SECA Coal-Based System Program

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SECA Coal Based System Program

- Completed SECA SOFC Program Phase I September 2005 and started SECA Phase II
- Initiated SOFC Coal Based Power Systems Program September 2006
- Combined the two programs into the program “SECA Coal based System”

SECA Coal Based System Program - Overview

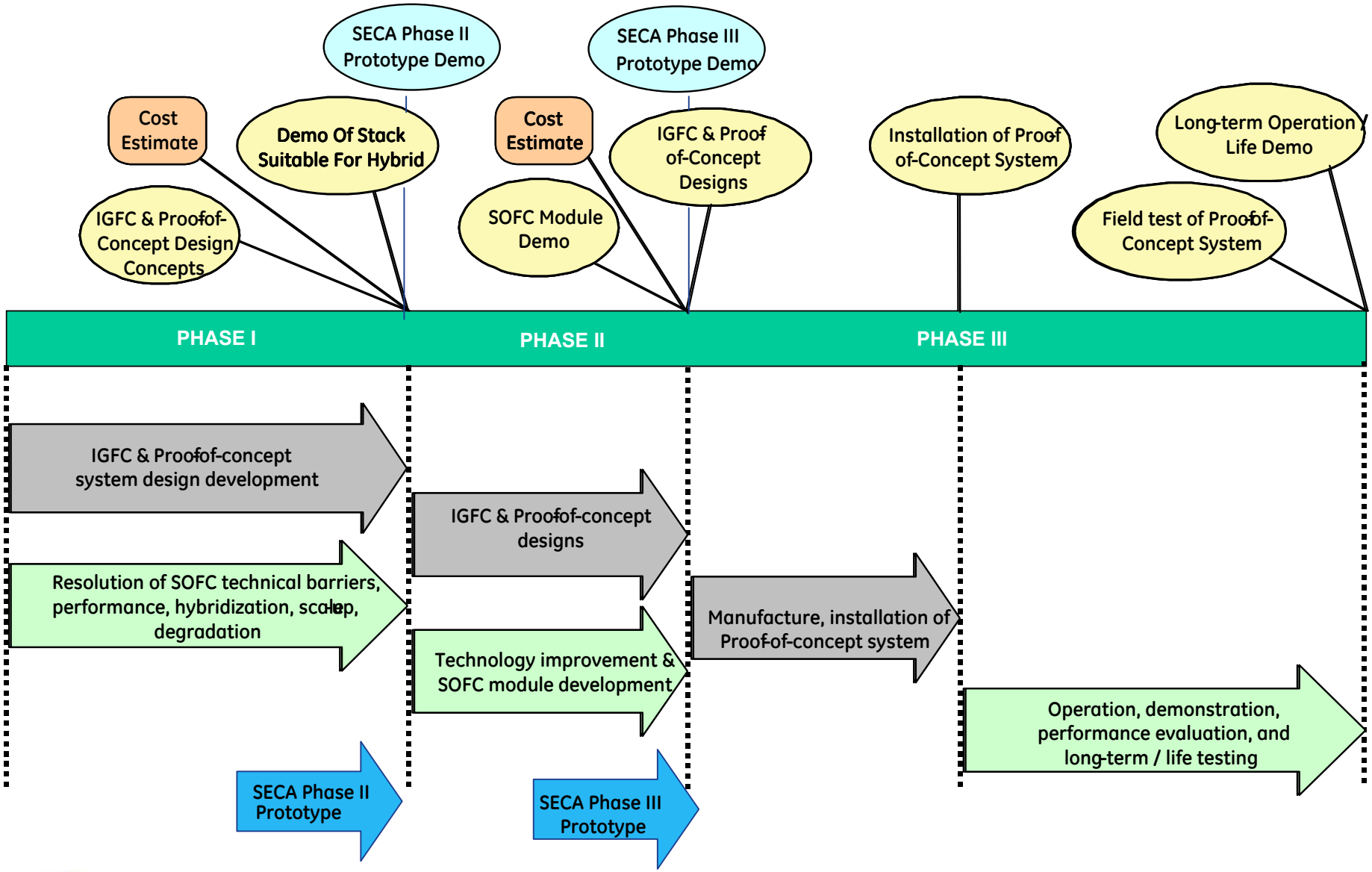
Program Summary

***Period of Performance*:**	Phase I: 2.75 years (1/2006 - 9/2008) Phase II: 2 years Phase III: 5 years
***GE Team*:**	GE - GE Global Research and GE Energy University of South Carolina Pacific Northwest National Laboratory

Program Objective

- Resolve identified barrier issues concerning SOFC technology and demonstrate SECA prototype systems and a SOFC building block stack for multi-MW system applications
- Develop and optimize a design of a large-scale (>100 MW) integrated gasification fuel cell (IGFC) power plant incorporating a SOFC and a gas turbine (GT) in a hybrid system that will produce electrical power from coal. The system will be:
  - Highly efficient (>50% HHV),
  - Environmentally friendly (90% CO_2 separation), and
  - Cost-effective ($400/kW projected factory cost, exclusive of coal gasification and CO_2 separation subsystems).
- Design, manufacture and test a proof-of-concept (POC) system derived from the IGFC design that demonstrates operation with the required performance characteristics.

