Extended Durability Testing of an External Fuel Processor for SOFC

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

Mark A. Perna
Rolls-Royce Fuel Cell Systems (RRFCS)
Canton, Ohio

DOE Project Officer: Jesse J. Adams
EERE-Golden Field Office
Golden, Colorado

Presentation Details

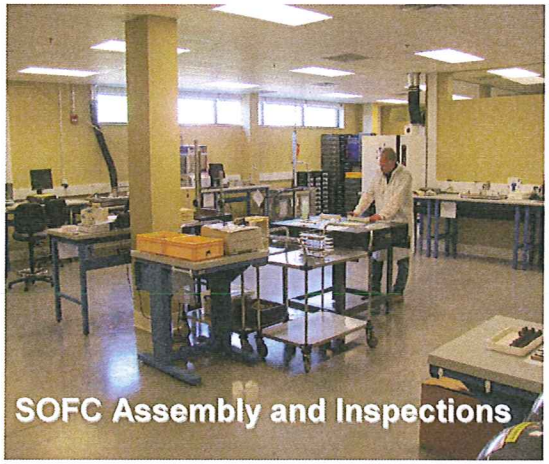
- Who is Roll-Royce Fuel Cell Systems
- What is our product
- Why an external fuel processor for SOFC
- Project overview for DE-FG36-08GO88113
- Where are we going

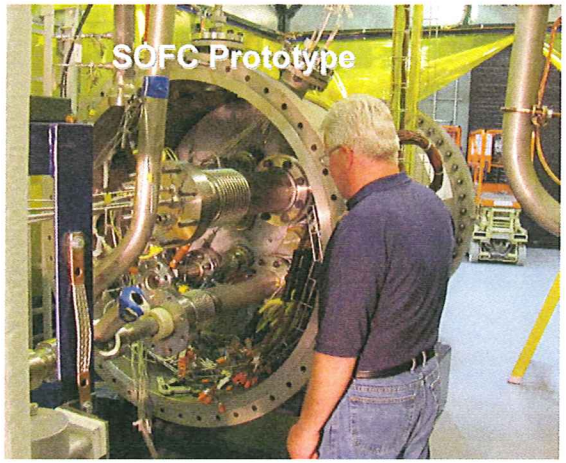
This presentation does not contain any proprietary, confidential, or otherwise restricted information

Rolls-Royce Fuel Cell Systems
Canton, Ohio

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Rolls-Royce Fuel Cell Systems





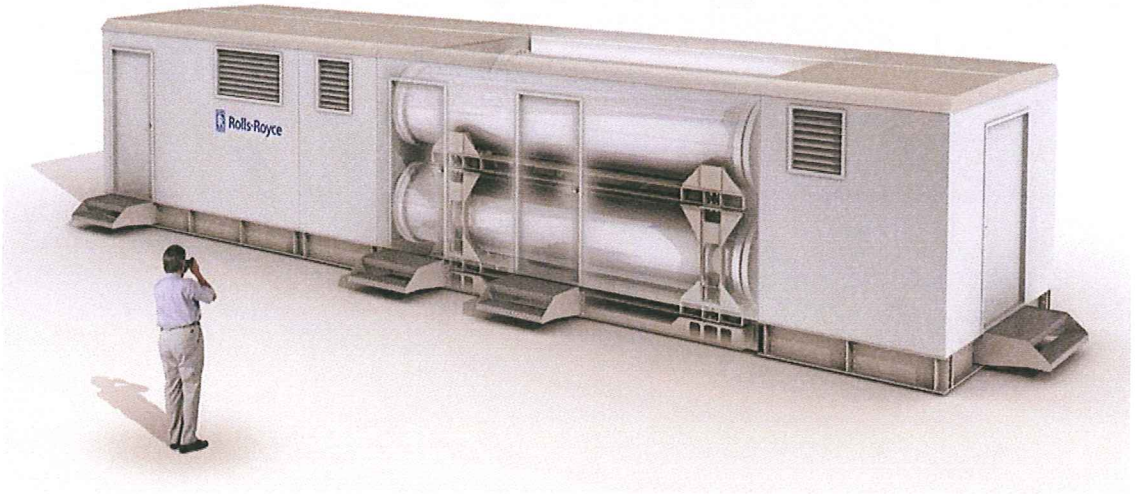
RRFCS activities in Canton, Ohio

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Our product vision:

