

Extended Durability Testing of an External Fuel Processor for SOFC

Presentation to DOE's Hydrogen and Fuel Cell
Technical Advisory Committee – June 3, 2010

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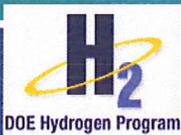
DE-FG36-08GO88113

Rolls-Royce Fuel Cell Systems

Presentation Details

- Who is Roll-Royce Fuel Cell Systems
- What is our product
- Why an external fuel processor for SOFC
- Project overview for DE-FG36-08GO88113
- Where are we going

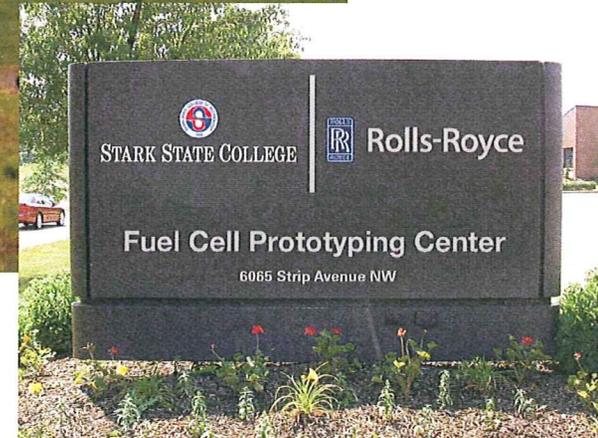
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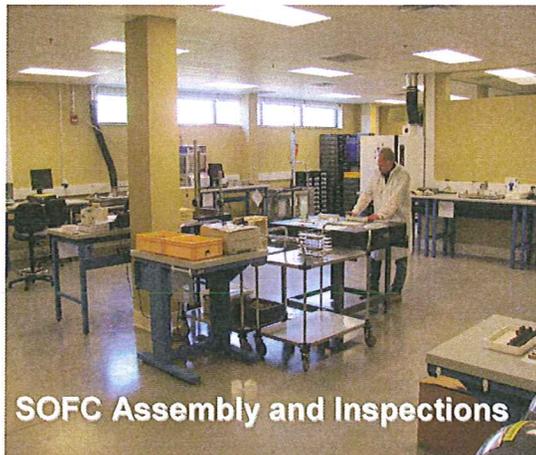
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SOFC Manufacturing Line



