Progress in Acumentrics' Fuel Cell Program

August 7, 2007

Outline

- Overview
- Cell Technology
- Process Developments
- Generator Developments
- Coal Systems
- SECA Phase I Machine Performance
- Summary

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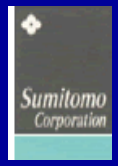
Acumentrics Corporation

Strategic Partners



GENERAL DYNAMICS
Strength on Your Side™

ChevronTexaco
Technology Ventures

Connecticut Innovations, Inc

Morgan Stanley

- *~ 80 Employees*
- *Manufacturing since 1994*
- *Based in Westwood, Mass.*
- *~40,000 sq. ft facility*
- *Profitable for the past 24 months*
- *Critical disciplines in-house*
  - Electrical Engineering
  - Mechanical Engineering
  - Chemical Engineering
  - Thermal Modeling
  - Ceramics Processing
  - Manufacturing
  - Sales & Marketing
  - Automation
  - Finance

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Acumentrics *Battery based UPS*

Uninterruptible Power Supplies for Harsh Environments

Industrial-UPS®
Commercial

Rugged-UPS®
Military

Features:

- Sealed electronics
- Able to withstand vibration
- Unity power factor input
- Wide input 80VAC - 265VAC
- Isolated 120 / 240VAC output
- Hot swap battery case
- Parallelable to 20 kWatts

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Field Demonstrations

- Operable on propane and natural gas
- Grid-tie and grid independent operation
- Cogeneration capable, transportable
- Operating for over 4900 hours line NG
- Over 18,000 hrs on latest 5 machines

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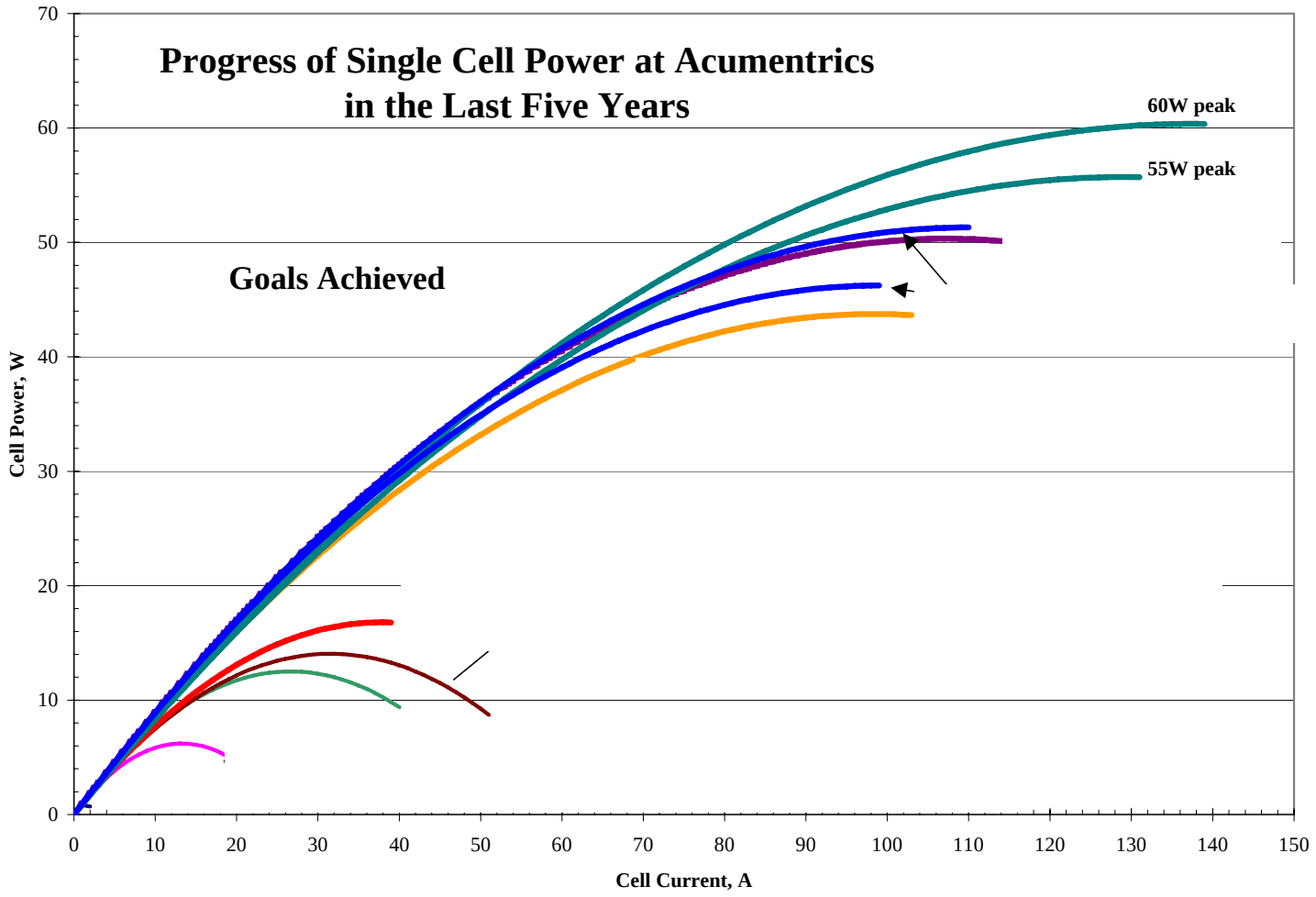
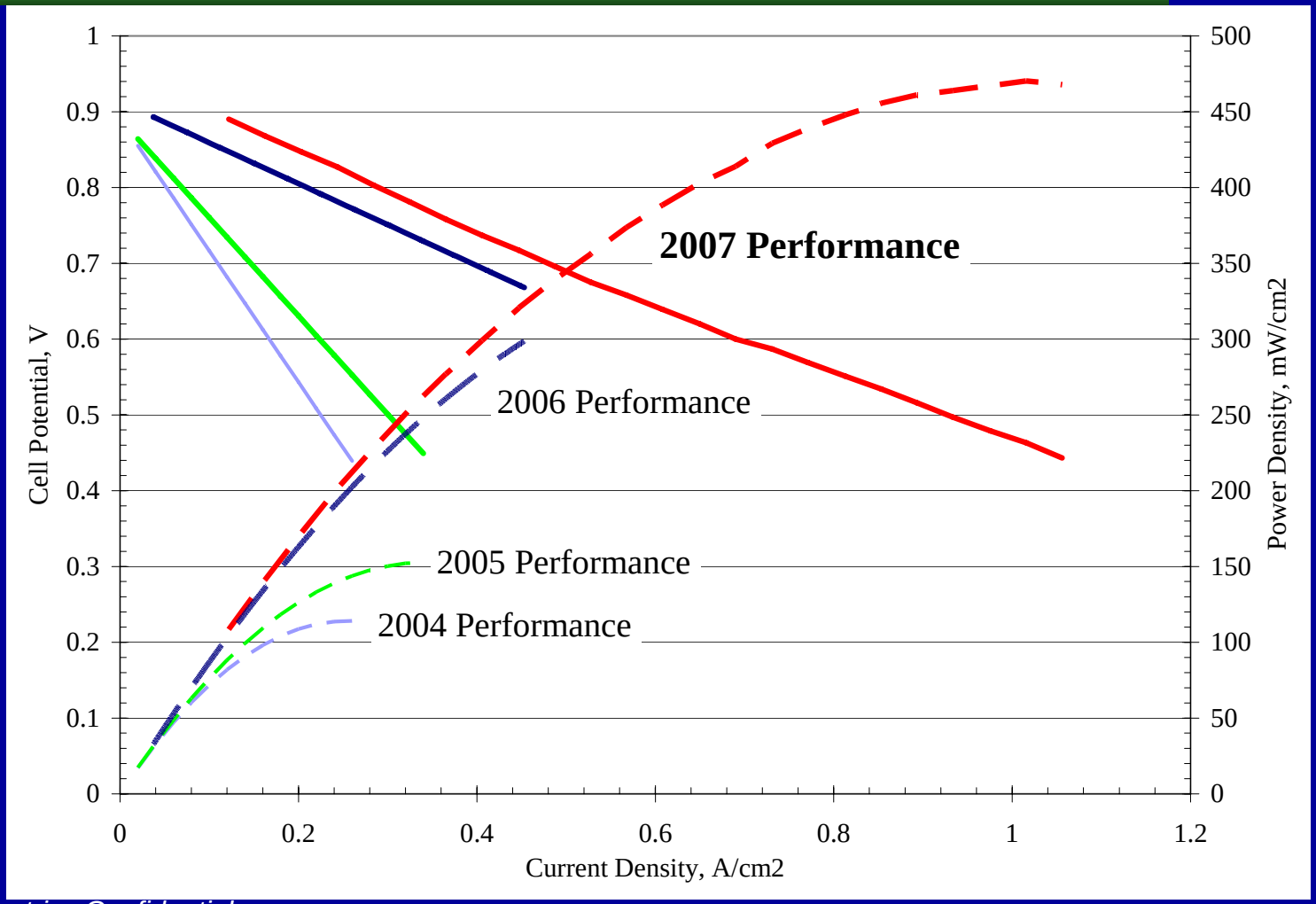
SECA Product Objectives