Program Features



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Presentation Outline

- SECA prototype demonstration
- SOFC stack technology
- System concept development

Prototype Demonstration - Highlights

PERFORMANCE PARAMETER	REQUIREMENTS	RESULTS
DC Efficiency	35%	41%
DC Peak Power	3-10 kW	5.4 kW
Steady State Degradation	<2% per 500 hrs	1.8% per 500 hrs
Thermal cycle	1	3
Power Cycle	9	15
Availability	80%	90%
Test Time	1500 hrs	1720 hrs

HIGHLIGHTS

- 2005: Demonstrated a SECA prototype system that met/exceeded key DOE minimum requirements
  - 41% peak efficiency
  - 5.4 kW peak power, ATR fuel
  - Projected mfg cost < $800/kW
  - System tested ~1700h at GE
- 2006: Prototype system – 75% reduction in system volume
  - 49% peak efficiency
  - 5.6 kW peak power, ATR fuel
  - ATR fuel
  - Projected mfg cost < $600/kW
  - System to be tested at NETL

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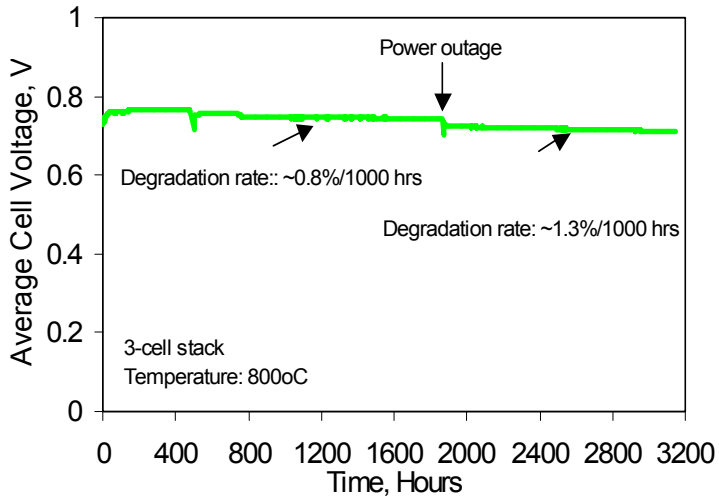
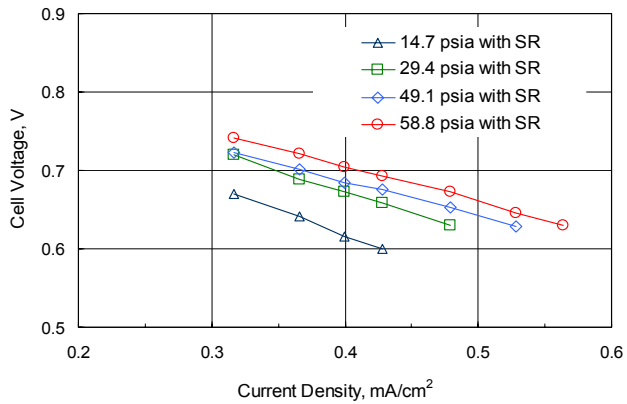
Stack Technology - Highlights

