2009 DOE Hydrogen Program Merit Review
Intergovernmental Stationary Fuel Cell System Demonstration, Topic 7C

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Richard Chartrand

plug power

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OVERVIEW

Timeline

- Project start date August 2007
- Scheduled end date July 2010

Barriers

- System efficiency
- System & fuel cell stack direct material cost
- System & fuel cell stack durability

Budget

- Total project funding $8.5 M
  - DOE share $4.25 M
  - Plug Power share $4.25 M
- Funding received in FY07 $46 K
- Funding received in FY08 $2.6 M
- Funding requested FY09-10 $1.2 M

Partners / Sub-contracts

- Construction Engineering Research Laboratory (CERL)
- Ballard Power Systems
- National Grid

RELEVANCE

- To design and produce an advanced prototype PEM fuel cell system with the following features
  - 5 kW net electric output
  - Flex fuel capable – LPG, NG, Ethanol
  - Reduce material and production cost and increase system & stack durability
  - Increase electrical efficiency over the existing GenSys 5U48 design
  - Increase total system efficiency by incorporating combined heat and power (CHP) capability

- To show a path to meet long term DoE objectives
  - 40% system electrical efficiency
  - 40,000 hour system / fuel cell stack life
  - $750/ kW integrated system cost (w/ reformer)
  - $400/ kW fuel cell stack cost (direct hydrogen)

APPROACH

- Concept Development (Task 1) - *100% complete*
  - ☑ Product requirements
  - ☑ Technology selection- ethanol evaluation
  - ☑ Prototype component and subsystem testing
  - ☑ Concept development
  - ☑ Go/ No Go - Concept design review
- System Definition (Task 2) – *100% complete*
  - ☑ System Specifications & requirements flow down
  - ☑ Module & component design
  - ☑ Module and component latitude testing
  - ☑ Go/ No Go - System interface review

☑ Task completed

⏳ Task in process

☐ Task not started

APPROACH – CONT.

- System Integration (Task 3) – *40% complete*
  - ☑ Prototype system design
  - ☑ System design review
  - ☑ Prototype system build
  - ⏳ Integrated system testing
  - ☐ System validation testing
  - ☐ Go/ No Go – Field readiness review
- Prototype Field Demonstration (Task 4) – *10% complete*
  - ⏳ Site installation planning
  - ☐ Installation and commissioning
  - ☐ Field operations and support
  - ⏳ National Grid demonstration
  - ☐ Decommissioning
- Project Closeout (Task 5) - *Work not started*
  - ☐ Post demonstration testing
  - ☐ DOE final report