- Culminate in a 5-10kW modular stack capable of meeting a number of market requirements.
- Widen our fuel choices.
- Build upon our knowledge of “ruggedized” products for harsh environments.
- Allow for modular build up to the 100kW class size.
- Allow for integration with military towable power units in the 5-20kW size.

Acumentrics Progress



Performance Comparison



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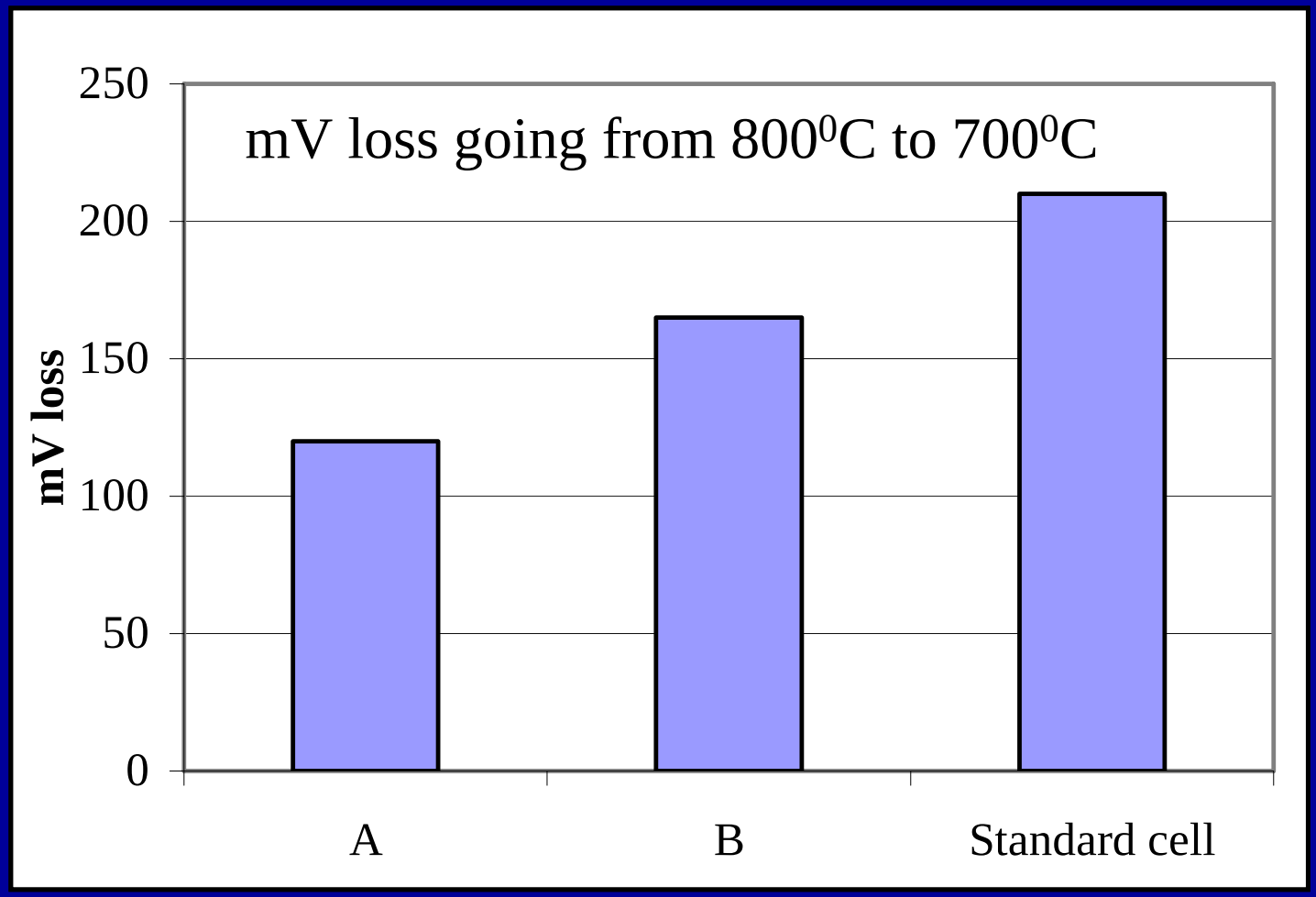
Cell Performance with Doping