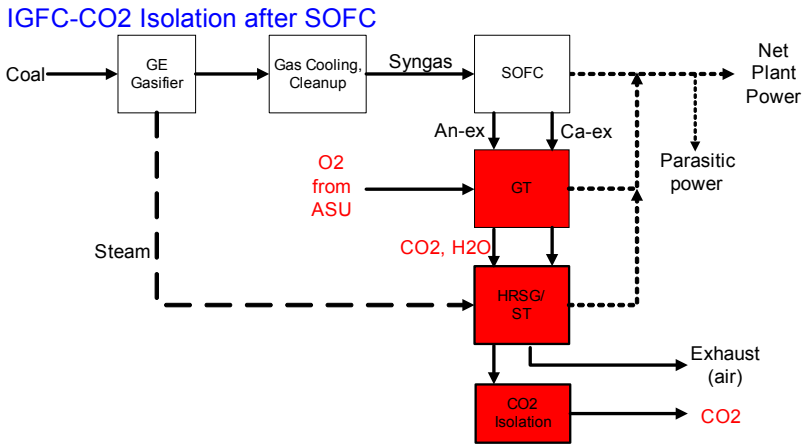


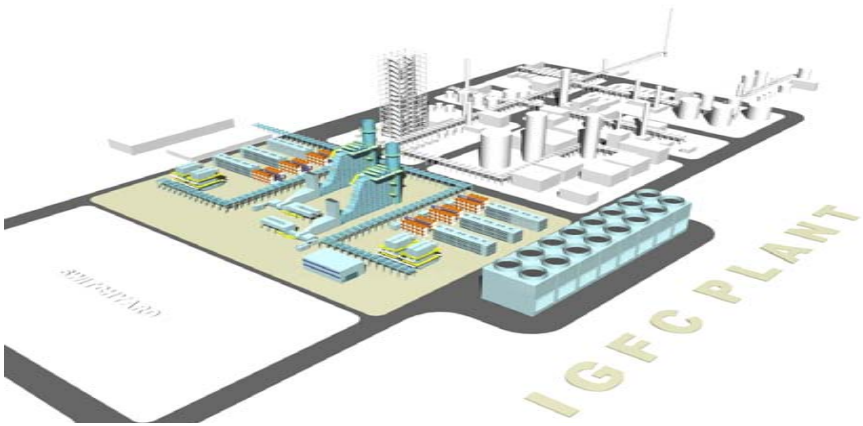


HIGHLIGHTS

- Single cell performance improvement and cell size scaleup demonstration
- Performance degradation rate 1.0-1.5%/1000 hours
- Multicell stack demonstration (height and footprint area)
- Stack operation under pressures

System Concepts -Highlights



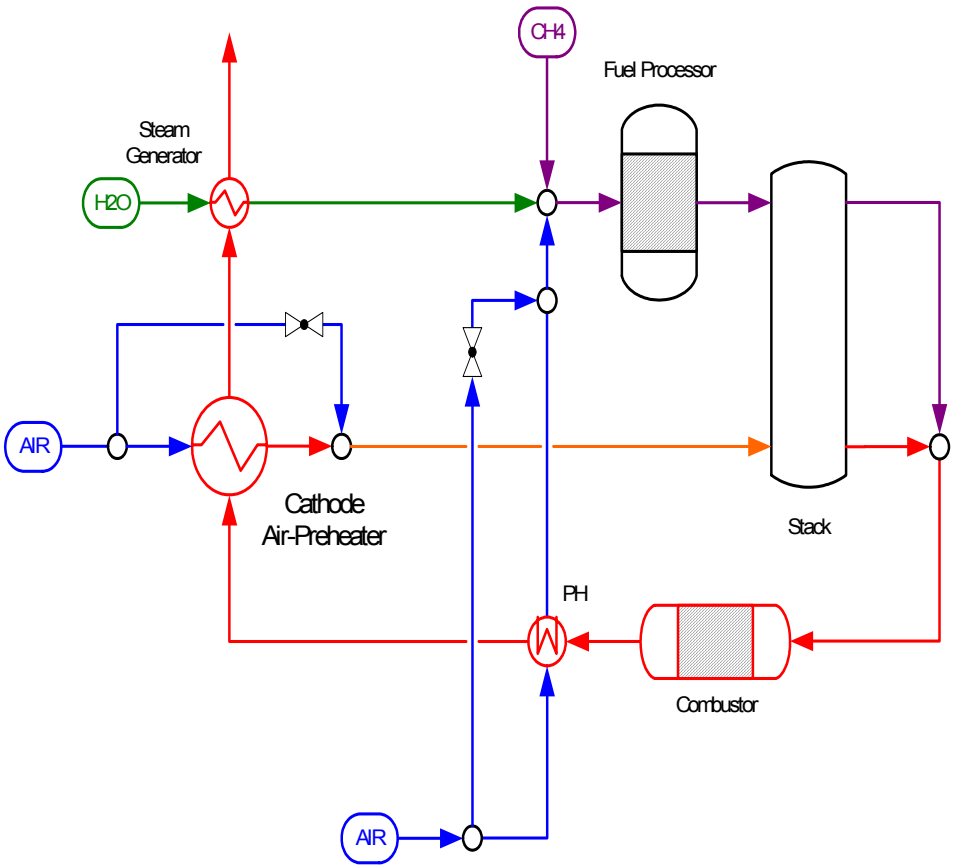


HIGHLIGHTS

- SOFC/GT hybrid systems
- IGFC concepts incorporating SOFC/GT hybrid
- IGFC system concepts
  - 500+MW
  - >50% efficiency (HHV)
  - 90% CO_2 separation

