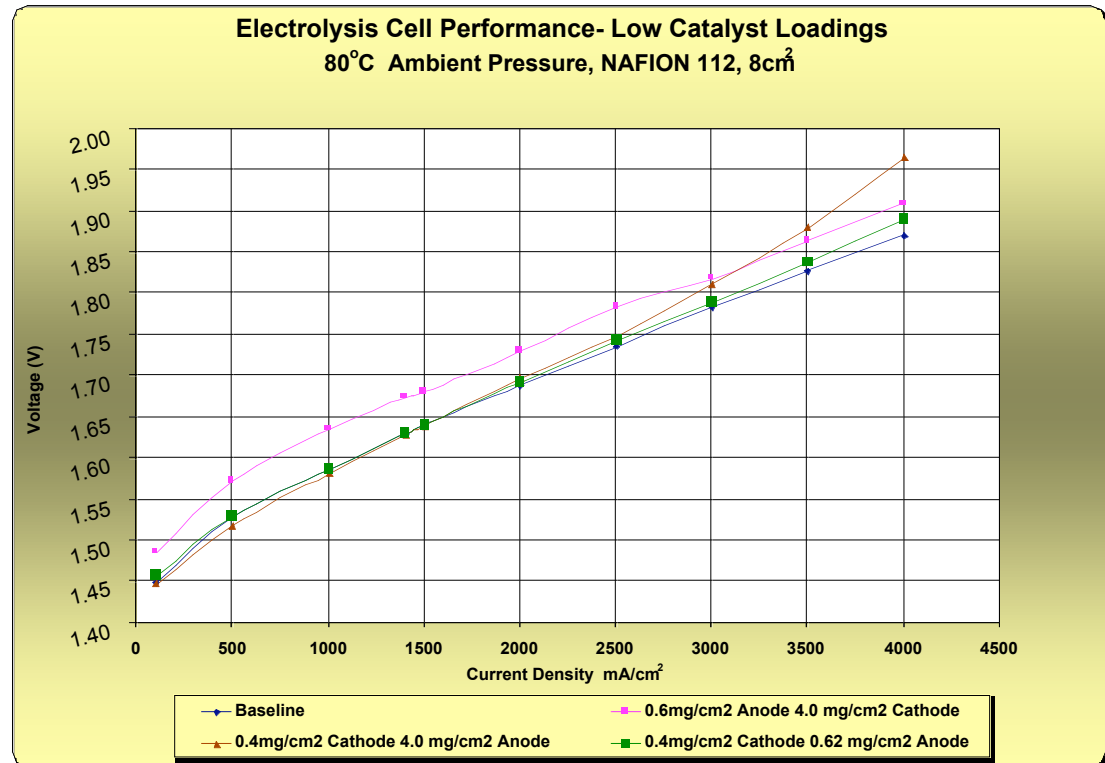


Technical Accomplishments

- Increased Operating Pressure
 - Developed and demonstrated operation of 140 scfd stack at 2000 psid
 - Developed, fabricated and demonstrated a system for production of 140 scfd hydrogen at 2000 psid

Technical Accomplishments

- Improved stack efficiency
 - Reduced cell voltage by 10% while decreasing MEA cost
 - Single-cell durability
 - Demonstrated > 1,000 hours



Interactions and Collaborations

- Collaboration with General Motors to develop low-cost electrolyzers for the hydrogen economy
- Center for Technology Commercialization in Westborough, MA will provide public education and outreach
 - K-12 teacher education
 - demonstrations and literature distribution at energy and transportation fairs and related venues

Future Plans

- Remainder of FY 2004
 - Develop and implement FMEA and MOC programs
 - Develop a low-cost anode support structure
 - Demonstrate and test in short-stacks
 - Durability testing of low-cost cathode support
 - Cycle in automated test-stand at 1,000 psid
 - Demonstrate for minimum of 10,000 cycles over 2,000 hours
 - Improvements to 2,000 psid system
 - Extended testing for approximately 500 hours

Future Plans

■ FY 2005

□ Cost Reduction

- Continue reduction in stack parts count
- Reduce stack costs by additional 35-50%

□ Stack and System Development

- Develop and demonstrate 3,500 psid electrolyzer stack and system
- Design, fabricate and demonstrate 5,000 psid short-stack