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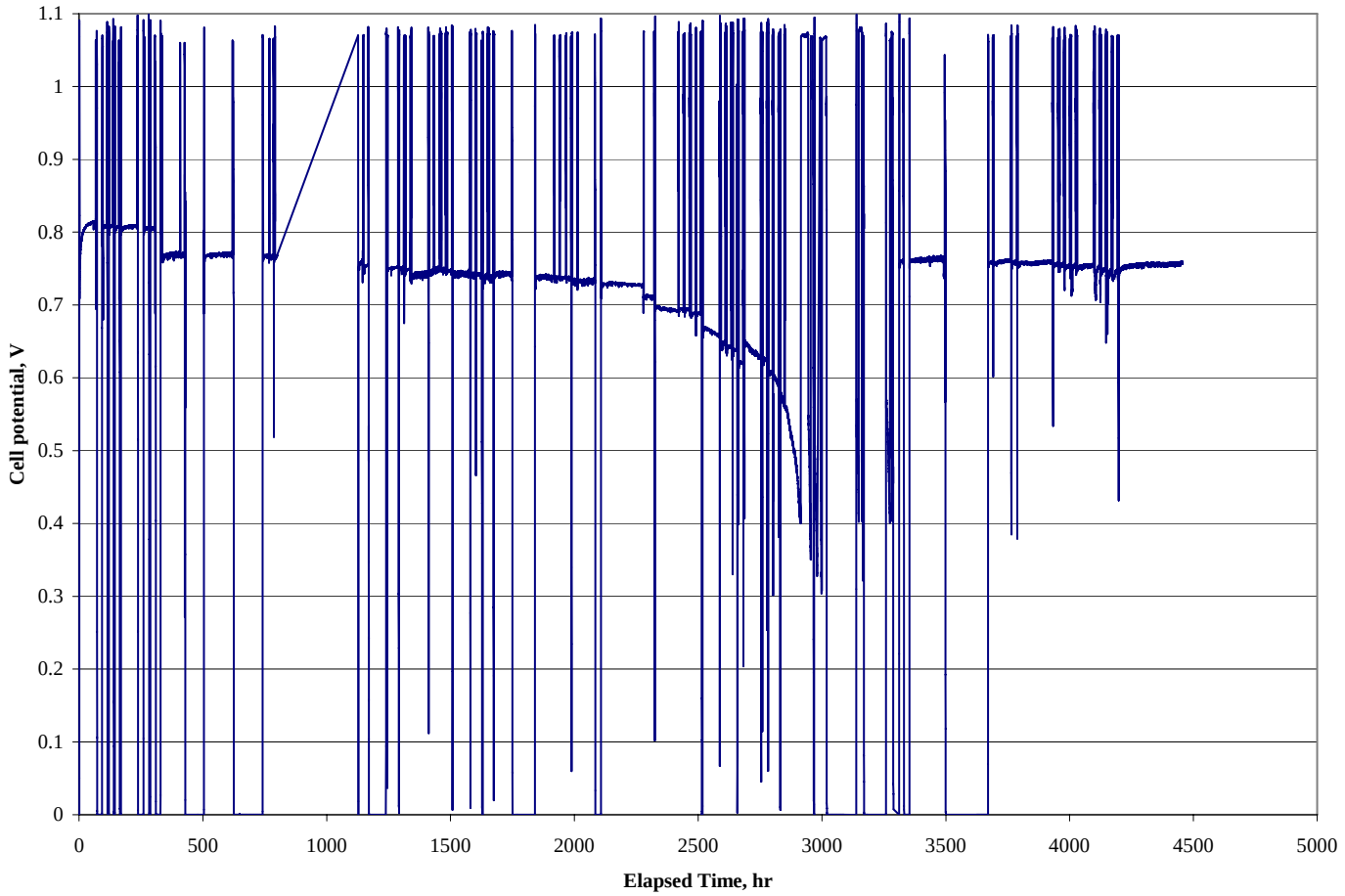
Thermal cycling of cells



- 101 Thermal Cycles
- -0.78%/1000hr overall degradation
- Consistent OCP through test
- 3073 hours operation
- Cycling continues