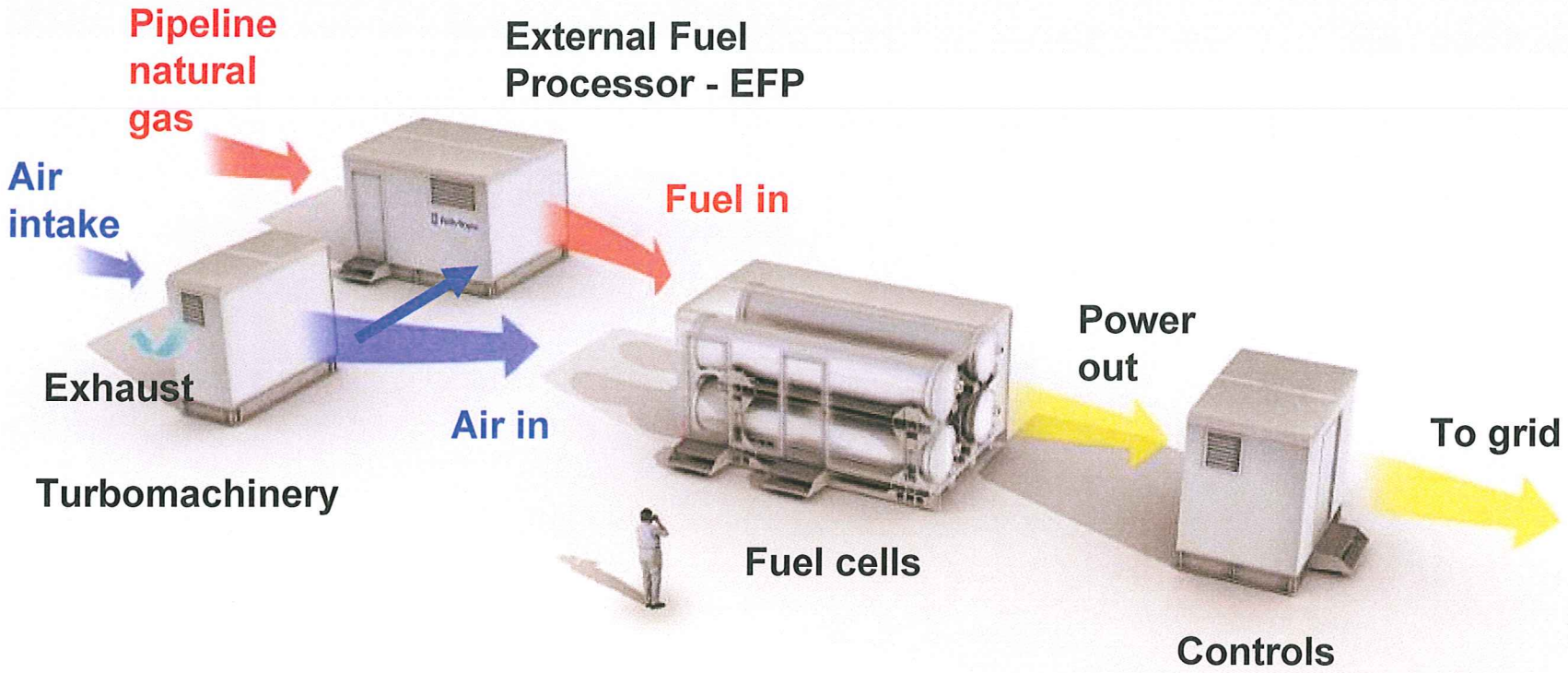
1 MWe SOFC generator for distributed power (utility) applications

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



This presentation does not contain any proprietary, confidential, or otherwise restricted information

Subsystems in a SOFC Power plant



This presentation does not contain any proprietary, confidential, or otherwise restricted information

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

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

This presentation does not contain any proprietary, confidential, or otherwise restricted information

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.**

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

This presentation does not contain any proprietary, confidential, or otherwise restricted information

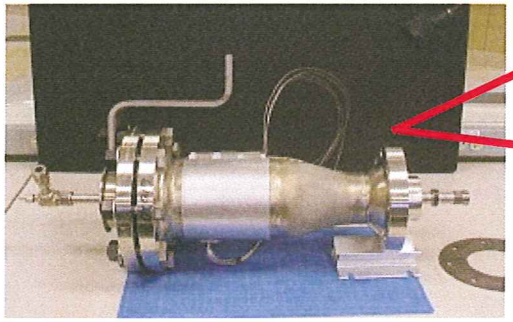
Desulfurizer subsystem generates high-pressure desulfurized natural gas