SOFC Assembly and Inspections

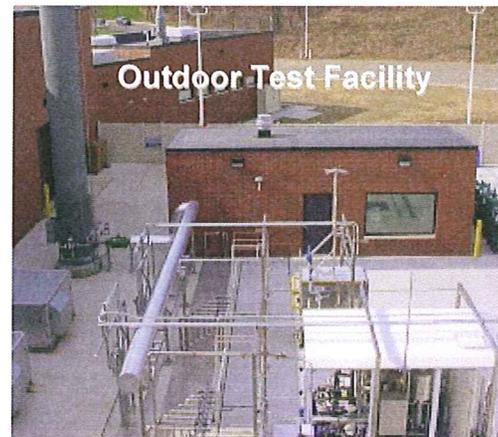


SOFC Test Stands



SOFC Prototype

RRFCS activities in Canton, Ohio



Outdoor Test Facility

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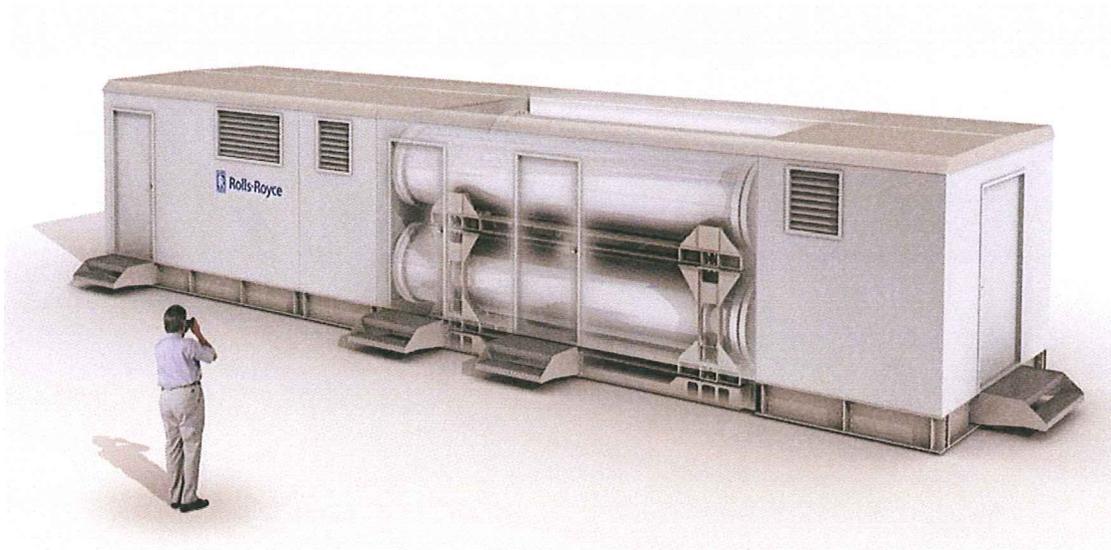
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Our product vision:

1 MWe SOFC generator for distributed power (utility) applications

- High electrical efficiency (60%)
- Low environmental impact (low emissions and low noise)
- Initial development targeting pipeline natural gas



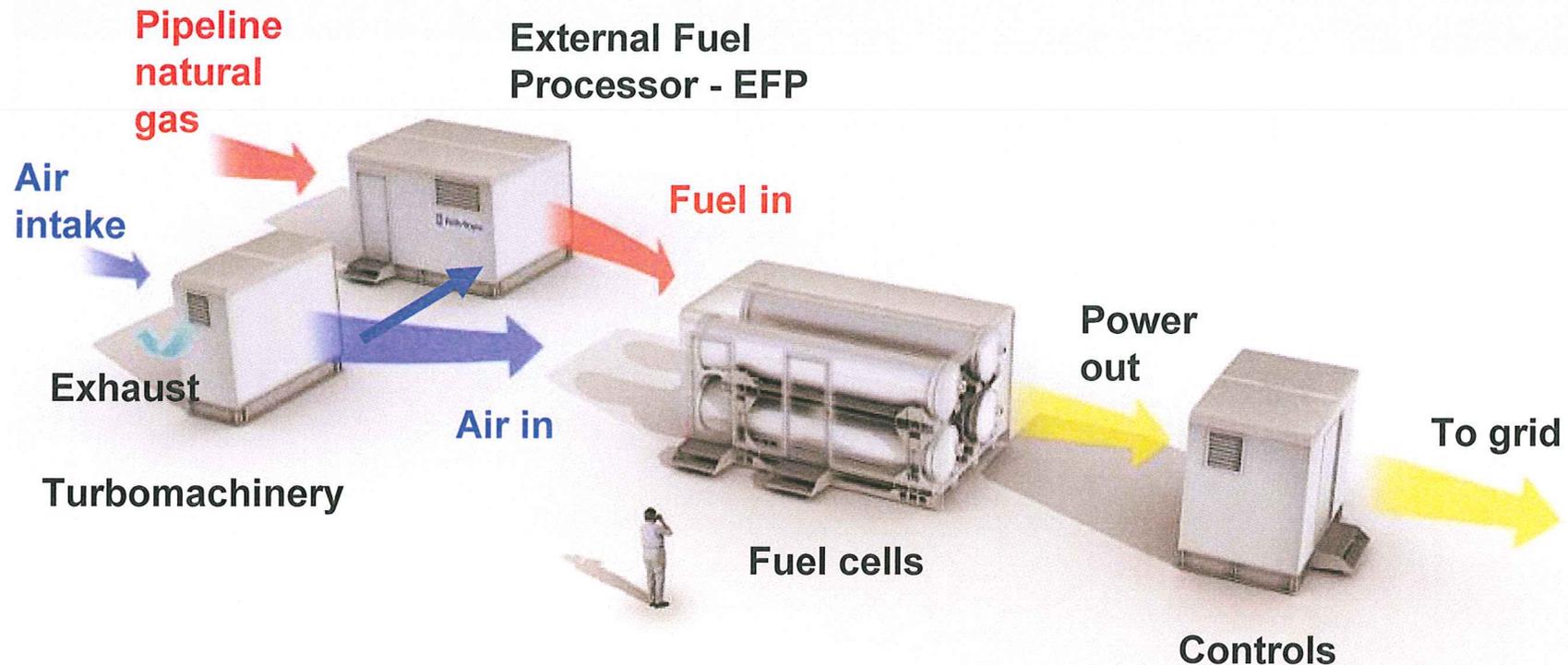
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Subsystems in a SOFC Power plant