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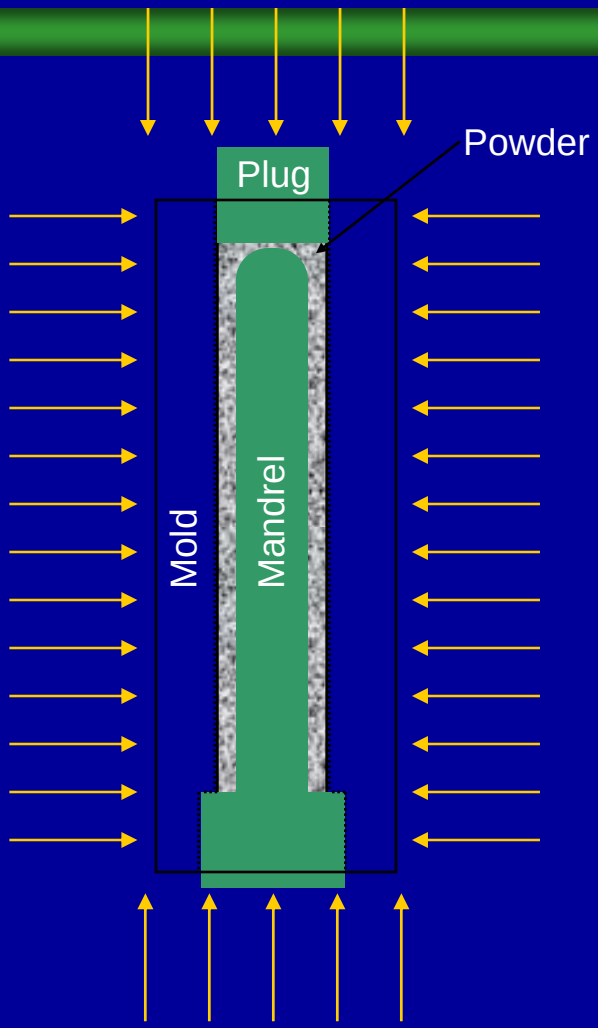
Fabrication Process Developments



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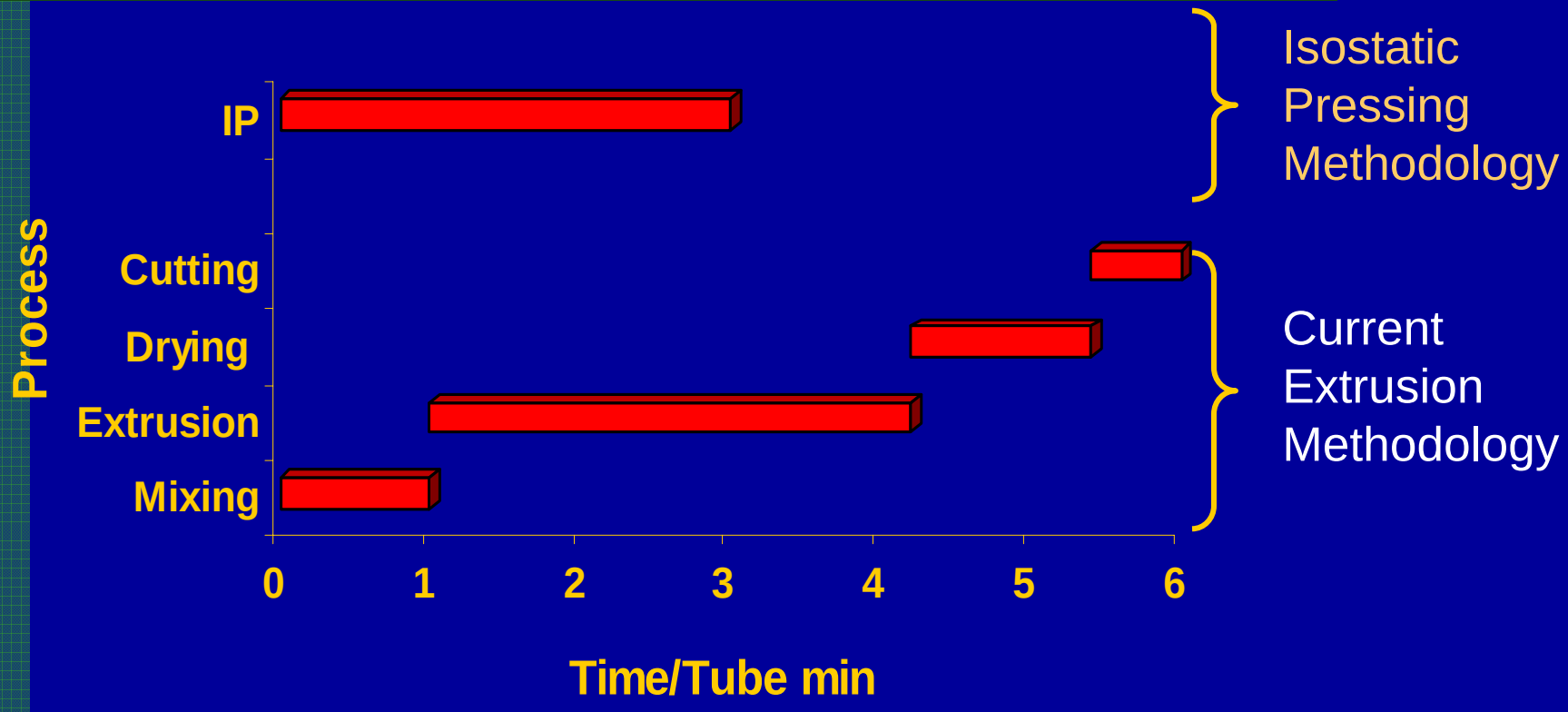
Isopressing Tube for 100kW+ Systems