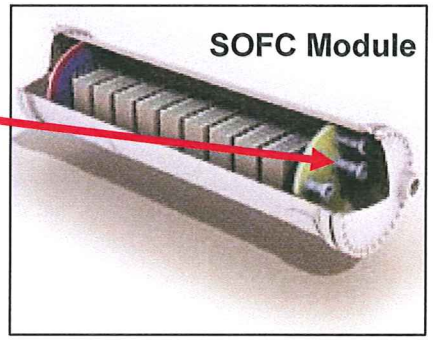
- Pipeline natural gas (sulfur<10 ppmv) and compressed air as reactants
- Pressurized catalytic reactor for oxy-desulfurization
- High-capacity sulfur-oxide sorbent (total outlet sulfur < 100 ppb)
- Automatic control system

This presentation does not contain any proprietary, confidential, or otherwise restricted information

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

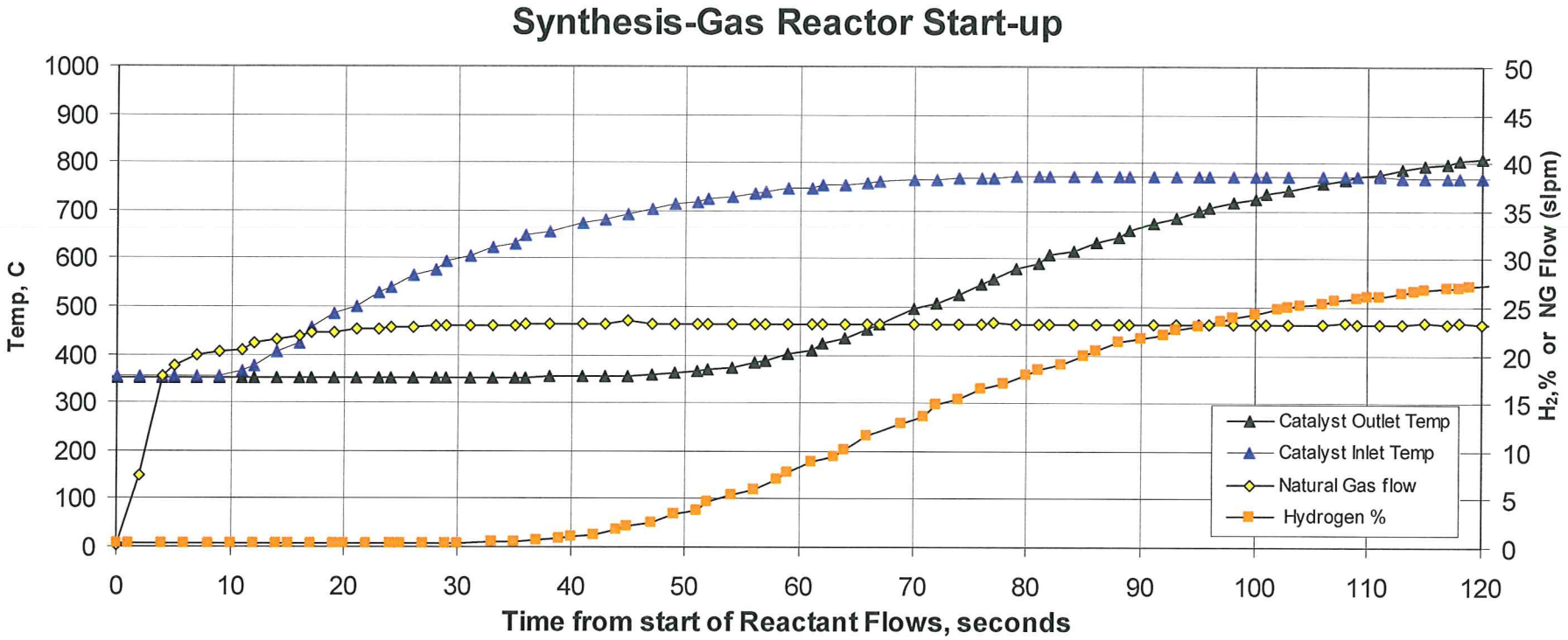
- Pipeline natural gas and compressed air
- Pressurized catalytic reactor
  - Rapid start-up (minutes)
  - Generate hot synthesis gas
  - Hydrogen and carbon monoxide ≤ Maximum
- Automatic control system





This presentation does not contain any proprietary, confidential, or otherwise restricted information