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Why an external fuel processor for SOFC?

- Provides all gas streams needed by the SOFC
- Eliminates need for on-site storage of high-pressure gases
- Uses only pipeline natural gas and air to provide:
 - 1) Nonflammable reducing gas for start-up & shutdown
 - 2) Hydrogen for heat-up and part-load operation
 - 3) Desulfurized natural gas for normal operation

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Project Overview – Durability Testing of EFP for SOFC

Timeline

- Project start: 01/01/2009
- Project end: 12/31/2011
- Percent complete: 33% (5/31/10)

Budget

- Project funding total \$1,968,000
 - DOE share = \$984,000
 - RRFCS share = \$984,000
- Funding received in FY08 - \$984K
- Funding in FY09 - \$0.0K
- Funding in FY10 - \$0.0K

Barriers

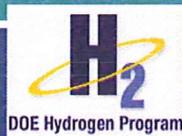
Fuel Processor

- Durability
- Performance
- Start-up and Shutdown time
- Transient operation

Partners

- RRFCS – project lead
- Ohio Department of Development / Stark State College of Technology
 - Funding for Outdoor Test Facility
 - Student Interns

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Overall Project Objectives

- **Conduct long-term testing with full-size components in relevant environments:**
 - 1) Start-gas subsystem - up to 1,000 hours in outdoor environment (hot/cold)
5-year service life
 - 2) Desulfurizer subsystem - 8,000 hours in an outdoor environment (hot/cold)
1-year maintenance cycle and 5-year service life
 - 3) Synthesis-gas subsystem - up to 1,000 hours in warm environment
5-year service life
- **Evaluate the impact of ambient temperatures (hot and cold environments) and long-term operation on key components such as catalysts, sorbents, heat exchangers, heaters, valves, reactors, piping, insulation, control system, and safety system.**

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Start-gas subsystem generates non-flammable reducing gas

- Low-oxygen content oxidant stream
- Small amount of pipeline natural gas
- Pressurized catalytic reactor to generate nonflammable reducing gas for start-up and shutdown
- Air-cooled heat exchanger cools product gas
- Automatic control system



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Desulfurizer subsystem generates high-pressure desulfurized natural gas

- Pipeline natural gas (sulfur < 10 ppmv) and compressed air as reactants
- Pressurized catalytic reactor for oxy-desulfurization
- High-capacity sulfur-oxide sorbent (total outlet sulfur < 100 ppb)
- Automatic control system



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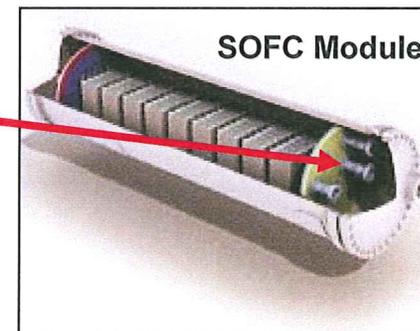


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Synthesis-gas subsystem generates a hydrogen-rich gas for SOFC heat-up and low-load operation

- Pipeline natural gas and compressed air
- Pressurized catalytic reactor
 - Rapid start-up (minutes)
 - Generate hot synthesis gas
 - Hydrogen and carbon monoxide \leq Maximum
- Automatic control system



