# Solid Oxide Fuel Cell Systems Print Verification Line (PVL) Pilot Line

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Project ID: FC080

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# Overview

## Timeline

- Start - 7/1/2010
- End - 6/30/2011
- 100% complete

## Budget

- Project funding total $1,250,000
  - DOE share $1,000,000
  - RRFCS (US) Inc. $250,000
- Funding received in FY10 $1,000,000

## Barriers and Risks

- Stack Block Test System
  - Mechanical performance
  - Long-term durability (>5000 hr)
  - Control and safety system performance

## Partners

- Stark State College – Prime Contractor
- RRFCS – Subcontractor
- Component suppliers

# Relevance
# Stationary power generation with fuel cells

**The Rolls-Royce Fuel Cell Systems (US) Inc. (RRFCS) 1 MWe Solid-Oxide Fuel Cell (SOFC) power plant concept is designed for base load stationary power generation applications. With its high electrical efficiency (~60%), negligible air emissions, and minimal noise profile, the concept is highly suitable for grid extension applications at substations and at points of use such as hospitals, universities, shopping malls, factory units, etc.**

**The 1 MWe SOFC power plant will be configured initially to use pipeline natural gas. Future development may target alternative fuels such as biogas.**

# Relevance (continued)



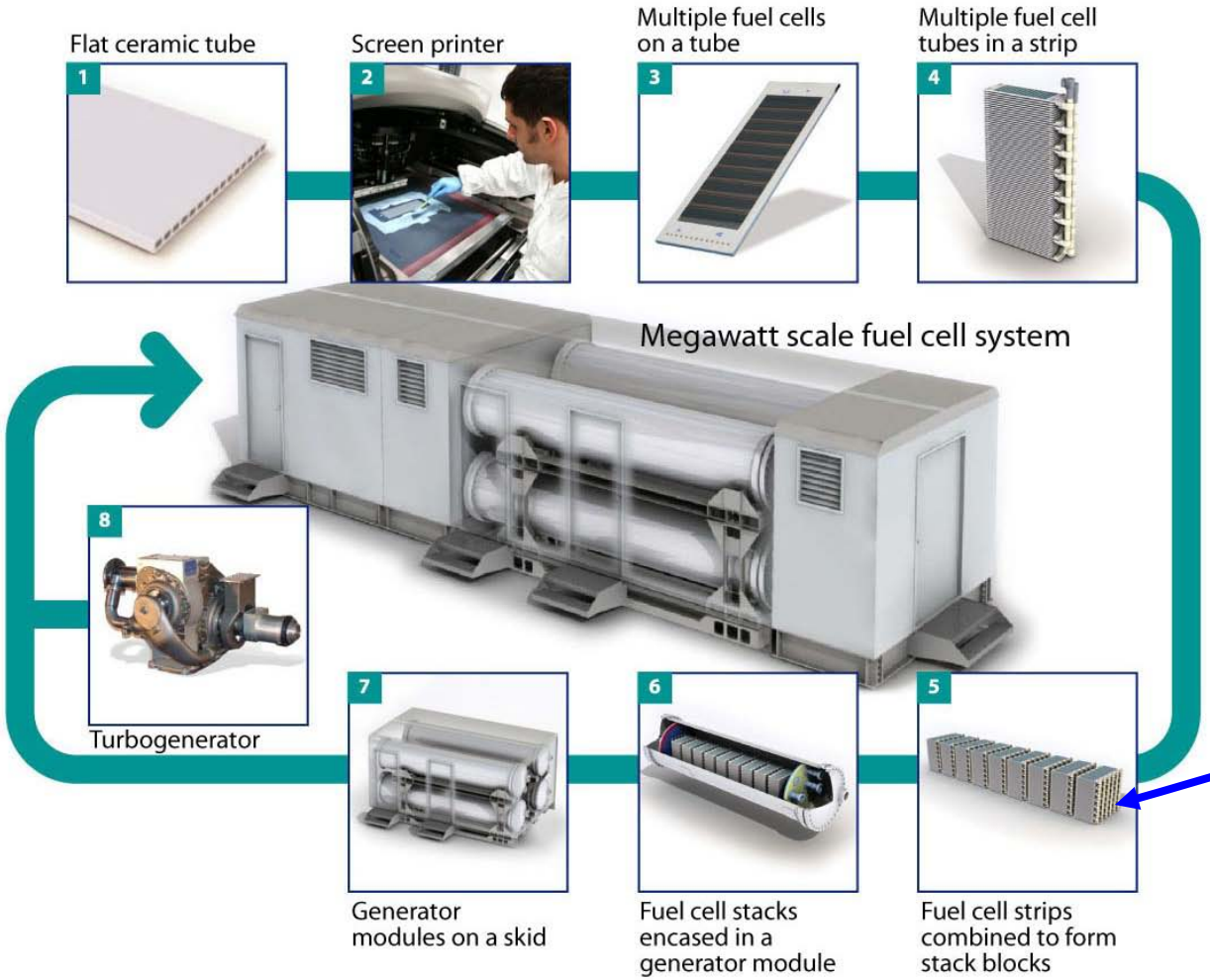
**RRFCS' SOFC power plant concept through its high efficiency, negligible air emissions and potential fuel flexibility directly supports the DOE Hydrogen and Fuel Cells Program's mission statement *"To enable the widespread commercialization of a portfolio of hydrogen and fuel cell technologies through basic and applied research, technology development and demonstration, and diverse efforts to overcome institutional and market challenges."***