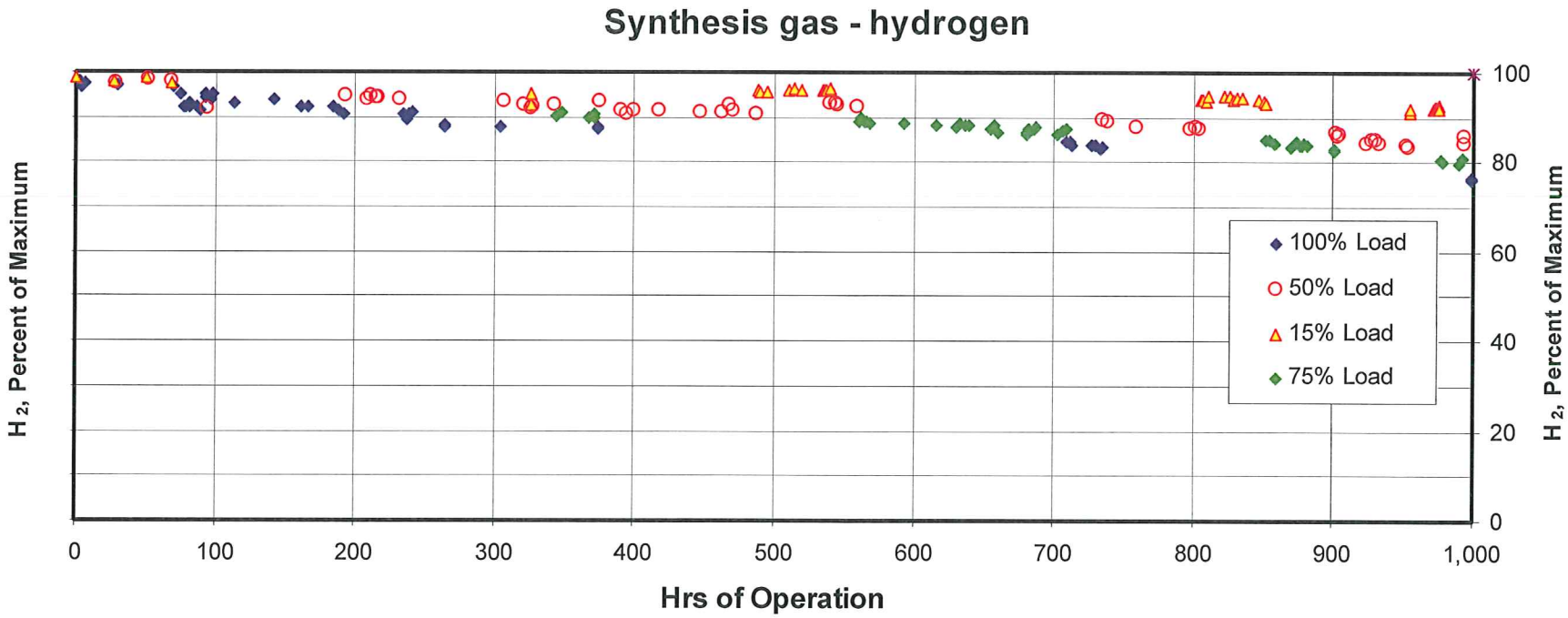
Synthesis-gas subsystem durability testing results



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

This presentation does not contain any proprietary, confidential, or otherwise restricted information