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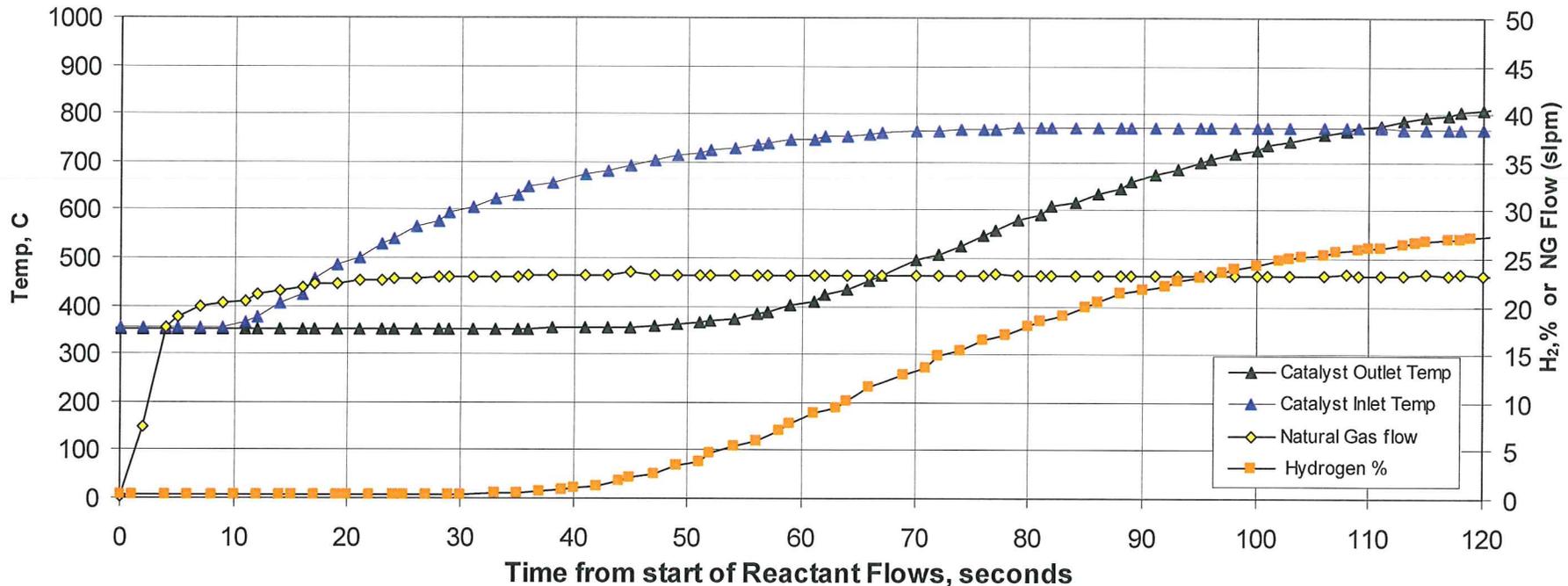


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Synthesis-gas subsystem durability testing results

Synthesis-Gas Reactor Start-up



- Rapid start-up achieved (< 1 minute) - generating significant hydrogen
- Hydrogen generation follows catalyst outlet temperature