Total Extrusion Time – 6 min/tube

Total IP Time – 3 min/tube

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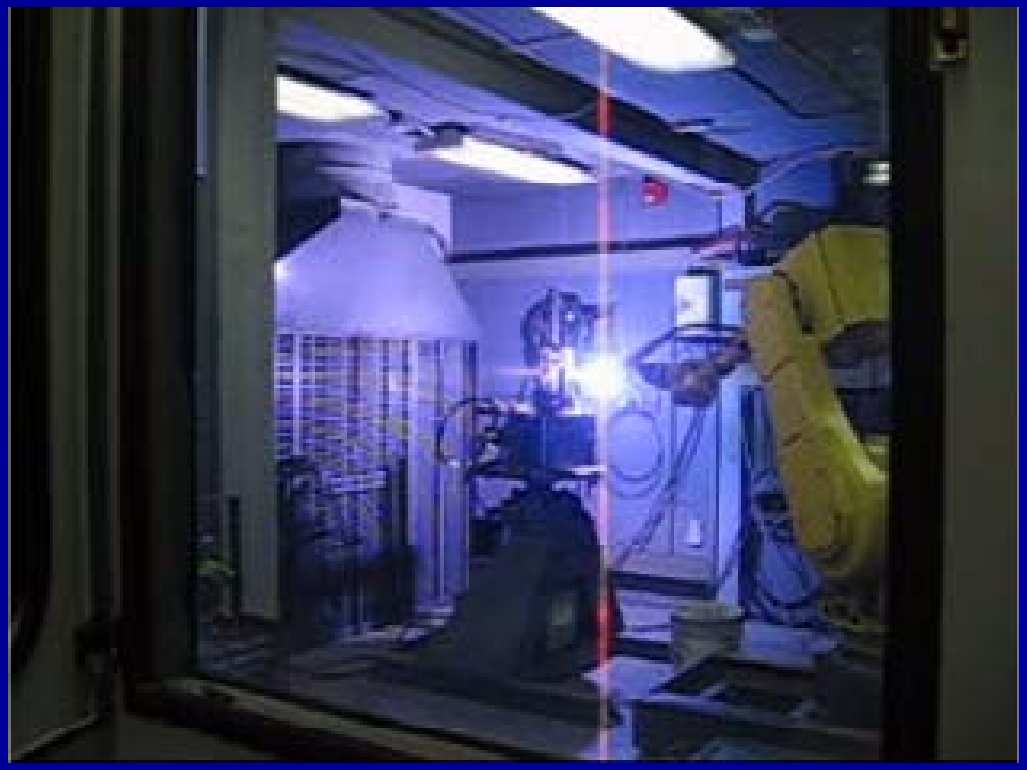
Plasma Spray Automation



Decreased cost due to automated processing

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Recuperator Development

- Phase II SBIR awarded July 2007 to further investigate Hybrid Solutions
- Full scale metallic and ceramic recuperators tested
- Metallic units are quite effective (82-90%) but oxidation resistance and life are a concern
- Ceramic units have been proven to survive but the effectiveness has been lower (65-75%) than metallic units
- 80+ Effectiveness required

Hybrid Recuperator Advantages

Metallic

Advantages

- Manufacturability
- Extended Surface
- Compactness
- Thermal Shock

Disadvantages

- High Cost
- Fouling/Oxidation

Ceramic

Advantages

- Low Cost Materials
- High Temp Stability
- Single Casting

Disadvantages

- Thermal Shock

Hybrid

Advantages

- Low Cost Materials Throughout
- Modular Manufacture
- Temperature Gradients on Ceramic are Reduced
- Materials Optimized for Temperature
- Thermal Expansion Unrestrained

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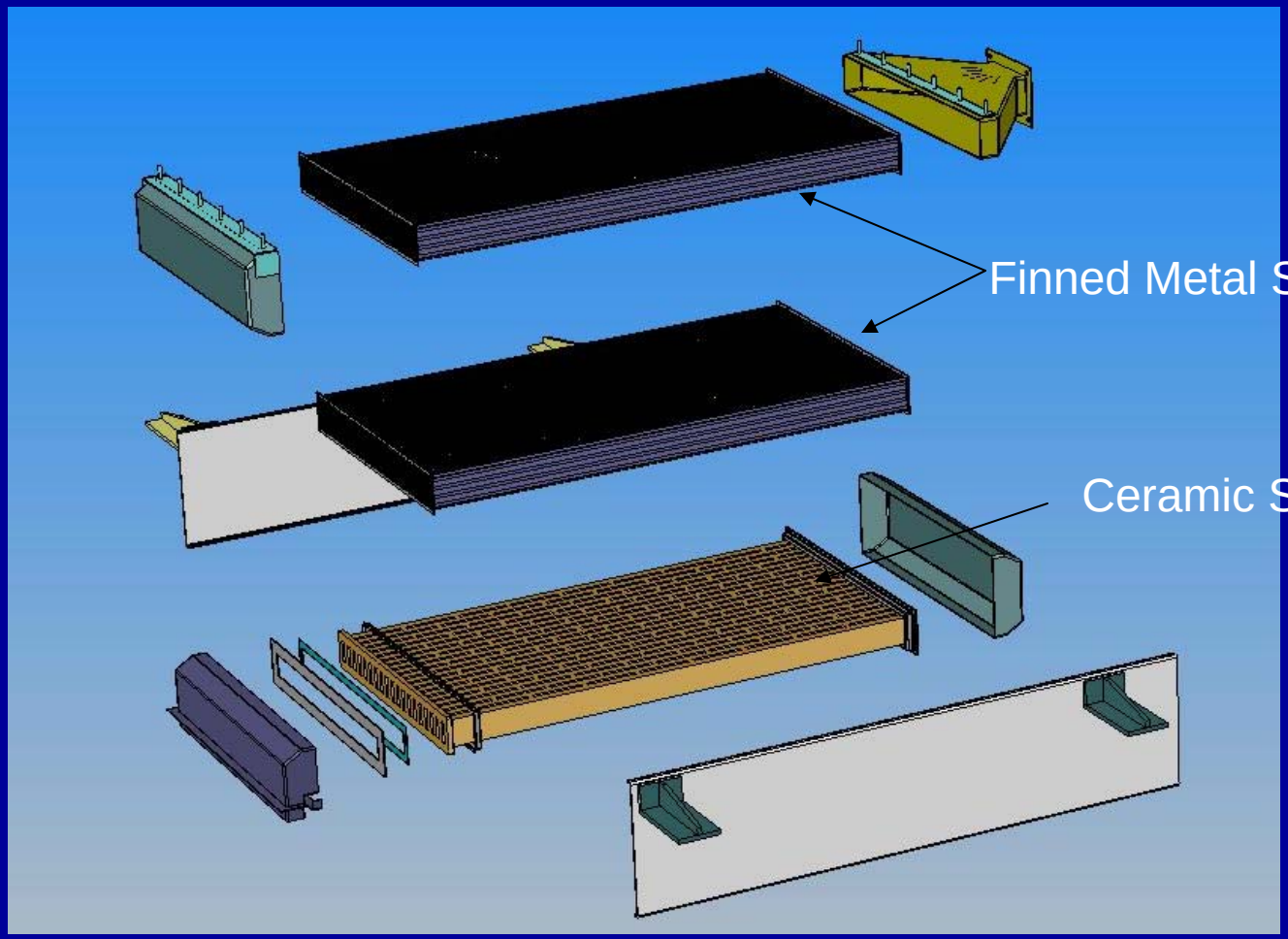
Hybrid Recuperator



