

Highly Efficient, 5kW CHP Fuel Cells Demonstrating Durability and Economic Value in Residential and Light Commercial Applications



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Plug Power Inc.

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ARRAH2003



OVERVIEW

Timeline

- Project start: October 2009
- Project end: September 2012
- 40% complete

Budget

- Total project funding: \$6.7M
 - DOE: \$3.35M
 - Plug Power: \$3.35M
- Funding in FY09: \$1.3M
- Funding in FY10: \$1.2M

Barriers

- Barriers addressed:
 - A. Durability
 - B. Cost
 - C. Performance

Partners

- Interactions/collaborations:
 - University of California Irvine
 - Sempra Energy
- Project leads:
 - Dr. Jack Brouwer
 - Randy Brown

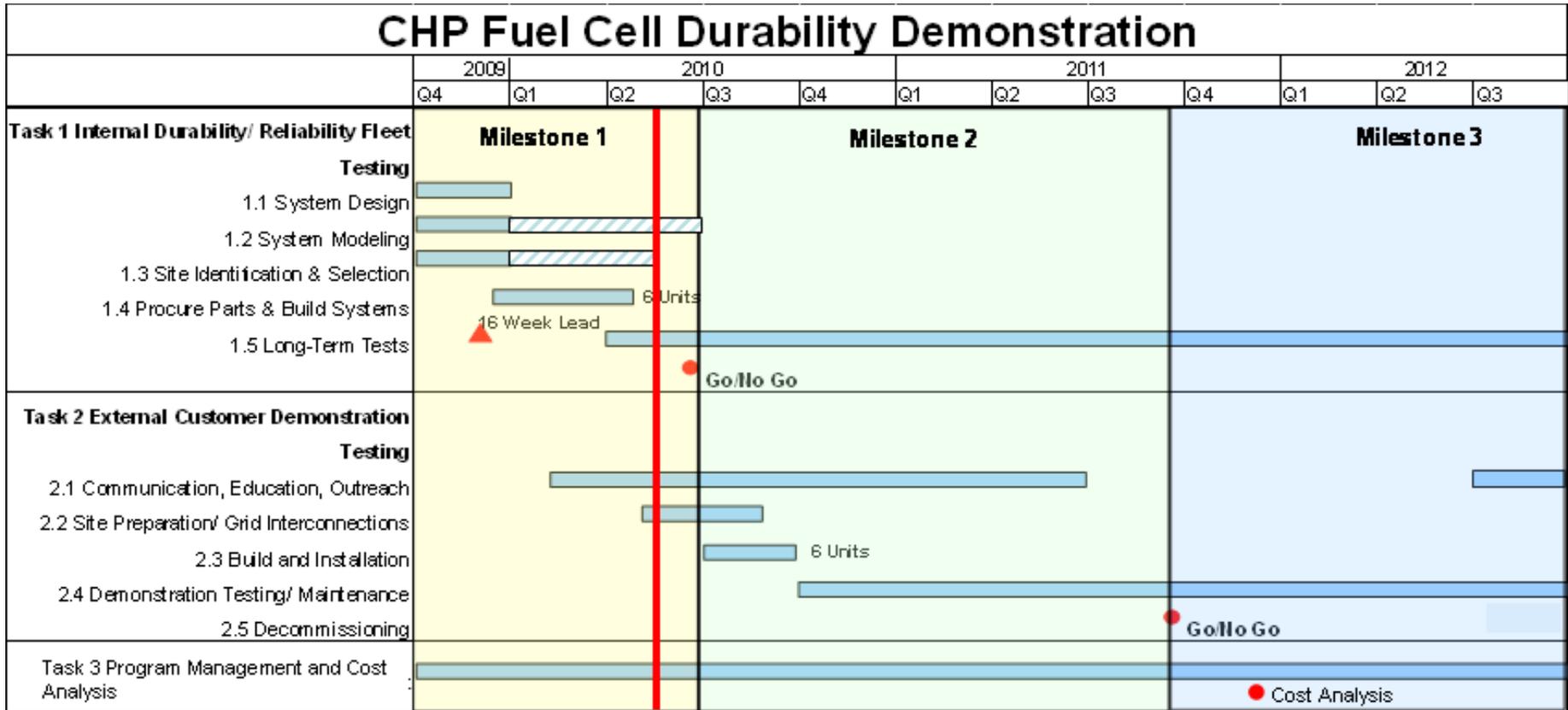
OBJECTIVES - RELEVANCE

The objective of this demonstration program is to substantiate the durability and economic value of **GenSys Blue** and verify its technology and commercial readiness for the marketplace.