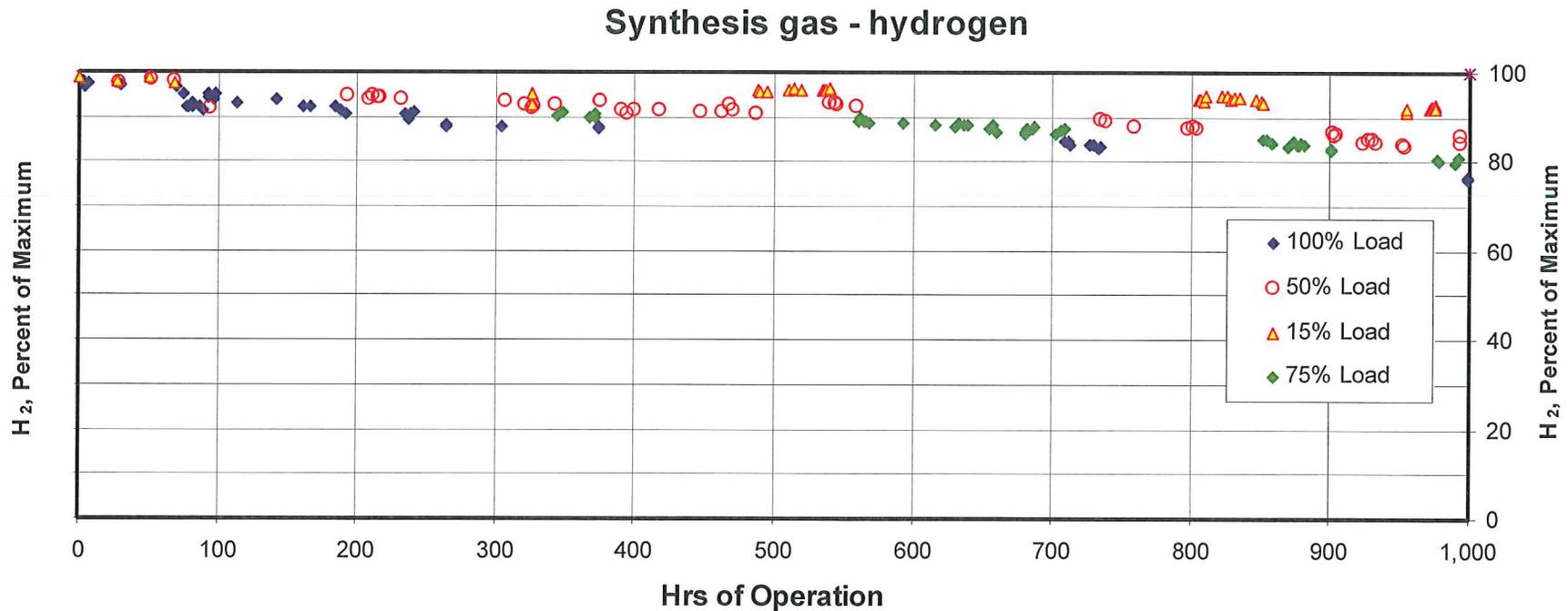
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Synthesis-gas subsystem results (cont.)



- Hydrogen generation meets specification and life requirement

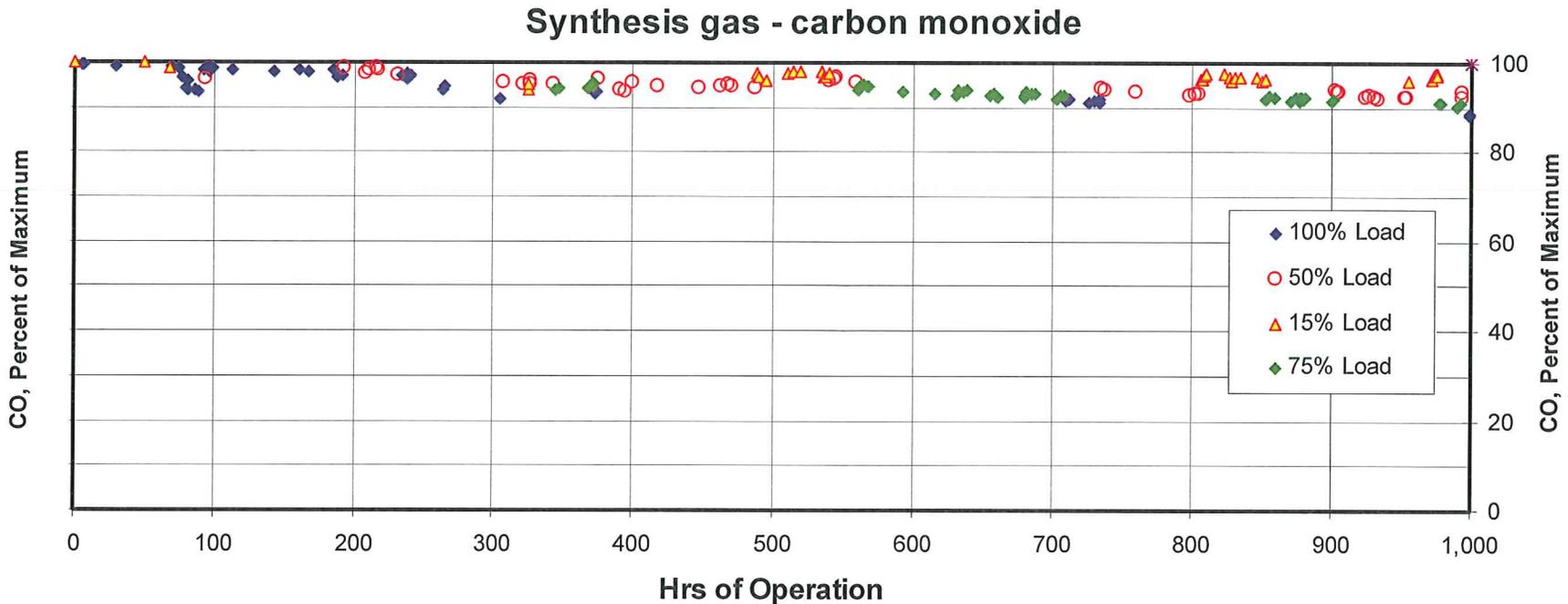
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Synthesis-gas subsystem results (cont.)



