Challenges for Solid Oxide Fuel Cells in the Future Energy System

Presented to the
Solid State Energy Conversion Alliance
Second Annual Conference
March 29, 2001
Arlington, Virginia

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Competitive Cost Positioning for Alternative Power Concepts

Delivered Cost of Power ($/kWh)

Increasing Market Penetration Potential

$0.0000 $0.0200 $0.0400 $0.0600 $0.0800 $0.1000 $0.1200 $0.1400

Capital Cost ($/kW)

0 500 1000 1500 2000 2500

PEM

Advanced Fuel Processing

SOFC

Baseline Load

Gas Turbine/Combined Cycle

Coal/Steam

Mid Range

1-10 MW Gas Turbine

Peaking

20-100 kW Microturbine

SECA target

20-100 kW Microturbine

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U.S. Department of Energy
Pacific Northwest National Laboratory
"We're facing, incredibly, another energy crisis!"

Rep. Billy Tauzin, Chairman, House Energy and Commerce Committee

Energy Crisis

- Inadequate Generation Investment
- Rapid Demand Growth
- Gas & Hydro Shortage
- Blocked Market Signals
- Command Based Regulatory Policy

Inadequate Transmission Investment

U.S. Department of Energy
Pacific Northwest National Laboratory
Efficiencies from markets are **not automatic**...

- FERC Report on Market Power (11/00)
- Price caps in the New England and California markets
- Immaturity of retail markets in all states
- Failures among retail marketers and e-commerce sites
- Lack of effective market signals and transparency
- Lack of consumer response options
- Lack of market based incentives for higher efficiency, cleaner energy conversion sources
- Bottlenecks in distribution resulting in imbalanced availability
- Incentives drive inefficiencies: focus on “islands of standby power” rather than overall power system reliability
Open Energy Markets: In Theory...
Increased Access and Competition Will Improve Efficiency,
Reduce Overall Costs and Incentivize Investment

Future Grid Systems

- Gas Industry Deregulation
- Open Access Transmission
- Open Markets
- Wholesale Power Competition
- Retail Power Deregulation

- Demand reactive
- Remote dispatch
- Interactive communication
The current energy system has inherent limitations that impede distributed generation.
The Future Energy System Will Evolve to Facilitate Open Markets ...
This new energy system embodies the features of a robust, reliable and efficient energy supply.

**CURRENT**
- Blackouts used to manage market and component failures
- Centralized, top-down control and planning is required
- Unidirectional control frustrates consumer responses and deployment of new technology
- Lack of resiliency can result in cascading system failure
- Layered and serial processes frustrate coordination and real-time responsiveness
- Top-down solutions, with regulatory checks, results in either over- or under-building
- Current system is not environmentally optimized
- Retards market based, efficient system solutions

**FUTURE**
- Stable, reliable, predictable, controllable, manageable, fails gracefully, quality power
- Fuel flexible, resilient, demand responsive, decentralized (markets, generation, control, etc.)
- Expands and contract with markets, distributed vs. central power, absorbs new technologies/markets/market instruments
- Withstands natural and deliberate threats to infrastructure
- Auditable, builds links between markets and institutions, dynamic system optimization, holistic
- 2nd law efficient, promotes and rewards efficiency, faster, easier to manage and maintain
- Environmentally friendly, incorporates externalities, responds to environmental dispatch
- Higher asset utilization, lower first cost, lower lifecycle cost
- Compatible with existing system, can evolve over time to new paradigm
Demands of the New Energy System on SECA Products

While application specific, typical applications will require:

- Interactive control and telecommunication systems:
  - Dispatch controllers
  - Transaction-based controls
  - Plug and play controls
- Multiple power outputs (AC, DC Mixed)
- Waste heat utilization (CHP)
- Broad range turn down capability
- Remote monitoring, diagnosis and prognosis
Reducing Demand: Commercial AC/DC Building Bus

- **Scenario**---Office bldg. with grid-connected fuel cell; 1 W/ft² DC-plug loads (computers, printers), 2 W/ft² fluorescent light ballasts @ 108V 20kHz AC
- **Currently**---expensive, 90% eff. synchronous inverter; 50% eff. DC converters; 90% eff. ballasts
- **Future**---Multiple power outputs provides DC at several voltages, frequencies; direct conversion for lights saves 15%; DC used directly saves 50%; downsized fuel cell & inverter; ballasts and DC converters eliminated
- **Opportunities**---integrated system design (supply, distribution, end-use); conversion technologies; appliances; fuel cell balance-of-plant
Taking advantage of the “Spark Gap”:
Remotely Dispatched, Fuel Cell Load Balancing

- Electric Distribution Company
- Gas Distribution Company
- 3rd Party Combination Equipment Owner/Power Marketer

- Load shifting
- Voltage support
- Other services
- Load shifting
- Storage

Signals to Equipment

Remote Dispatch

Payments for power services

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Crosscutting Science & Technology
R&D Areas

- Complex, adaptive systems theory & applications
- Genetic (and other adaptation) algorithms applied to markets, regulations, controls
- Network topologies and stability
- Control theory for large-scale, dispersed, hierarchical networks
- Simulation of massive, complex, coupled economic/engineering hierarchical networks
- Microtechnology applications in sensors, controls, equipment
Solid State Energy Conversion Alliance

LUNCH!