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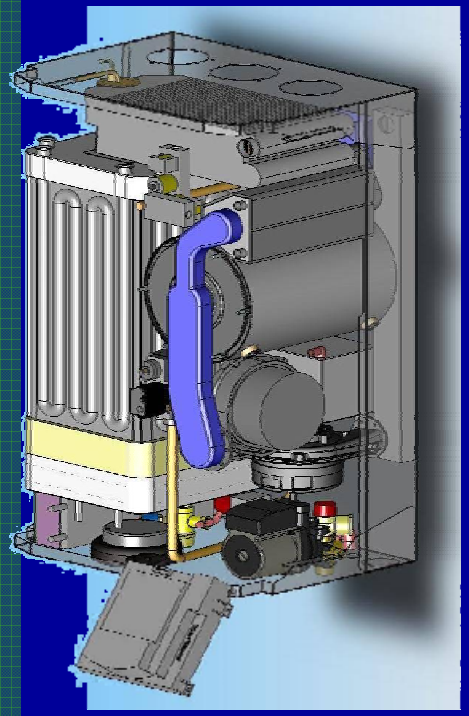
1kW Home CHP Appliance



- First Prototype
- Fully operational:
  - 1kW electric
  - 25kW (85k BTU/hr) Thermal
  - 75-90% total Eff.
  - 33”x22”x18”
  - ~180 lbs total
  - ~100lbs thermal system

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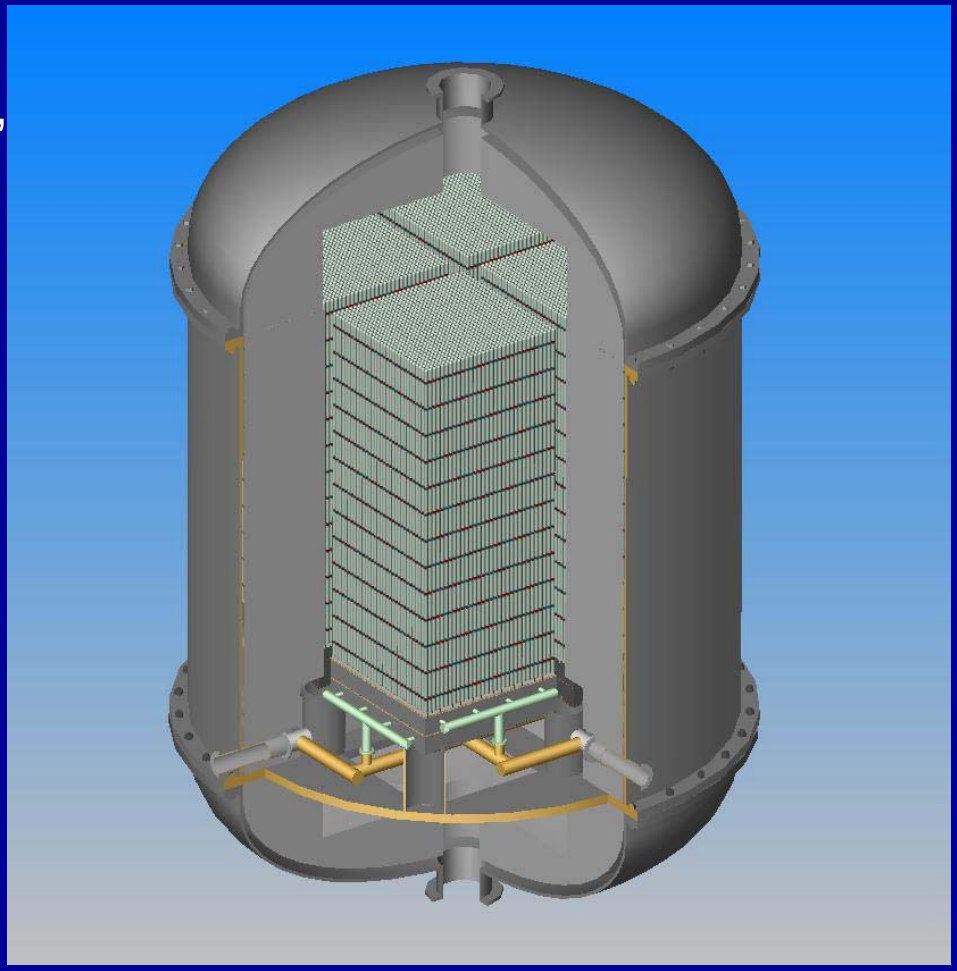
1 MW SOFC Module

- Four bundles per vessel, 1 MW each
- Pressurized
- 2 meter long tubes
- 13 Interconnects