- **Program directly aligns with fuel cell technology development and demonstration.**

**RRFCS' SOFC power plant concept for stationary power supports the DOE Hydrogen and Fuel Cells Program's key goal to *"develop fuel cell technologies for early markets such as stationary power (primary and backup) …"***

- **Program provides the test system necessary for long-term operation of the fundamental building block of the RRFCS 1MW fuel cell plant – the fuel cell stack block – at full system operating conditions.**

# Relevance
# Stack Block Fit to 1MW Fuel Cell Product




**The stack block is duplicated to build-up 1 MW of capacity.**

**Performance testing in SBTS at block scale is business critical.**

# Relevance: Project Objectives



## Complete the electrical/mechanical build and commission test of SBTS

- Provides block-scale test system for the active fuel cell tubes produced by the Print Verification Line (PVL)
- Initial commissioning tests to qualify SBTS operation and control

Completed SBTS ready for test

# Relevance to American Recovery and Reinvestment Act of 2009



**Alignment of ARRA goals of job creation/maintenance, and spurring economic activity and investment in long-term growth. Completion of the Stack Block Test System (SBTS):**

- **Created/retained 5+ jobs in Ohio**
- **Supply chain benefited from procurements used in fabrication/build of SBTS**
- **Investment supports long-term development of the stack block by providing a facility for testing of components produced by the Print Verification Line (PVL), a fully automated production line for printing anode and cathode electrodes on fuel cell substrates.**
- **Creates the basis for future manufacturing decisions**

**Alignment with FCT ARRA project goals of accelerating the commercialization and deployment of fuel cells:**

- **SBTS is available to support development and performance testing of the fuel cell stack block beginning in 2011**

# Relevance
# Barriers and Risks



**SBTS operation successful at the end of 2010**

- **Demonstrated SBTS mechanical performance over the required range of fuel cell operating temperature, pressure and anode/cathode gas compositions**
- **About 200 hrs of operating time at temperature; long term operation in 2011**
- **Control and safety system hardware/software demonstrated up to powered stack operation**
  - **Powered stack operation in 2011**