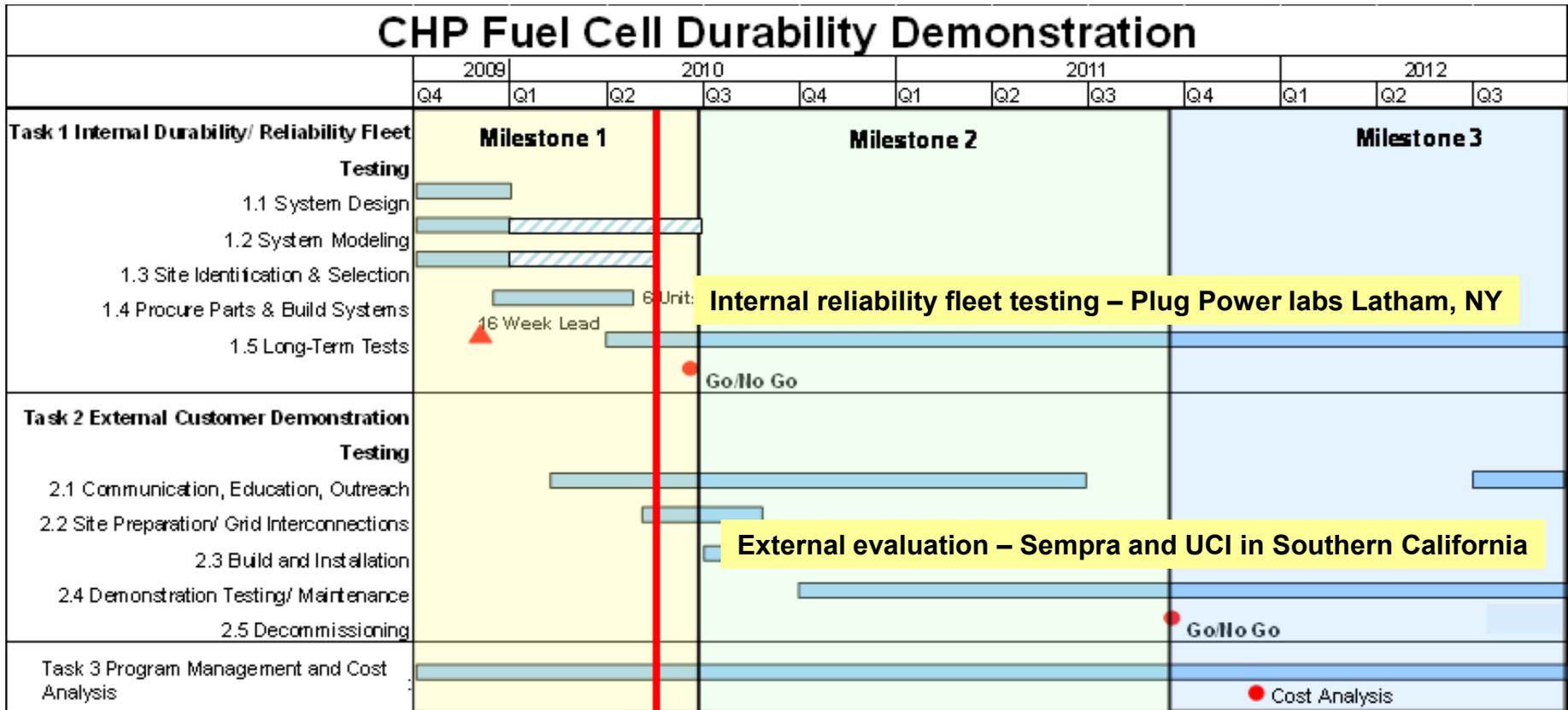
Characteristic	Units	Goal	1st GO - 2Q10	2nd GO - 2Q11
Electrical efficiency at rated power	%	40	>30	>30
CHP efficiency at rated power	%	90	>80	>80
Cost (qnty < 15)	\$/kWe	10,000	20,000	20,000
Durability at < 10% rated power degradation	hr	10,000	2,000	8,700
Noise	dB(A)	<55 at 10m	<55 at 10m	<55 at 10m
Emissions (combined NO _x , CO, SO _x , hydrocarbon, particulates)	g/MW/hr	< 1.5	< 1.5	< 1.5