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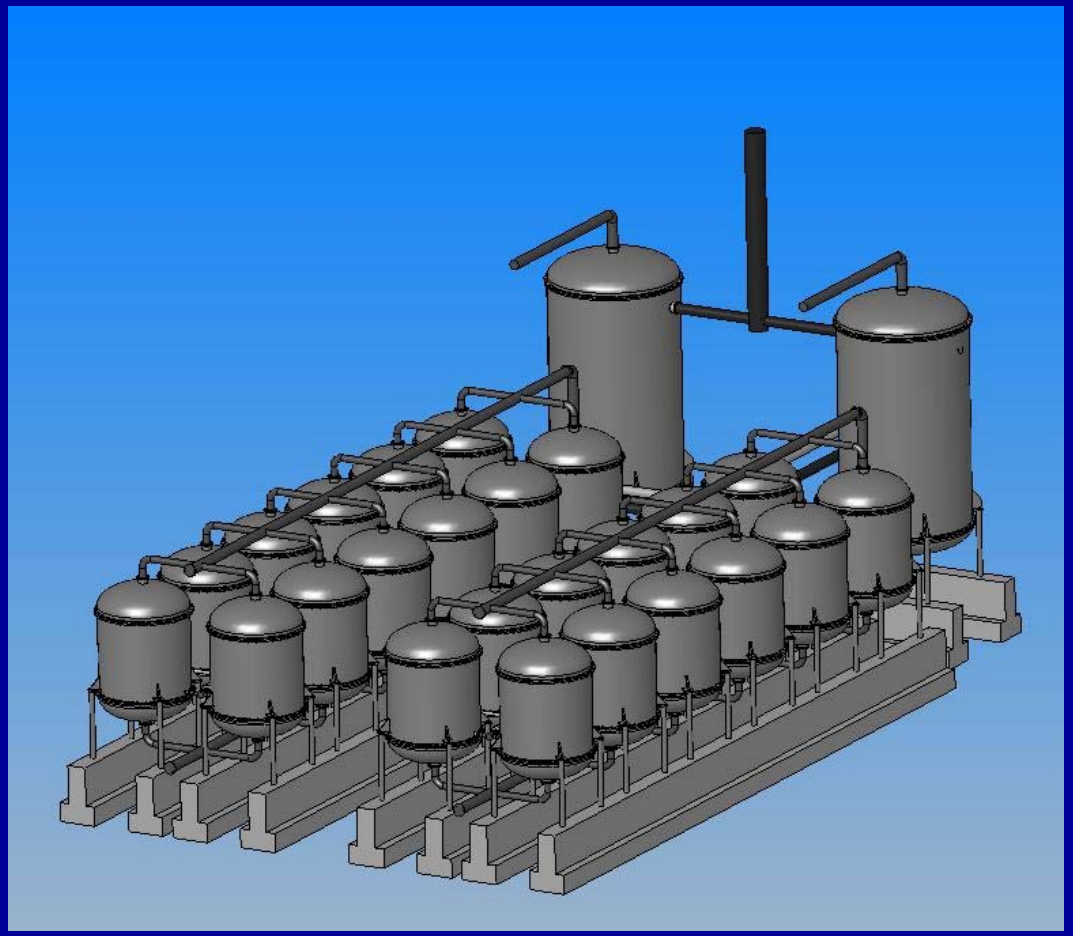
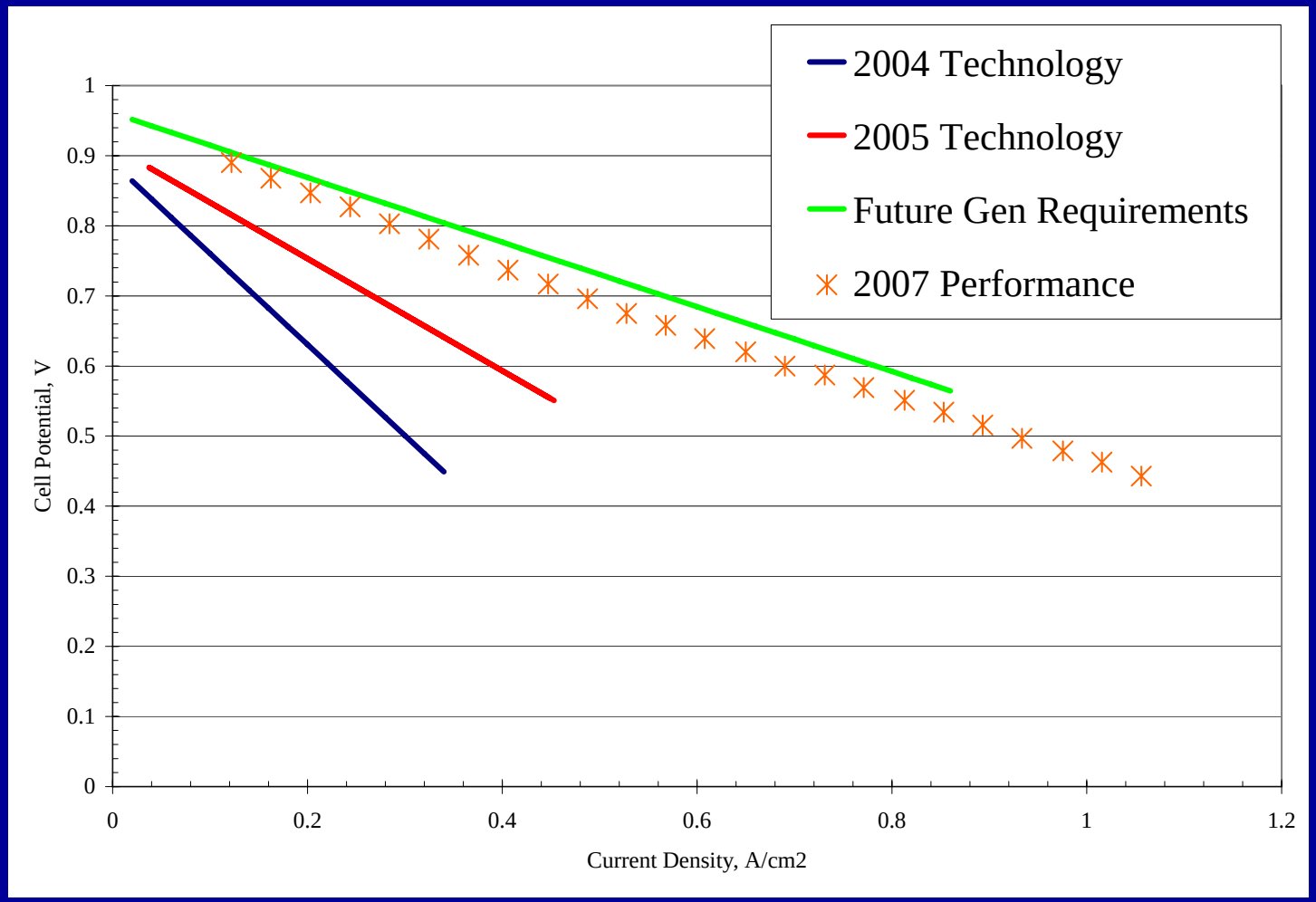
100MW Coal Fueled SOFC Plant