- Carbon monoxide generation meets specification and life requirement

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Milestones

No.	Description	Planned	Actual	Status
1	Start Preparation of Synthesis-gas Subsystem	January 2009	January 2009	completed
2	Begin Synthesis-gas Subsystem Durability Testing	April 2009	September 2009	completed
3	Start Preparation of Desulfurizer Subsystem	July 2009	December 2009	completed
4	Complete Synthesis-gas Subsystem Durability Test	September 2009	April 2010	completed
5	Complete 1,000 hours Operation of Desulfurizer	September 2010		on schedule
6	Start Preparation of Start-gas Subsystem	July 2009	December 2009	completed
7	Begin Start-gas Subsystem Durability Testing	September 2010		on schedule
8	Complete Desulfurizer Subsystem Test	October 2011		on schedule
9	Complete Start-gas Subsystem Test	October 2011		on schedule
10	Complete Final Report	December 2011		on schedule

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Project Summary

- An approach was developed for evaluating durability and performance of an external fuel processor for a 1 MWe SOFC
- Durability testing completed on Synthesis-gas subsystem
- The Desulfurizer and Start-gas subsystems have been installed in the outdoor test facility
- Commissioning Desulfurizer and Start-gas rigs is underway

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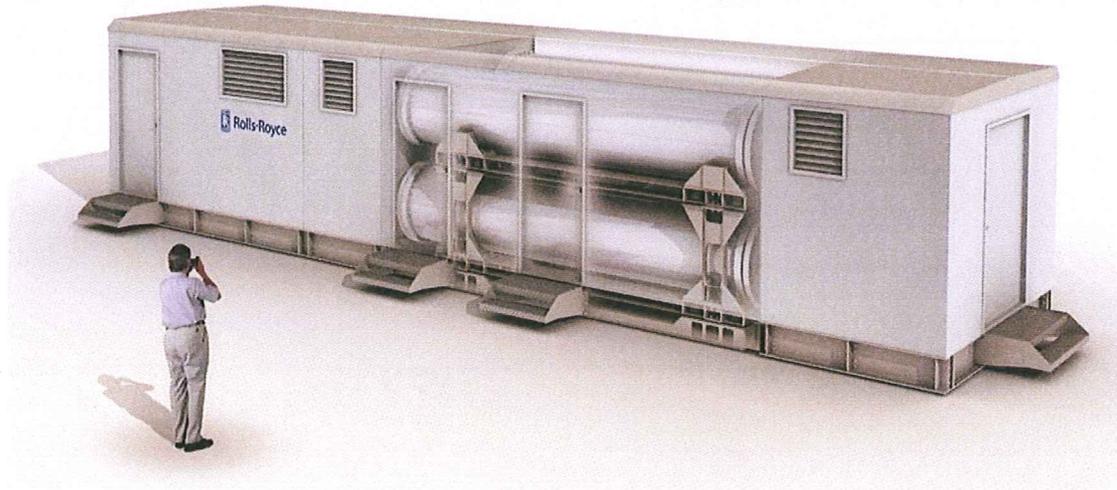
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Where are we going?

1 MWe SOFC generator for distributed power (utility) application

- Future development targeting green fuels such as biogas/digester gas, landfill gas, and coal synthesis gas



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