Adapting Planar Solid Oxide Fuel Cells for use with Solid Fuel Sources in the Production of Distributed Power

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Program Objectives

- Quantify impacts of synthesis gas composition on performance of a commercial planar solid oxide fuel cell system (cell and stack)
  - H$_2$S content
  - CO/H$_2$ ratio and energy content of gas
  - Particulate
  - Metal content

- Demonstrate long term operation of pSOFCs using actual sold fuel-derived synthesis gas

- Integrate CHP into distributed H$_2$ production
Project Approach

Distributed CHP and Hydrogen

- Develop fuel cell CHP from solid fuels
- Test pSOFCs for tolerance to syngas contaminants using single cell and stack platforms
- Use of CO tolerant pSOFCs allow $H_2/CO$ separation without gas shift reactors
- Integrate CHP into distributed $H_2$ production
Project Approach

Distributed CHP and Hydrogen

- Fuel Feeder
- Gasifier
- Electrostatic Cyclone
- Final Particle Control
- Reaction chamber
- Return from Cyclone
- H$_2$O + O$_2$
- CO/H$_2$ Separation
- CO + H$_2$ to SOFCs
- H$_2$ to automotive fuel

H$_2$ to automotive fuel
Project Approach

Solid Oxide Fuel Cells

Fuel: CO and H₂

\[ \text{CO} + \text{H}_2 + \text{O}_2 \rightarrow 2\text{e}^- + \text{H}_2\text{O} + \text{CO}_2 \]

Useful Power

Air

\[ \text{O}_2 + 4\text{e}^- \rightarrow 2\text{O}^{2-} \]

La-MnO₃ Cathode

Ni-YSCZ Anode

YSZ electrolyte
Technical Barriers and Targets

HFCIT Program Plan

• DOE Technical Barriers for Distributed Generation
  – Improved CO tolerance
  – Develop CHP fuel cell systems
  – Verify integrated stationary fuel cell systems
  – Mitigate technical barriers to stationary fuel cells

• DOE Technical Targets for 2010
  – 40,000 hours durability
  – $1000/kWe
## Budget

### Budget and Expenditures

<table>
<thead>
<tr>
<th>Category</th>
<th>Budget</th>
<th>Expenditures</th>
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</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>$673,269</td>
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<td>Fringe Benefits</td>
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<td>Travel</td>
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<td>Equipment</td>
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<td>Supplies</td>
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<td>Contractual</td>
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<td>Other</td>
<td>$263,165</td>
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<tr>
<td><strong>Total Direct Charges</strong></td>
<td>$1,705,735</td>
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<td><strong>Indirect Charges</strong></td>
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<td><strong>Total</strong></td>
<td><strong>$2,295,570</strong></td>
<td><strong>$629,103</strong></td>
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<table>
<thead>
<tr>
<th>Share Type</th>
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<tbody>
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<td>DOE Share</td>
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<tr>
<td>Cost Share</td>
<td>$368,826</td>
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Project Safety

Hydrogen, Carbon Monoxide and H₂S Concerns

• FMEA Analysis
• Chemical hygiene training
• H₂S training
• Gas containment and scrubber system
• Operational SOP’s
• PSD’s – gas monitors, SKAT packs, room monitors
• Verification gases to test monitors/detectors
• Notification and review with local authorities for the types and quantities of gases used
<table>
<thead>
<tr>
<th>Project Timeline</th>
<th>Completion Dates</th>
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<tbody>
<tr>
<td>1. Modeling syngas/SOFC interface</td>
<td>Aug 03-Dec 04</td>
</tr>
<tr>
<td>2. Fabricate/install syngas system</td>
<td>Sep 03-May 04</td>
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<tr>
<td>3. Fabricate/install cell test stands</td>
<td>Sep 03-May 04</td>
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<tr>
<td>4. SOFC training for interns</td>
<td>Apr 04-Jun 04</td>
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<tr>
<td>5. SOFC material analysis baseline</td>
<td>May 04-Aug 04</td>
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<tr>
<td>6. Synthetic syngas testing</td>
<td>May 04-Dec 05</td>
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<tr>
<td>- 6.1 Baseline syngas</td>
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<td>- 6.2 Effect of Hg</td>
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<td>- 6.3 Effect of sulfur</td>
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<td>- 6.4 Effect of particulate</td>
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<td>- 6.5 Effect of energy content</td>
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<td>- 6.6 Effect of $O_2$ in oxidizer</td>
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<td>7. Electrostatic separation testing</td>
<td>Aug 04-Sep 06</td>
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<td>8. $H_2$:CO separation or shift</td>
<td>Aug 05-Aug 07</td>
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<tr>
<td>9. Integration of fuel cells/gasifier</td>
<td>Jan 06-Aug 07</td>
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</tbody>
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Project Accomplishments

Gas Delivery (including H₂S)
Project Accomplishments

Gas Delivery (including H₂S)
Project Accomplishments

Test Stands
Project Accomplishments

Fuel Cell

- Edge of Manifold
- Discoloration along Crack line
- Markings possibly indicating presence of water
- Crack line
Project Accomplishments

Modeling

- Aspen platform
- Electrochemical model
- Thermal model
- Reforming/Gas Cleaning model
- Flow model
Interactions and Collaborations

Academic and Industrial Partnerships

- SOFCo-EFS (Fuel Cells)
- Case Western Reserve University
- University of Cincinnati
- State of Ohio’s Air Quality Development Authority
- BAARD (Power Generation)
- Enercon (Gasification/Steam Reforming)
Future Work

Near and Long Term Plans

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Near and Long Term Plans

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- Gasifier
- Reaction chamber
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- Final Particle Control
- CO/H₂ Separation
- CO + H₂ to SOFCs
- H₂O + O₂
- H₂ to automotive fuel