- Multiple vessels
- Two heat exchangers



Future Gen Fuel Cell



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Stack Testing: Recirculated Steam

- Operation condition on July 30
- SECA stack technology utilizing 800C recirculation blower
- Operation time: total about 890 hrs
- Electric power:
  - DC 8.8kW
  - AC 7.1kW
- Electric Efficiency
  - 52% DC LHV
  - 43% AC LHV
- Overall efficiency: 84%LHV (70deg-C hot water)

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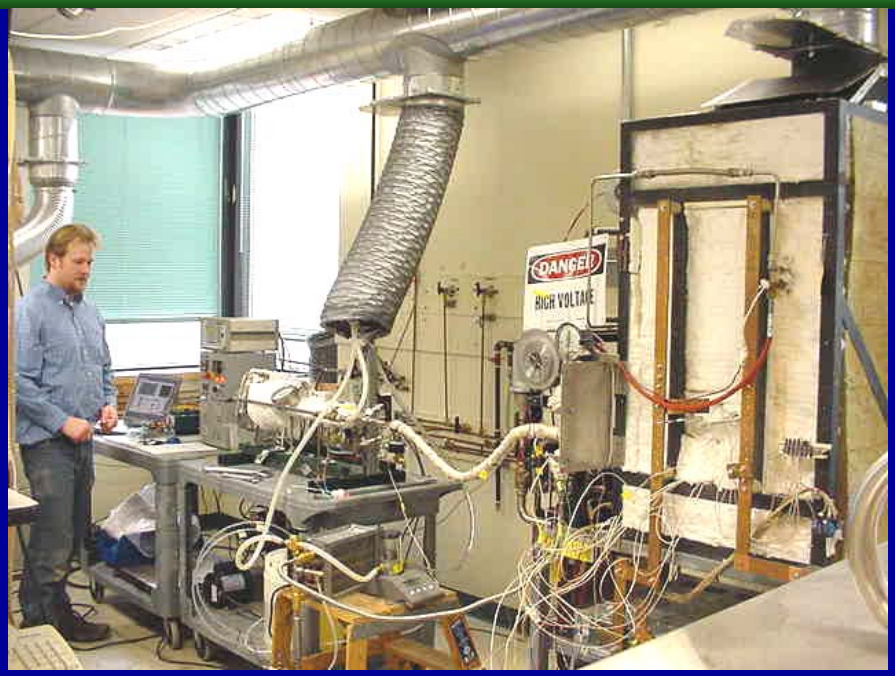
Testing on JP-8



- 5.5hr total testing
- Reformer startup (cold to operating) <10min
- Fully stable reformer operation in 20min

- Load following within 30 seconds (manual)
- Should be faster when integrated
- S/C<=1; low water requirements

- One day test
- Achieved 27% efficiency
- At higher FU, expect to hit ~31%

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SECA Performance Results

	Goal set by SECA	Acumentrics Phase I Generator	NETL Testing
Peak Power DC	3-10kW	6.1kW	6.2kWDC (NETL)
Degradation Rate %/500hr	≤2%/500hr	-0.00035% /500hr	-1.5%/500hr
Peak Efficiency %	35%-55%	36.9%	>35%
Availability %	>80%	97.5%	96% (including startup, testing, thermal cycles, and grid failures)
Transient Power Degradation %	<1%	0.75%	Not measurable
Cost $/kW	<$800/kW	$729/kW	

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NETL Testing Summary

- 890hrs total testing
- 2172 kW-hr produced, 6.2kWDC(net) peak power, ten power cycles, four efficiency points
- 856 hr >1500W net DC
- 3 thermal cycles (one deep)
- 96% availability (including all testing, startup, and grid failures)

SECA generator operation

- 4694 hrs operation (as of July 30, 2007)
- 11,402kW-hr produced
- 10 Thermal cycles
- 20 power cycles
- Degradation not measurable
- 6.2kWnetDC peak

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Summary

- Moved into Phase II based on successful completion of Phase I goals
- Tripled Power Density over Program Start
- Minimized Degradation (including thermal cycles)
- Significantly Advanced and Simplified Design
- Reduced Cost & Weight and Improved System Density
- Significant progress toward coal-based gas compositions and larger cells and systems

Acknowledgement

Strategic Alliance Partners

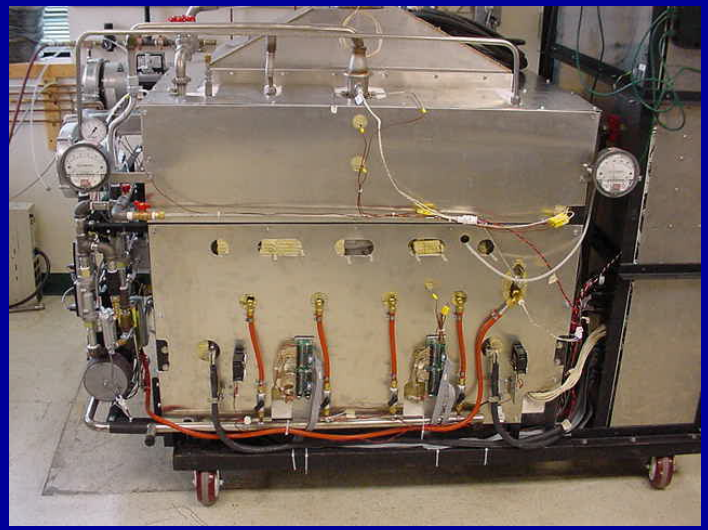
National Park Service

UAF CERL EPRI

Propane Energy Research Council

Department of Energy-National Energy Technology Laboratory

Heather Quedenfeld, Project Manager



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