☑ Task completed

⏳ Task in process

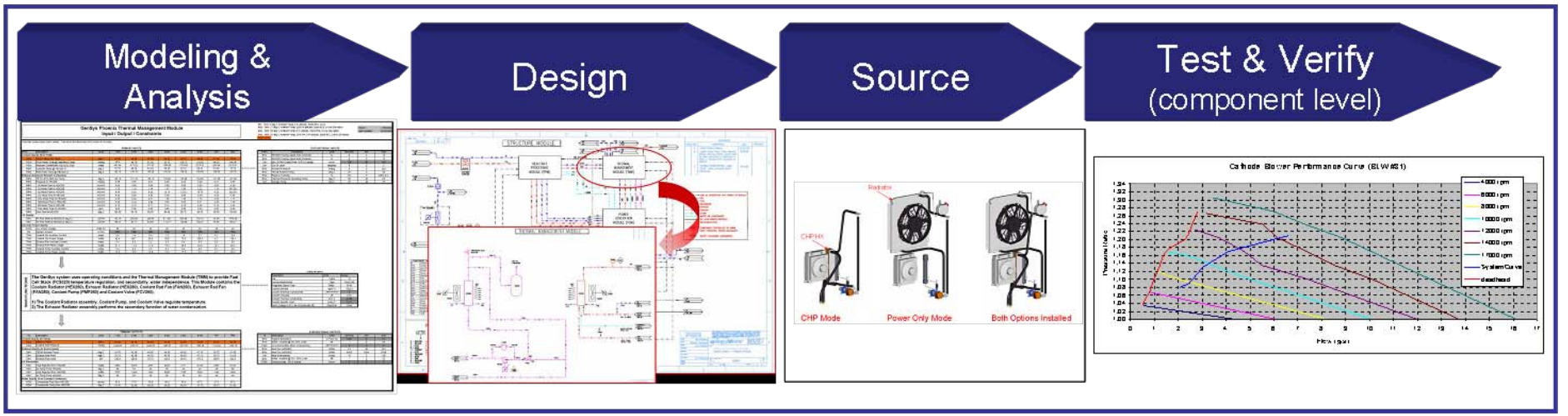
☐ Task not started

TECHNICAL ACCOMPLISHMENTS
PREVIOUS YEAR'S ACCOMPLISHMENTS

- Completed system simulation, and controls development necessary to demonstrate system operation on ethanol feedstock in the laboratory
- Created a cost model and cost reduction plan to close gap between current state and DOE targets
- Developed controls, implementation strategy and system attributes necessary to define a commercially viable continuously operating PEM based fuel cell system
- Successful evaluation and selection of fuel cell stack technology for this project and engaged Ballard Power Systems for collaboration on this project
- Selected the system architecture to be used for this demonstration project

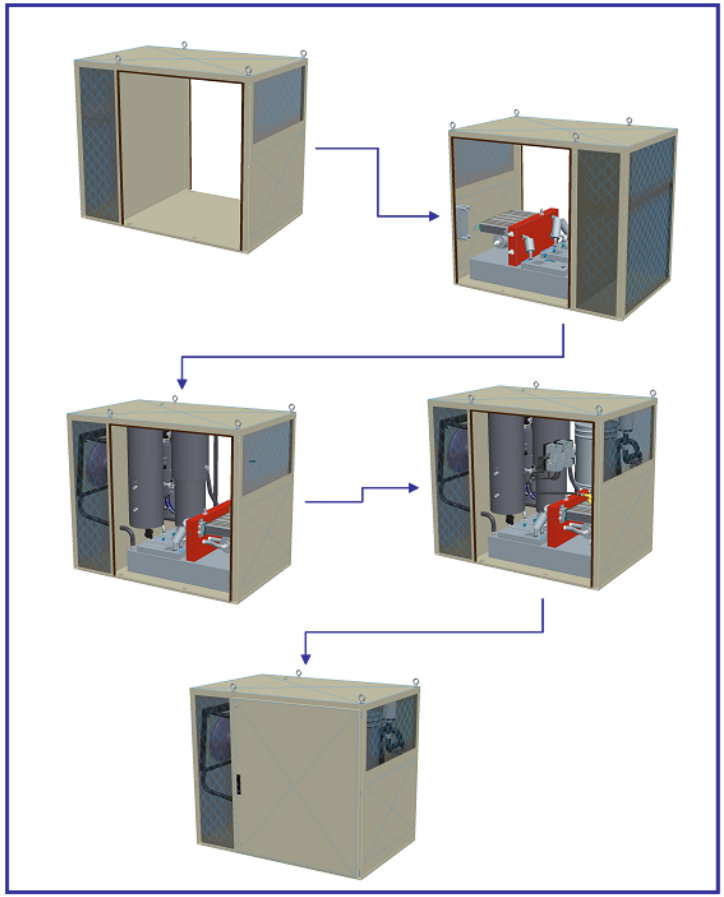
TECHNICAL ACCOMPLISHMENTS
SYSTEM DEFINITION (TASK 2)

- Completed 168 design iterations using process simulation modeling to optimize system performance and generate component design requirements
- Specified and sourced prototype hardware required to meet system requirements
- Completed testing of a statistically significant sample of all system components to test their capability of meeting requirements
- Successfully passed system concept design review in June 2008



TECHNICAL ACCOMPLISHMENTS
INTEGRATED PROTOTYPE SYSTEM DESIGN (TASK 3.1 & 3.2)