MILESTONES - APPROACH



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TECHNICAL ACCOMPLISHMENTS – SYSTEM DESIGN

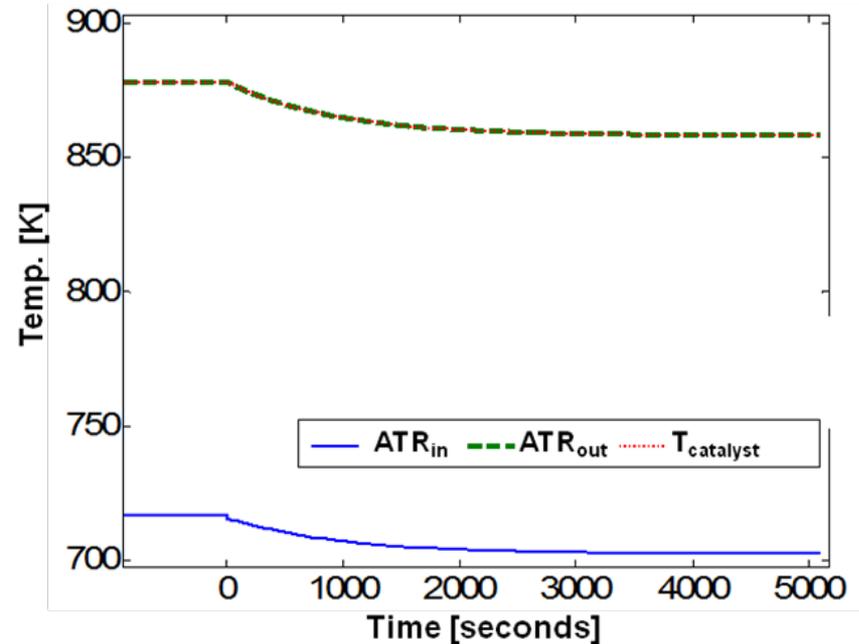
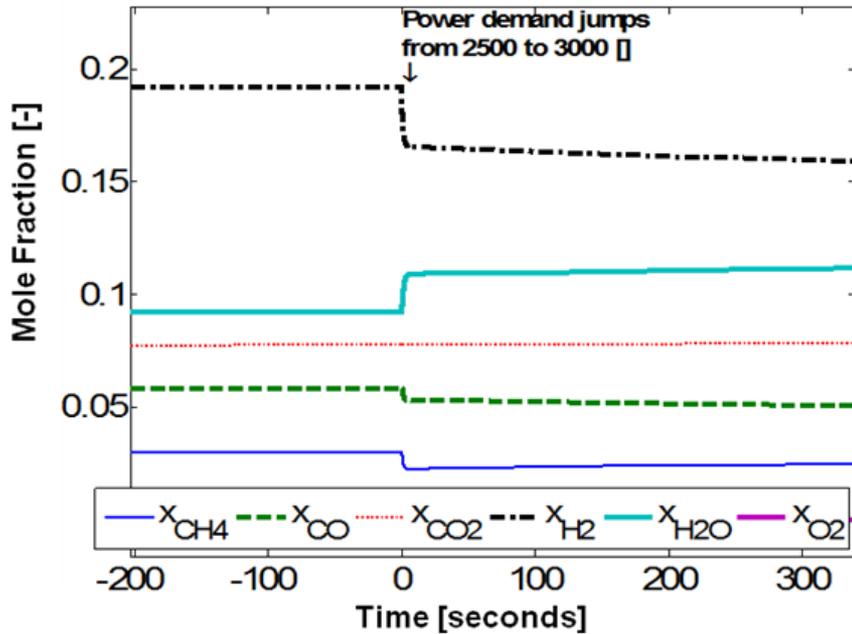
Product Characteristics	
Minimum Continuous Output	0.5 kW
Maximum Continuous Output	2.5 kW to 5.0 kW
Operating Fuel	Natural Gas
Dimensions	101cm x 71cm x 122cm
Weight	250kG
Nominal Voltage	120Vac 60Hz or 230Vac 50Hz
Efficiency (Electric/CHP)	30% / 85% LHV
Integrated Burner	Variable Output (7kW / 25kW)
Operating Conditions	
Location	Indoors
Ambient Temperature Range	0°C - 40°C

