**Use Of High Temperature Electrochemical Cells For Co-Generation Of Chemicals And Electricity**

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**Approach**
- Direct-Methane Solid Oxide Fuel Cells (SOFCs) for:
  - Electricity generation and
  - Production of syngas (H₂+CO) or other chemicals

**Motivation**
- Increase value of SOFC stacks via sale of both electricity and chemical products
- Improve prospects for commercialization
- Achieve highly efficient utilization of natural gas
- Reduce cost of syngas produced from natural gas
- Cost of hydrogen (from syngas) too high compared with DoE targets ($2.50/kg, equivalent to 1 gallon gasoline)
- Reduce cost of liquid fuels derived from syngas (methanol, synthetic diesel)

**Other Advantages**
- No dilution of syngas by nitrogen, as in air partial oxidation
- Avoids explosive methane-air mixtures as in partial oxidation reformers
- More appropriate H₂/CO ratio (≈2) for Fischer-Tropsch synthesis than steam reforming

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**Project Objectives**
- Demonstrate EPOx in high-performance SOFCs
- Evaluate conditions and geometries that yield stable direct methane operation
- Demonstrate stable direct-methane operation
- Evaluate conditions for thermally self-sustained operation
- Extend from methane to natural gas

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**Electrochemical Partial Oxidation (EPOx)**
- Desired reaction is partial oxidation:
  \[ \text{CH}_4 + O^2- + H^+ \rightarrow CO + H_2 + 2e^- \]
- Adjust CH₄ flow rate such that O²⁻/CH₄ ~ 1
- 3-4 times that in a direct-methane SOFC, where the aim is to produce electricity by completely oxidizing methane:
  \[ \text{CH}_4 + O^2- + H^+ \rightarrow CO + H_2 + 2e^- (\approx 22,000 \text{ J} / \text{ mol}) \]
- Predicted equilibrium products versus O²⁻/CH₄

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**Conclusions**
- Methane-fueled SOFCs operated under appropriate conditions produce both syngas and electricity
- Coking can be suppressed by using barrier layers
- SOFCs operated at T=750 °C, V=0.4V, and O²⁻/CH₄=1.2:
  - High electrical power output (~0.7 W cm⁻²)
  - High syngas production rates (~20 sccm cm⁻²)
  - Thermally self-sustaining conditions
- Can produce syngas/hydrogen at lower cost than other methods
- Due to the value of the electricity produced
- Sale of both electricity and syngas increases the value of the fuel cell
- Important because fuel cell cost is a key barrier to commercialization

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