Proceedings of the 1999 U.S DOE Hydrogen Program Review
NREL/CP-570-26938

Technology Development and Validation of Industrial Fuel Cell Vehicles Phases II/III

(Project Status and Plans)

Presented to

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by

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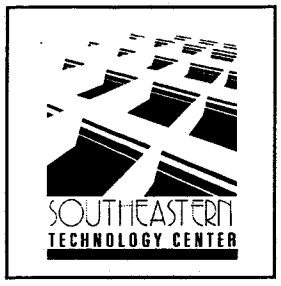
Industrial Fuel Cell Vehicle(IFCV) Phase II/III Project

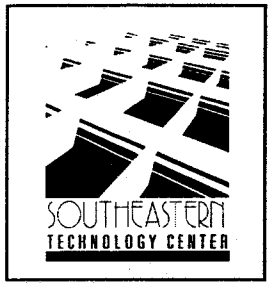
- **Objectives:**
  - **Develop/validate small electric vehicles using PEM fuel cell power systems and onboard MH H_2 storage.**
  - **Develop/validate compatible H_2 generator.**
- **Potential applications: airports, warehouses, maintenance, landscaping, other off-road uses.**
- **$1.07 million total, 50.5% cost-shared**



Summary of Rationale and Approach

- **Phase I Feasibility Study in FY 1998**
  - **–Preliminary market analysis**
  - **–Benefits of small IFCVs with onboard MH storage**

    Efficiency - Range - Environmental
  - **–Significant niche market for off-road applications**
- **Business Plan outlined pathway to commercialization**
  - **–Technology development and validation**
  - **–Marketing, financial, teaming plans**
  - **–Target costs and prices**
  - **–Potentially 3 years to FPU**

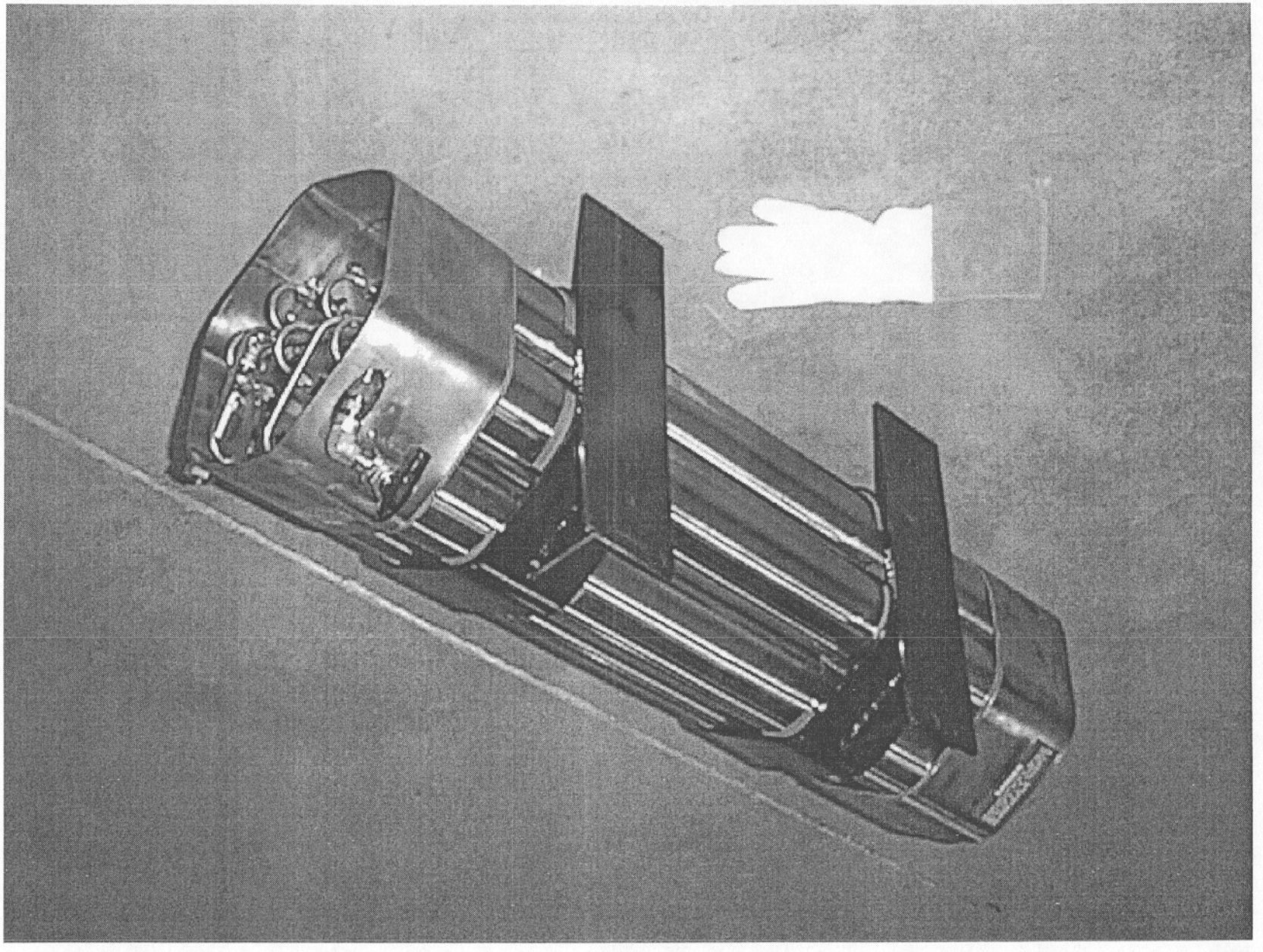


Summary of Rationale and Approach (Cont.)

