# Jadoo Power Fuel Cell Demonstration

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# Overview

## Timeline

- Start: 1/1/2010
- End: 1/31/2012
- 5% Complete

## Budget

- Total: $4,821,152.00
  - DOE share: $2,202,491.00
  - Contractor share: $2,618,661.00

## Barriers

- Reducing stack and BOS to size allowing portability
- Reliability of SOFC system under rough field conditions
- User factors related to start-up times and refueling
- Effectiveness/complexity of processing propane to remove sulfur
- Potential constraints on type or source of propane

## Partners

- Project is led by Jadoo Power
- Development partner is Delphi Inc.
- Field test partners are NASCAR Media Group and the City of Folsom, CA

# Objectives

- The development of 2 portable electrical generators in the 1000 watt range utilizing Solid Oxide Fuel Cells as the power element and propane as the fuel.
- The development and demonstration of a proof-of-concept electro-mechanical propane fuel interface that provides a user friendly capability for managing propane fuel in a manner that supports the widespread adoption of fuel cells.
- The deployment and use of the fuel cell portable generators to power media production equipment over the course of several months at multiple high profile automobile racing events staged in multiple locations throughout the United States.
- The deployment and use of the fuel cell portable generators at scheduled events by first responders (police, fire) of the City of Folsom California to power equipment in emergency and/or off-grid situations.
- Capturing data with regard to the systems' ability to meet DOE Technical Targets and evaluating the ease of use and potential barriers to further adoption of the systems.

# Relevance

- Project is focused on exploring the efficacy of replacing gasoline powered portable generators at large outdoor events and in first responder applications with propane powered fuel cells
- Jadoo Power has identified multiple specific issues with regard to the staging of outdoor events such as music festivals, sporting events, and road races that would be ideally suited for the application of a small fuel cell generator powered by propane
- Jadoo Power has identified multiple promising applications in police, fire and disaster response situations that are not well served by gasoline powered generators
- This project will further the development of emerging technologies including SOFC and propane fuel management that could supplant gasoline powered generators in many applications
- This project is funding development activities that could lead to near term commercialization of fuel cell technology in multiple applications where internal combustion engine- based generators have significant drawbacks

# Approach

- Portable generator to be developed by leveraging parallel work by Delphi related to use of SOFC in trucking APU application
- Delphi SOFC technology to be modified and packaged for portable application with AC power capability
- Delphi developing desulfurizer to allow use of commonly available propane as fuel source
- Jadoo Power developing electromechanical fuel interface by leveraging prior learning from development of a interface between PEM fuel cells and Metal Hydride canisters
- Systems to be developed for 2 key applications that could lead to commercialization
- Systems to be deployed and transported between multiple racing and first responder events to evaluate ruggedness, portability and suitability for real world applications

# Key Goals and Targets

- Develop propane desufurizer with the ability to reduce the level of sulfur in propane to less than 10 ppb for 8 continuous hours
- Develop SOFC portable generator with the ability to produce 1KW using propane for 8 continuous hours by combining an SOFC stack with an AC inverter and relevant balance of plant
- Key targets include operation of generator at minimum 30% efficiency for minimum of 2000 cumulative hours
- Develop a user-friendly electromechanical propane fuel interface that can indicate the amount of propane within ± 10% of the actual amount for the entire range from full to empty
- Test 2 SOFC generator units at several NASCAR racing events in 2011 as replacements for gasoline powered generators
- Test SOFC generators in first responder applications with Folsom Police and Fire Departments
- Analyze technical performance and human factors issues to evaluate readiness of the technology to move into commercialization phase

# Tasks and Milestones

| | |
|---|---|
| Task 1 | Requirements Definition |
| Milestone 1 | Complete Applications Specs for portable generator, desulfurizer and propane fuel interface |
| Task 2 | System Design – Generator |
| Task 3 | System Design – Desulfurizer |
| Milestone 2 | Demo ability of desulfurizer to reduce sulfur in propane to <10ppb for 8 continuous hours of operation |
| Task 4 | System Design – Fuel Interface |
| Task 5 | Build and Test Demonstration Generators |
| Milestone 3 | Go/No-Go – Demo ability of portable SOFC to produce 1kW for 8 continuous hours |
| Task 6 | Build and Test the Fuel Interface |
| Milestone 4 | Demo proof-of-concept unit of propane fuel interface that indicates ±10% propane fuel level for entire state of fill range |
| Task 7 | Deployment, Demonstration and Field Test |
| Task 8 | Final Testing |
| Milestone 5 | Delivery of Value Proposition Report of Task 7 to DoE |
| Task 9 | Project Management and Reporting |

# Accomplishments – General

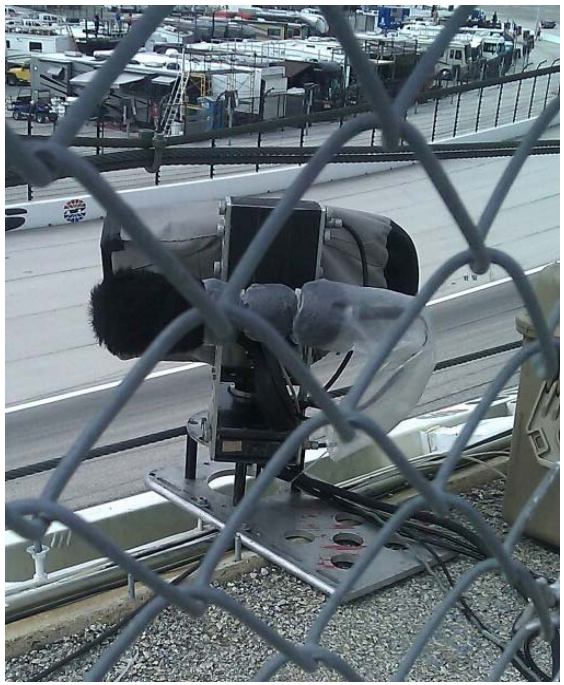
- Project start delayed to early 2010 due to change of SOFC subcontractor after award
- Most research activities related to propane interface completed
- Initial tasks related to development of SOFC generator are underway
- Detailed analysis of NASCAR camera equipment power needs completed including baseline load evaluation and logistics evaluation
- Focus group with City of Folsom, City of Sacramento, Office of Emergency Services, CalFire and FEMA has been conducted to identify applications and issues related to potential usage of fuel cell generators by First Responders
- Hydrogen Safety Program has been developed
- This project has resulted in job creation/retention in California, New York and Michigan

