• Issues
• Customer requirements
• Technical challenges
• Summary
• Growing rate and changing patterns of power consumption

• Transmission and distribution concerns

• Desire for reduced emissions

• More efficient use of natural resources

• Energy independence

• Use of indigenous fuels
Fuel cell mitigates combustion irreversibility and provides additional output.

Residual energy from stack recovered in GT.

Attractive Efficiency and Emissions – Technical Challenges Remain
Benefits in efficiency across broad power range
## Top Level Customer Requirements

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>Commercial &amp; Industrial</th>
<th>Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost of Electricity</strong></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Capital</strong></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>O&amp;M</strong></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Reliability, Availability</strong></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

Different customers have different needs to address.
Customers Want….

Unaided Mentions of Features and Benefits

- Automatic Operation
- Capacity
- Reliability
- Cost Effective
- Maintenance
- Clean
- Heat
- Response Time
- Noise
- Life Expectancy
- Size
- Other
- Monitoring
- Safety
- Quality
- Legal
- Easy Service
- Compatibility
- Co-Generation

* Out of 55+ respondents
Why will customers buy SOFC and SOFC/hybrid?

Competitive COE Difficult with Small, Simple Cycle SOFC

Large SOFC Hybrids Can Compete on COE

Rely on Complementary Value Propositions

- Reliable Power
- High Quality Power
- Environmental Benefits
- Cogeneration Opportunities
- Portable Power

- Competitive in some applications at $600 - $800/kW
- Potentially disruptive at lower price
- Potential for use with gasified coal

Early strategy must focus on customers with compelling needs.
## Key Technical Challenges

<table>
<thead>
<tr>
<th>Challenge</th>
<th>SECA &amp; Simple Cycle</th>
<th>SOFC/Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Cost Manufacturing</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Cell Life</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Cell &amp; Stack Power Density</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Stack and System Thermal Management</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Power Conditioning</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Controls</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Fuel Processing</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Scale-Up</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Hybrid Systems Design &amp; Integration</td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>
Summary - SOFC & SOFC Hybrid

- Potential to be disruptive in power generation industry

- Support National Energy Policy goals
  - Efficiency
  - Multi-fuel, including coal
  - Complementary to hydrogen economy

- Significant risks
  - Cost-challenged