- Completed mechanical models necessary for full CAD representation of prototype system
- Created the design documentation necessary to source chosen components
- Successfully integrated the selected components and subsystems previously tested
- Created system Bill of Materials (BOM) and cost analysis necessary to project system cost in production volumes
- Successfully passed System Design Review with DOE personnel in Nov. 2008



Review identified no potential functional, performance or production related issues and the project was advanced to next phase

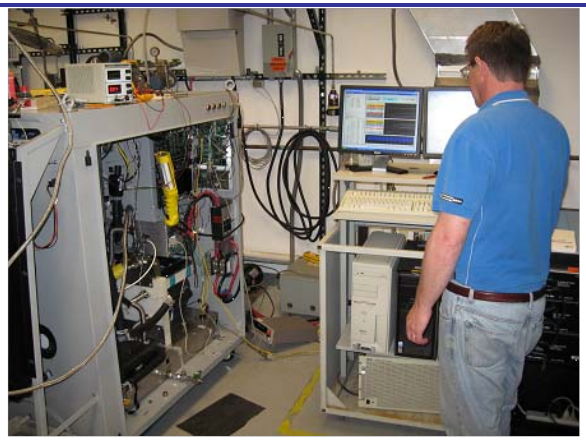
TECHNICAL ACCOMPLISHMENTS
PROTOTYPE SYSTEM BUILD (TASK 3.3)

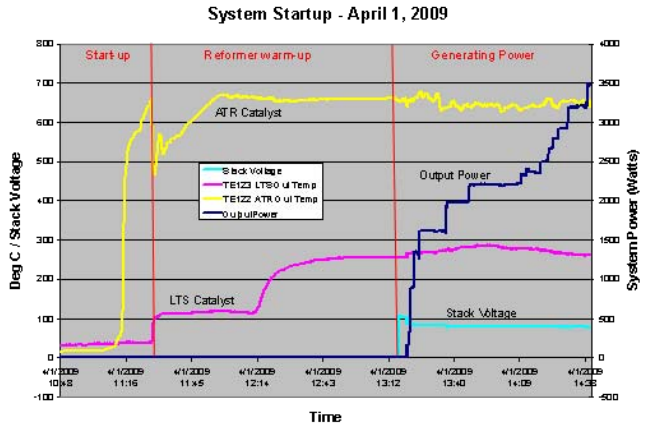
- Components and subsystems were acquired for build of prototype system
- System was built at Plug Power's Latham facility
- Production assembly procedures and system Bill of Materials were verified during the process

Prototype system was fabricated, assembled, debugged and running in a 7 week timeframe

TECHNICAL ACCOMPLISHMENTS
SYSTEM INTEGRATION TESTING (TASK 3.4)

- Project is currently undergoing system integration testing
- Automated system controls are being developed to operate each subsystem
- Parameters are being optimized for both steady state and transient operating modes