# Preliminary Findings - Events

- There are numerous large scale outdoor events staged globally each year
- Most events deploy portable generators for a variety of purposes depending on the location and the amount of grid power available
- Televised events require power for a suite of media production equipment
- This project is focused on the replacement of small gasoline generators that are used to power the following:
  - Fixed camera positions
  - Robotically-assisted remotely-controlled cameras
  - Coax/fiber converter boxes that connect cameras to production trailers
- Key issues that favor the application of clean generator technology:
  - Generators are sometimes in close proximity to workers and patrons
  - Internal combustion engine-based generators result in noise and vibrations thereby limiting the ability to locate them close to camera positions
  - High efficiency generators may result in less frequent refueling thereby simplifying event production and staffing

# Potential Event Application

Media production of televised racing events includes several cameras on top of the press box and several remotely controlled cameras on perimeter of race track



Robotically Assisted Remotely Controlled Camera

Fixed Camera Position with Special Effects Module

# Preliminary Findings – First Response

- Police and Fire agencies use portable generators for:
  - Emergency lighting
  - Portable radio repeaters
  - Two-way radio recharging
  - Ruggedized laptops
  - Emergency medical equipment
- Drawbacks of utilization of gasoline powered generators include:
  - Fuel leaks and spills
  - Inability to refuel without interrupting power
  - Inability to use in indoor situations
  - Rapid deployment requirements
  - Ability to use in hazardous environments

# Accomplishments – Propane Interface

- Researched propane industry standards and practices for storage, transport, safety and measurement of propane fuel, including methods of propane fuel level measurement, tank designs and sizes
- Compared various current industry technologies and methodologies for measurement of propane levels
- Evaluated potential of applying existing technologies and methodologies to a portable SOFC propane fueling system
- Determined potential factors that may relate to application requirements for portable fuel cell propane tank fuel level determination, operation and safety

# Preliminary Findings – Propane Interface

- Current fueling and fill status monitoring techniques include:
  - Pressure Measurement (consumer applications)
  - Mechanical float devices (industrial applications)
  - Optical, microwave or electromagnetic sensors (industrial applications)
  - Weight measurement (industrial applications)
- Current solutions have following drawbacks for widespread use in portable fuel cell applications:
  - Lack of granularity and accuracy (pressure measurement)
  - Inability to support manifold configurations
  - Positional dependence (pressure, floats, optical, microwave, electromagnetic)
  - Cost and complexity (optical, microwave, electromagnetic)
- Possible new solutions may include the following:
  - Dynamic realtime weight measurement
  - Tracking of usage rate by fuel cell with dynamic subtraction of fuel level from known full point – development of software algorithm and parameters
  - Integrated mechanical, fluid and electrical interface between system and tank
  - Realtime communications between fuel cell system and tank

# Accomplishments – Generator/Desulfurizer

- Preliminary analysis of sulfur impurity limitations of SOFC stack
- Preliminary analysis of sulfur content of various commercial sources of propane
- Preliminary analysis of desulfurizer performance requirements from characterization of various commercial sources of propane fuel
- Preliminary analysis of commercially available components necessary for propane desulfurizer
- Confirmation that all required desulfurizer components are commercially available

# Collaborations

- Jadoo Power System Inc. is the prime contractor
- Jadoo is doing primary development work on the propane fuel interface and will perform final system testing prior to deployment
- Delphi Inc. is a subcontractor with responsibility for the primary development work on the SOFC generator including the desulfurizer, the SOFC power plant and the AC inverter
- NASCAR Media Group will provide key operational resources for the deployment, transportation, operation and testing activities as a subcontractor

# Future Work

| Timing | Activities |
|---|---|
| ***Remainder of 2010*** | • Revise and upgrade Hydrogen Safety Plan<br>• Finalize Application Specifications for Desulfurizer, SOFC Generator, and Propane Interface<br>• Complete the development/test all subsystems and systems<br>• Perform systems integration and final testing to validate performance targets<br>• Make go/no go decision on deployment readiness<br>• Finalize all field test plans, train NASCAR field personnel and arrange logistics for racing season |
| ***2011*** | • Deploy generators in City of Folsom tests<br>• Deploy and stage SOFC generators at first racing event<br>• Transport generators to subsequent events for testing<br>• Consolidate performance data and prepare final reports |

# Summary

- This  project is at an early stage of execution
- Initial technical research on feasibility and specification development has continued to show promise
- Extensive review of NASCAR operations has identified specific equipment suites that would be suitable in terms of power levels, locations and user needs for the application of the SOFC generators
- Interaction with multiple local, state and federal first responder organizations have indicated some common applications that would be well served by a portable fuel cell generator that does not depend on gasoline as a fuel source