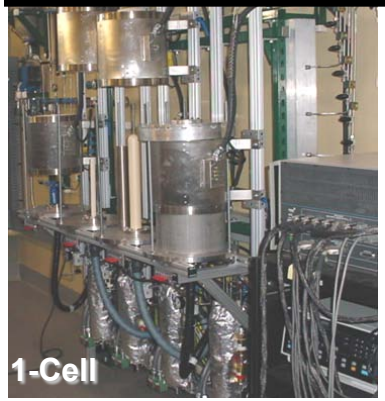
# Approach

## SBTS critical to RRFCS product development roadmap

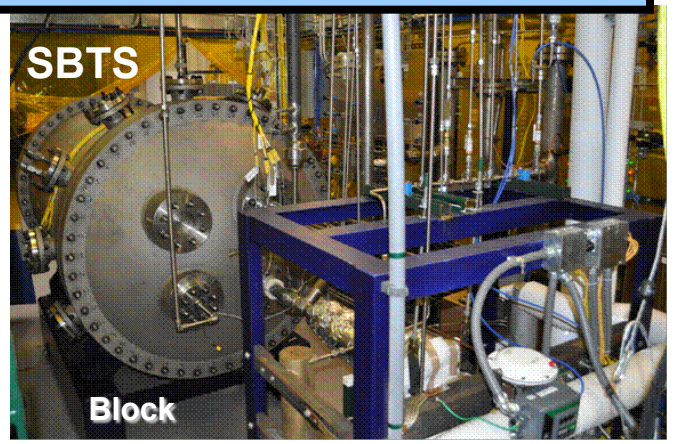


**Manufacturing: PVL and Assembly**


**Test Systems from Cell to Block Scale**





# Approach SBTS History

**SBTS progress and support**

**with RRFCS participation at each gate**

1. **ODOD Grant TECH 08-053: facility design, test vessel and internals build**
2. **DOE DE-FE0000303: SBTS modifications to support SECA fuel cell testing in an integrated gasification cycle with $CO_2$ concentration**
3. **DOE DE-EE0003229: SBTS facility and controls completion; mechanical commission test (current contract)**

# Approach
## SBTS Scope/Task Structure

- Task 1 – Controls software and HMI completed and exercised under Task 3
- Task 2 – Complete stack and component wiring; connect stack power controllers(8); install stack instrumentation.
- Task 3 – Perform mechanical commissioning to exercise all components and control loops except those associated with stack electrical power. Verify safety system functionality. At completion, SBTS is ready for electrical stack operation.

# Approach
# Program Completed in March 2011

| Milestone | Milestone Description | % Complete | Comments |
|---|---|---|---|
| 1 | Complete the control system software (ready for SBTS operation) | 100 | Control software performs automatic operation to stack power loading; manual control supports stack power operations. |
| 2 | Complete electrical tasks (ready for SBTS operation) | 100 | Electrical bus bar and GFI installed. Eight load controllers allow variable stack block loading during performance testing. |
| 3 | Start commissioning tasks | 100 | Mechanical commissioning complete. Anode and cathode gas flow controls, start gas, reactor operation and safety system demonstrated. Ready for electrical commissioning in 2011-Q2. |
| 4 | Inspect apparatus at end of commissioning | 100 | Stack and hot internals inspected following mechanical commissioning tests. Operating changes to the start burner control. |