Plug Power design initiatives:

- **Controls and efficiency improvements**
 - Start-up, thermal response and heat modulation improvements, improved thermal recovery
 - From 89% peak total efficiency to 94%
- **Manufacturability improvements**
 - Enclosure, piping, insulation and wiring
 - Reduced build time from > 120 hours to < 50
- **Design for certification**
 - Integrated with commercial automatic burner control system
 - Reduced exhaust temperature
- **Reduction in material cost**
 - From ~\$90k to \$58k in volumes < 20

The design task for the program is complete yielding a more robust, better performing, lower cost system.

TECHNICAL ACCOMPLISHMENTS – SYSTEM MODELING

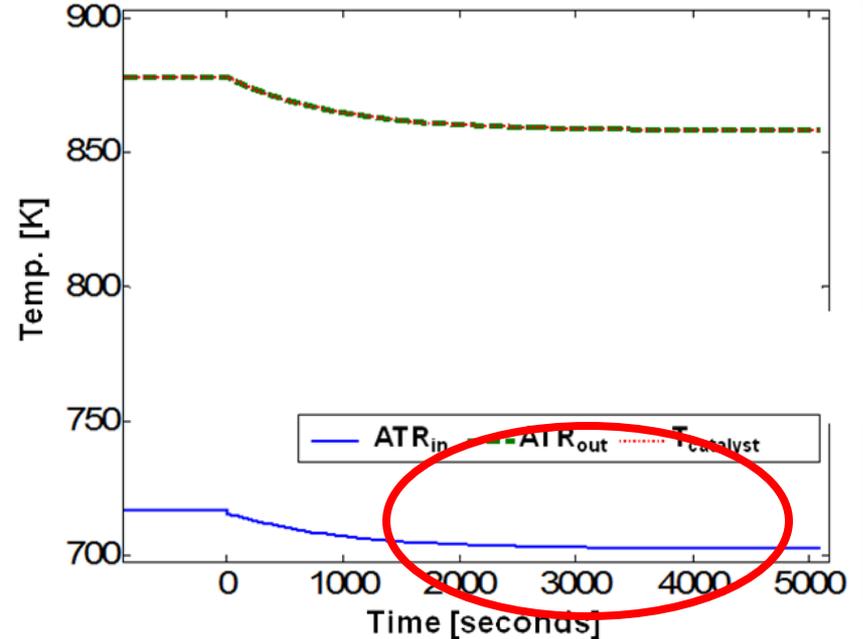
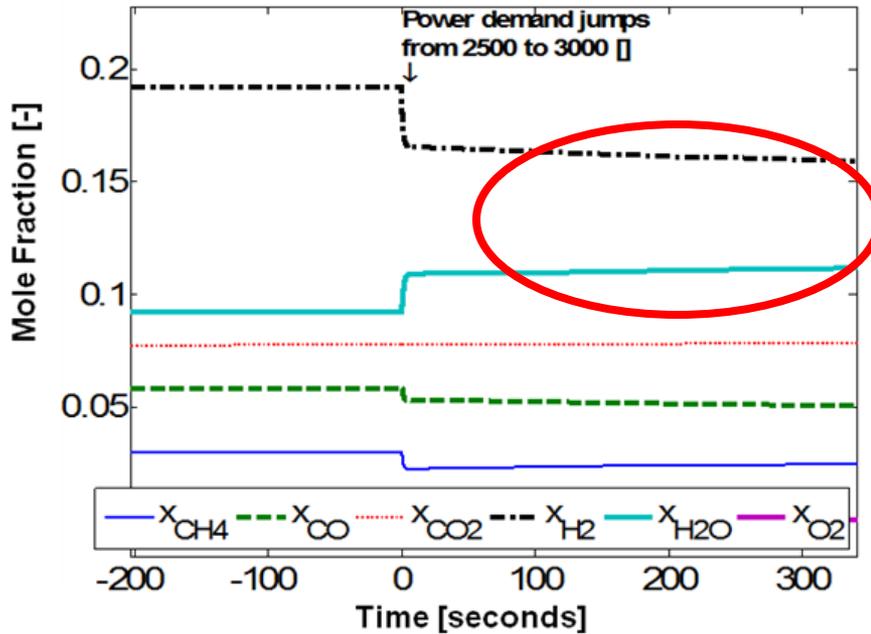