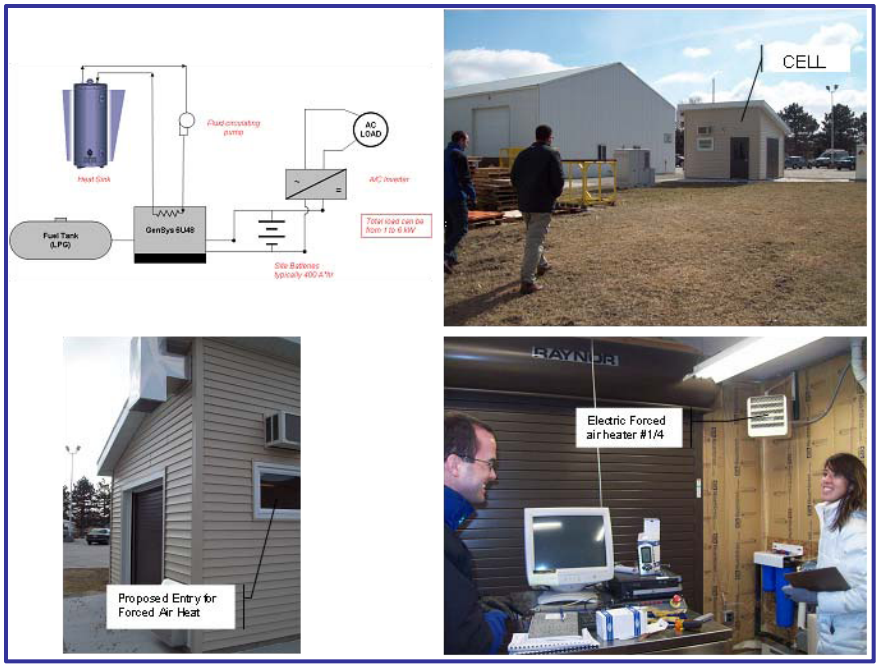




System has shown acceptable performance across the operating range

TECHNICAL ACCOMPLISHMENTS
SITE PLANNING AND PREPARATION (TASK 4.1)

- Visited CERL facility in Feb 09 to discuss possible install sites for prototype
- Install location will be the CERL Electrolyzer Lab (CELL)
- System will provide electric power and heat for the lab
- Install will use grid tied inverter, building currently uses 9.5 KW of electric forced air heat, the fuel cell system will exceed this demand



Project is on schedule for installation of prototype at CERL facility in 3Q09

TECHNICAL ACCOMPLISHMENTS
NATIONAL GRID DEMONSTRATION (TASK 7.a)

- Task is to demonstrate a Plug Power manufactured GenSys high temperature system with collaboration from National Grid
- System has been designed and assembled and is awaiting installation
- Plug Power, National Grid and DOE filed a joint press release on November 16, 2008 announcing this installation
- Site visits of possible sites conducted in Dec '08

System will be installed on the Union College campus in Schenectady NY

COLLABORATIONS

- Partners
  - Ballard Power Systems (Sub-contract, Industry): Collaborations about how best to perform system integration of a PEM based fuel cell stack
  - Construction Engineering Research Laboratory (Partner, Federal): Collaboration to provide opportunity to test prototypic hardware under simulated field conditions
  - National Grid (Partner, Utility): Collaboration to provide opportunity to install system in application
- Technology Transfer
  - Collaboration with Ballard to improve reactant humidification, start-up and shut-down protocol and operating conditions to maximize fuel cell performance and stack life
  - Collaboration with CERL and National Grid provide opportunity to test fuel cell systems performance in their intended application in advance of commercial deployment

FUTURE WORK

- FY2009
  - Complete system level problem identification & design verification tests
  - Collect data necessary to compare actual system efficiency to modeled efficiency
  - Conduct field readiness review
  - Complete site planning and system installation
  - Commission prototype system @ CERL & commence field operation and support
  - Commission GenSys High Temperature system at Union College and commence field operation and support
- FY2010
  - Complete field operation and support
  - Decommission system
  - Post demonstration testing & analysis
  - Project close out

SUMMARY

- Relevance – Provides the platform to perform the work necessary to improve overall system efficiency, reduce system and stack material cost and investigate system and materials improvements necessary to increase stack performance and durability
- Approach – Combine past experience and project learning into a state of the art prototype system which can be used as a baseline for a commercial product
- Technical Accomplishments and Progress
  - Completed the analytical and design work necessary for prototype system, received a “go” decision from DOE for next phase of project
  - Completed the fabrication and assembly of prototype system and began system integration testing
  - Achieved system material cost reduction of 53% (in production quantities) when compared to prior year’s system material cost roll-up
- Technology Transfer / Collaborations – Active partnership with Ballard Power Systems brings together industry leading knowledge in fuel cell stacks and system integration
- Activities for Future – Complete system validation and testing to collect the data necessary to validate system design

HEADQUARTERS
968 Albany-Shaker Road
Latham, New York 12110
Phone: (518) 782-7700
Fax: (518) 782-9060

CANADA
13120 Vanier Place
Richmond, British Columbia
V6V 2J2
Phone: (604) 303-0050
Fax: (604) 231-0400

EUROPE, MIDDLE EAST & AFRICA
7301 BC Apeldoorn
P.O. Box 880
The Netherlands
Phone: 31 55 53 81 000
Fax: 31 55 53 81 099

www.plugpower.com