# Accomplishments and Progress Summary



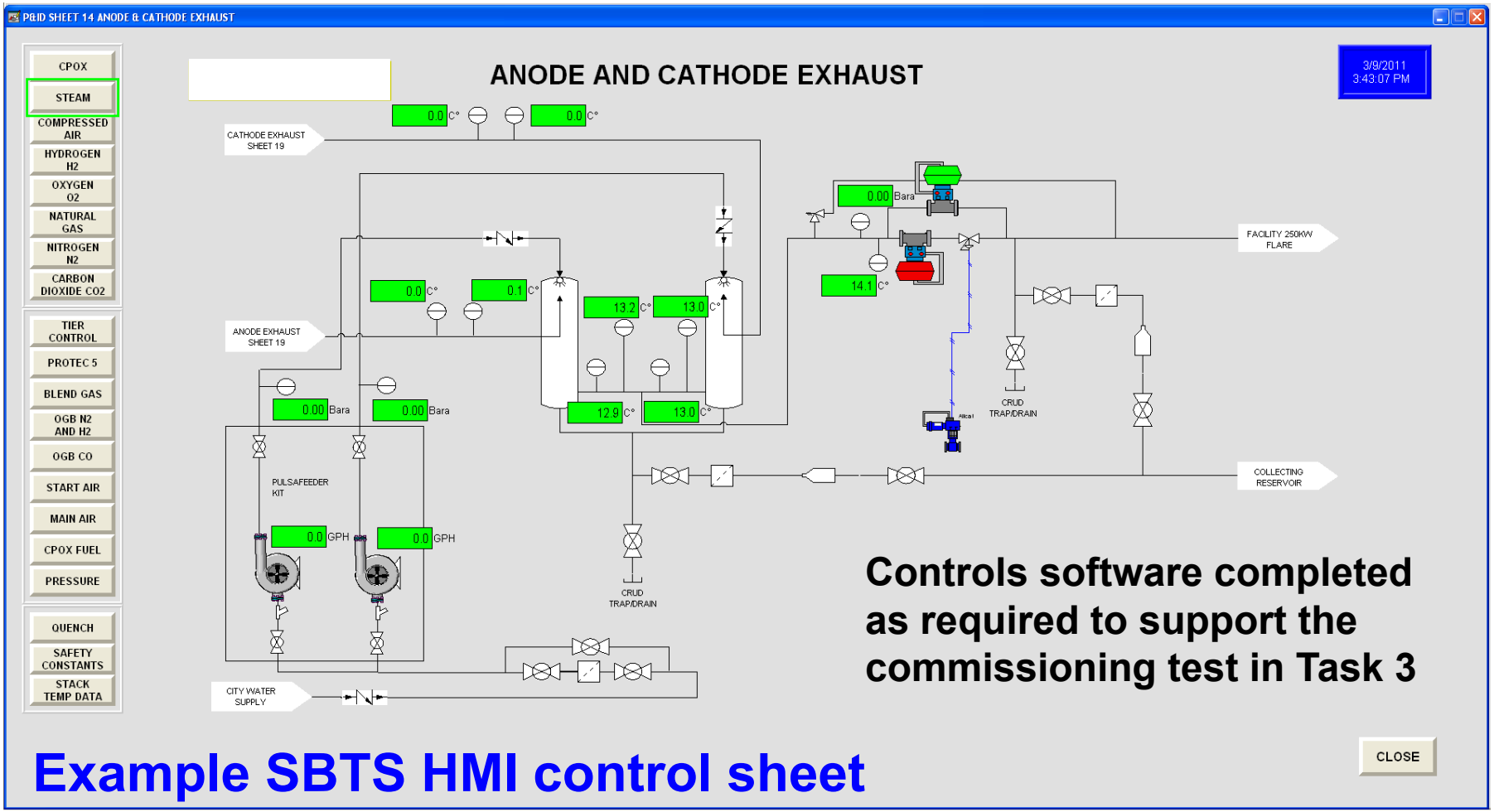
**SBTS operation successful at the end of 2010**

- **Demonstrated SBTS mechanical performance over the required range of fuel cell operating temperature, pressure and anode/cathode gas compositions**
  - **Installed stack prototype for anode/cathode flow circuitry but not electrically connected**
- **About 200 hrs of operating time at temperature; long term operation in 2011**
- **Control and safety system hardware/software demonstrated up to powered stack operation**

**SBTS is ready for powered stack operation in 2011**

# Technical Accomplishments and Progress

## Task 1 Controls Software




**Example SBTS HMI control sheet**

# Technical Accomplishments and Progress

## Task 2 Facility Electrical and Controls Wiring

DC power cabinet and load controller wiring complete.

# Technical Accomplishments and Progress

## Task 3 Mechanical Test Commissioning

# Collaboration


- **Stark State College**
  - Prime Contractor
  - 2-Year Community College
  - Provides skilled technicians, interns and employees to RRFCS and the fuel cell industry for development, testing and manufacturing
- **RRFCS alliance with SSC**
  - Subcontractor
  - Large, For-Profit Business
  - Developing MW-scale fuel cell systems for stationary applications
  - Workplace for Stark State college interns and graduates
- **Ohio Third Frontier Program**
  - Funded construction of SSC Fuel Cell Lab and RRFCS Prototyping Center and for development of SBTS
- **Significant supply chain**
  - Vessel fabrication, tubing/fittings, electrical wiring/components, electrical panel supply, controls software

# Future Work

- All work associated with this contract is expected to be complete at the time of this presentation

# Summary

- Relevance
  - Alignment with the DOE Hydrogen and Fuel Cells Program mission and goal statements
  - Alignment with ARRA and FCT ARRA goals of job creation/retention and accelerating fuel cell commercialization
- Approach
  - All technical and project management performance targets achieved
- Technical Accomplishments
  - Contract scope complete; SBTS supporting RRFCS fuel cell development and performance characterization at block scale
- Collaborations
  - Stark State College and RRFCS recognized in Ohio as a model for public/private sector collaboration
  - Supply chain development
- Future work
  - Contract complete; SBTS deployed for RRFCS commercial use