UCI is leading the system modeling effort. The steady state model shows good correlation; the dynamic model is experiencing difficulty converging due to our system architecture.



National Fuel Cell Research Center

TECHNICAL ACCOMPLISHMENTS – SYSTEM MODELING



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TECHNICAL ACCOMPLISHMENTS – SITE SELECTION



Sempra Energy in California is assisting the team with site selection in their territory for external reliability testing:

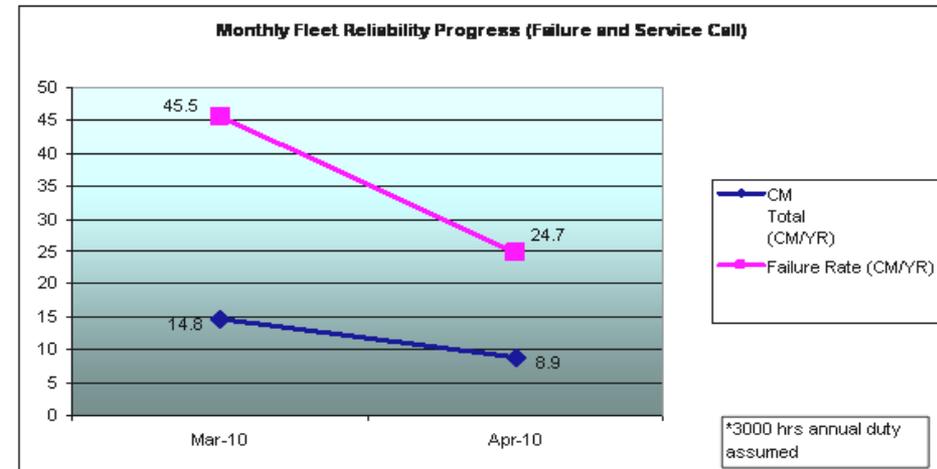
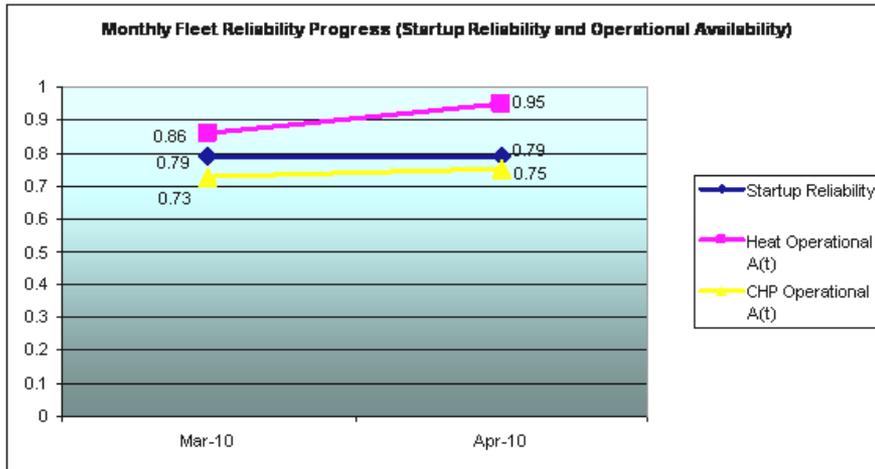
- LPA campus in Irvine, CA (3 systems)
- Sempra Energy employee homes (3 systems)