- **Phase II/III Project Approach**
  - –Overlap tech development and validation, save time, money
  - –Upgrade PEM fuel cells (FCs) in 2 existing Gators
  - –Replace pressurized tanks with MH storage beds (tech xfer)
  - –Evaluate electrolyzer for compatible refueling
  - –Stagger assembly and test schedules to incorporate adv. technology
  - –Evaluate performance, reliability, costs of commercial designs
  - –Multi-disciplined, skilled, committed team

Past Results

- Two FC Gators tested 17 months Palm Springs Airport
  - –Different configuration
  - –Good performance, utility, refueling
  - –Suggested refinements incl. reliability, power drain
- MH storage system evaluated onboard transit bus
  - –Larger configuration (15 kg H_2)
  - –Good performance, refueling
  - –Suggested refinements incl. Improved material, lower cost
- Phase I Feasibility Study
  - –Compared two FC concepts - PEM, Alkaline
  - –Phases II and III proposed, selected



Current Year Results

- Established detailed tech/cost/schedule plans
- Developed T-H performance model (USC)
  - Generated flowsheet data for range of expected power, pressure
  - Benchmark vehicle performance data
- MH selected, beds fabricated for Gator 1 (WSRC)
  - Evaluating materials, designs for Gator 2
- Completed compressor evaluation (Deere)
  - Reduced Gator 1 pressure, 20 to 10 psig
  - Gator 2 compressor types/pressure under study
- Established FC design specs for Gator 1 (EP)
  - Support system requirements nearly complete
  - Stack assembly behind schedule

FC and Power System Design Specs

FC Stack Output	**Avg. 8.5 KW Peak 10 KW**
•No. of cells	**60**
•Gravimetric power density	**204 w/kg**
•Active Area	**292 cm^2/cell**
•Stack voltage	**36 - 60 vdc**
•Dimensions	**7" x 12" x 16.5"**
•Cooling water	**Temp. in, 60°C Temp. out, 65°C Flow, 3.5 gpm**
•H2 and air pressures	**10 psig**
•Batteries	**3 12-volt 2 2-volt (In series)**

Key MH Storage Design Specs

•Material:	La-Ni-Al mischmetal
•Capacity:	4.2 lbs H_2 (delivered)
•Bed size:	3.5 inch dia. X 30-in. SS tube
•Bundles:	2 bundles, 7 tubes each
•Pressure:	Design 500 psig Operating 100 psig

Current Year Results (Cont'd.)

- Gator 1 chassis reinforced, ready for MH (EP, Deere)

- HM50 electrolyzer designed, assembled, shipped, installed at USC (TBEES)
  - –Supports up to 3 vehicles

- Instrumentation and data requirements developed (USC, YT)
  - –Most fittings and sensors installed Gator 1
  - –USC test plan complete, YT in prep.

- Costs within budget

- Project on schedule except FC assembly

Plans for Future Work

- **FY 1999**
  - –Complete assembly Gators 1 (5/31) and 2 (9/24)
  - –Complete refueling and Gator 1 performance tests at USC
  - –Begin Gator 1 field tests at YT
  - –Begin design/economic evaluation of commercial vehicles
- **FY 2000**
  - –Complete refueling test Gator 2
  - –Complete field tests Gators 1 and 2 (3/30/00)
  - –Retest Gator 1 component performance
  - –IFCV market evaluation
  - –Complete evaluations, decide readiness Phase IV

Key Milestones Toward Commercialization

Complete assembly first prototype IFCV	**May 1999**
Baseline designs FC, MH storage, electrolyzer	**Mar. 2000**
Decision on commercialization	**June 2000**
Construct FC production facility	**June 2001**
IFCV FPU	**Dec. 2001**
Production rate 1,000 IFCVs/yr.	**May 2002**
Production rate 10,000 IFCVs/yr.	**May 2003**
Positive cash flow	**May 2004**

Status of Economic Evaluation

- **Economic targets established in Phase I**
  - **–Basis prelim. market analysis and expectations for FC, MH success**
  - **–Cost and price - $ 5,000/$6,000**
  - **–$ 1,500 total for FC and MH systems**
  - **–Potential niche market 10,000 IFCVs/yr.**

- **Reassess economics in Phase II/III**
  - **–Extend/validate market evaluation**
  - **–Update IFCV performance, reliability, and cost based on test results**
  - **–On schedule to complete March 2000**

Major Barriers and Safety Issues

- **Cost is the major challenge**
  - **FC : Improve performance (specific power, current density, lower pressure and power drain)**
  - **Reduce costs (components, assembly, volume mfg.)**
  - **MH: Increase H2 capacity at modest temp./press.**
  - **Reduce material costs**
  - **Reduce bed fabrication cost**
- **Demonstrate cost effective refueling**
- **Address liability and safety concerns**
  - **–Manageable based on experience to date**
  - **–Extend for commercial IFCV designs**

Status: Technology Transfer and Partners

- Metal Hydride system for H_2 storage
  - –Originally developed for defense programs
  - –Design patented by WSRC
  - –Demonstrated onboard public transit bus
- Other proprietary information
  - –Project team members
  - –FC, vehicles, electrolyzer
  - –Procedures in place to protect, utilize proprietary info

Technology Transfer and Partners (Cont'd)

Phase II/III IFCV Team

Energy Partners, Inc.	**PEM Fuel Cells**
Deere & Company	**IFCV assembly & sales**
Westinghouse Savannah River Co.	**MH storage system**
Teledyne Brown Engineering	**H2 generators**
Univ. of SC/CEE	**Performance modeling, H_2 storage/refueling testing**
York Technical College	**Tech. Validation IFCV**
Southeastern Technology Center	**Project mgmt. & integration**