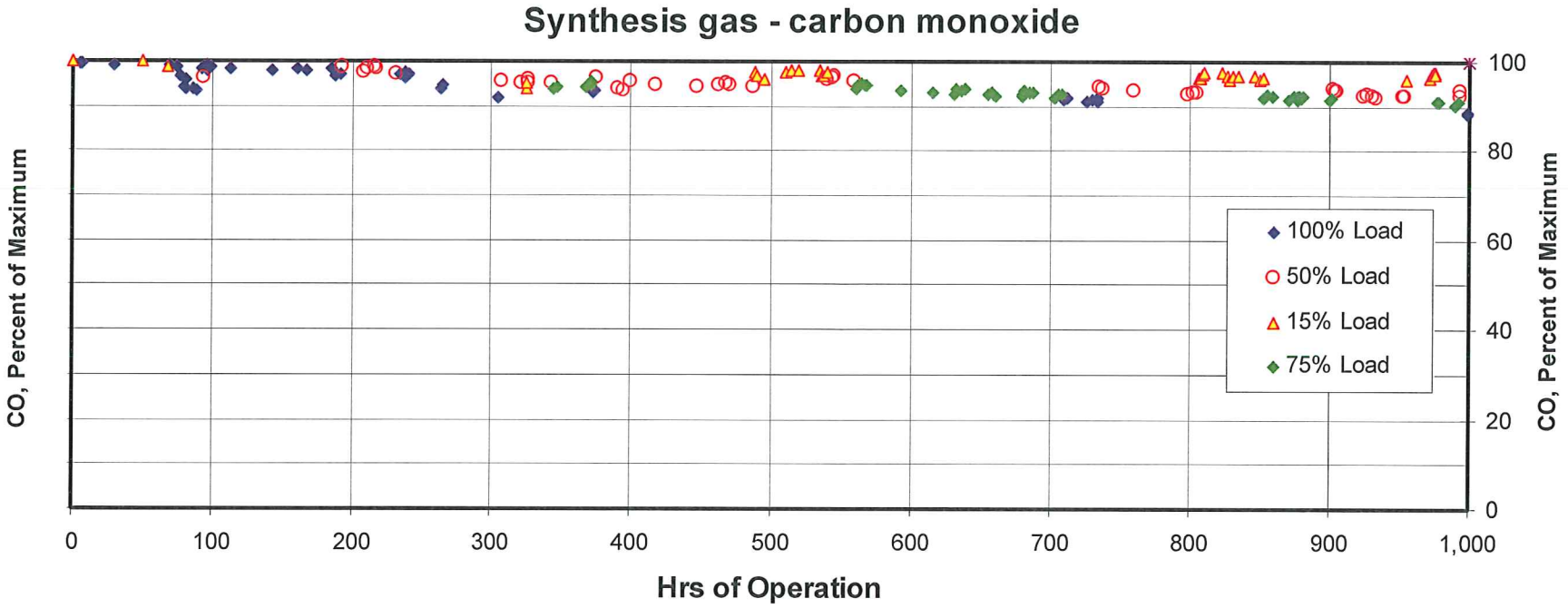
Synthesis-gas subsystem results (cont.)



- Hydrogen generation meets specification and life requirement

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Synthesis-gas subsystem results (cont.)



- Carbon monoxide generation meets specification and life requirement

This presentation does not contain any proprietary, confidential, or otherwise restricted information

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**

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Project Summary

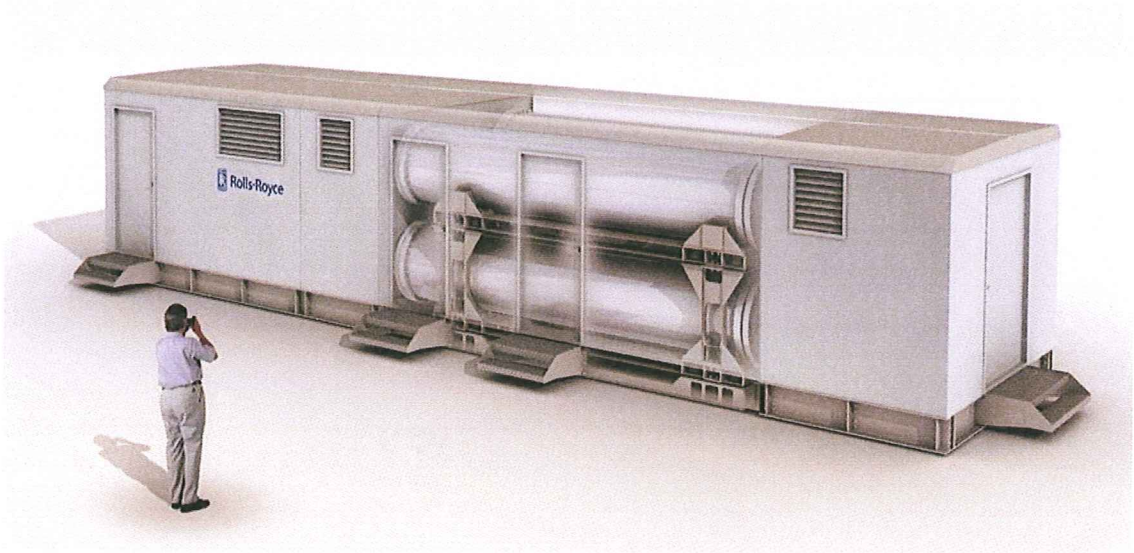
- An approach was developed for evaluating durability and performance of an external fuel processor for a 1 MWe SOFC
- Durability testing completed on Synthesis-gas subsystem
- The Desulfurizer and Start-gas subsystems have been installed in the outdoor test facility
- Commissioning Desulfurizer and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

This presentation does not contain any proprietary, confidential, or otherwise restricted information

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



This presentation does not contain any proprietary, confidential, or otherwise restricted information