TECHNICAL ACCOMPLISHMENTS – LONG TERM TESTING

Internal fleet dashboard metrics:

- 5 systems commissioned, 1 in process
- Over **3500** run hours
- **8 MWhrs** of electricity and **30MWhrs** of heat produced
- Unadjusted startup reliability of **80%**
- Unadjusted heat availability of **95%**
- Unadjusted CHP availability of **76%**
- CHP availability (supplier delivery issues removed) of **92%**



TECHNICAL ACCOMPLISHMENTS – OUTREACH

Communication, education and outreach events to date:

- Ribbon cutting ceremony for *GenSys Blue* installation at Union College in Schenectady, NY
- Alumni Day at Union College
- New York State Science, Technology, Engineering and Mathematics (STEM) Educational Collaborative at Ballston Spa High School in Ballston Spa, NY
- United States Fuel Cell Seminar in Palm Springs, California, *GenSys Blue: Fuel Cell Heating Appliance*
- Ballston Spa High School technology field trip
- Plans for system on display at the Schenectady Museum
- UCI takes over in California



NYS Assemblyman Jim Tedisco with Union College faculty, Plug Power and National Grid employees at ribbon cutting ceremony (DOE 7C)

COLLABORATIONS

- **University of California Irvine – National Fuel Cell Research Center**
 - University, cost sharing partner within the program
 - NFCRC develops a system model for product development, refining controls and improving operation
- **Sempra Energy**
 - Industry, non-cost sharing partner within the program
 - Sempra Energy is providing sites for testing and will assist in interconnection and fleet evaluation
- **LPA**
 - Industry, non-cost sharing partner outside of the program
 - LPA will act as a site host and will assist in site design for the three systems installed on their campus
- **California Air Quality Management District (AQMD)**
 - State agency, non-cost sharing partner outside of the program
 - AQMD will evaluate fleet data against California air quality standards
- **National Renewable Energy Laboratory (NREL)**
 - National lab, non-cost sharing partner outside of the program
 - NREL will assist in fleet data analysis

PROPOSED FUTURE WORK

- **1st GO/NO GO Decision** **June 2010**
 - Prior to shipping systems to California the team will hold a GO/NO GO decision based on the program objectives
- **System Builds and Installations in California** **September 2010**
- **Begin External Reliability Fleet Testing** **September 2010**
- **Complete System Model** **December 2010**
 - UCI will verify system model against reliability fleet results
- **2nd GO/NO GO Decision** **September 2011**
 - Based on achievement of the program objectives the team will decide whether or not to invest in upgrading the fleet and continuing long term testing
- **Perform Economic Analysis** **December 2011**
 - Using fleet performance data, Plug Power will publish an economic analysis of the viability of this CHP technology
- **Complete Long Term Testing** **September 2012**

SUMMARY

- Plug Power believes that high-temperature PEM fuel cell technology creates a compelling value proposition in the residential and light commercial micro-CHP market
- Plug Power and its partners are executing a meaningful, long term, reliability testing program and economic analysis to gauge this technology's readiness for the marketplace
- The program has strong collaboration with industry, government agencies and national labs in order to effectively evaluate the technology's performance
- The program is off to a good start, evaluating the early data and making system and process improvements in order to harden the design



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