SECA Prototype Demonstration

SECA Prototype System Schematic



- Design features
  - Self contained unit
  - Anode supported planar SOFC, 4 stacks with 150 cm^2 active area cells
  - Autothermal reforming (ATR) fuel processor
- Operation features
  - Thermally self sustaining
  - Methane operation
  - Internal reforming

Prototype System

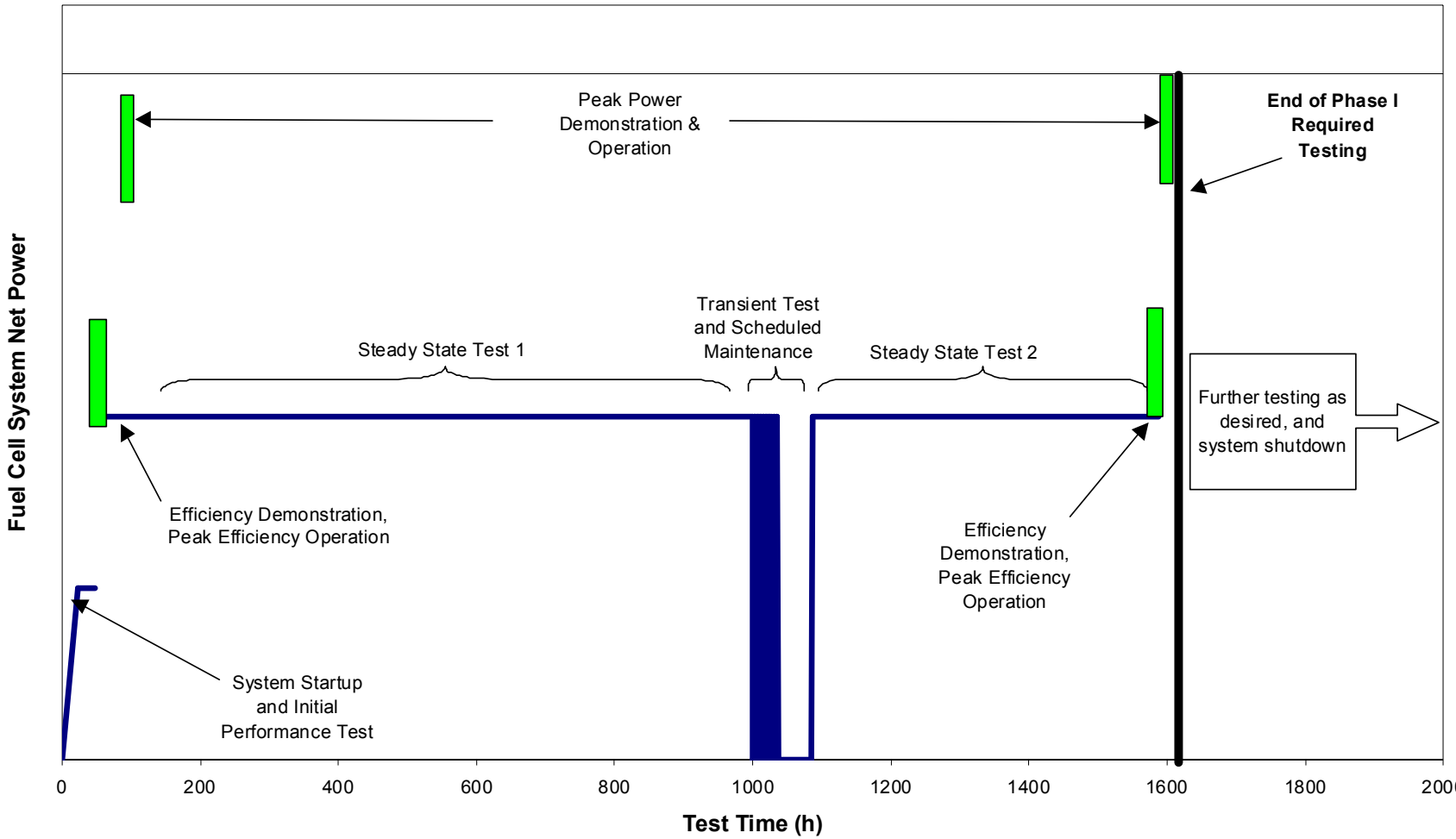
SOFC STACK

ATR FUEL PROCESSOR

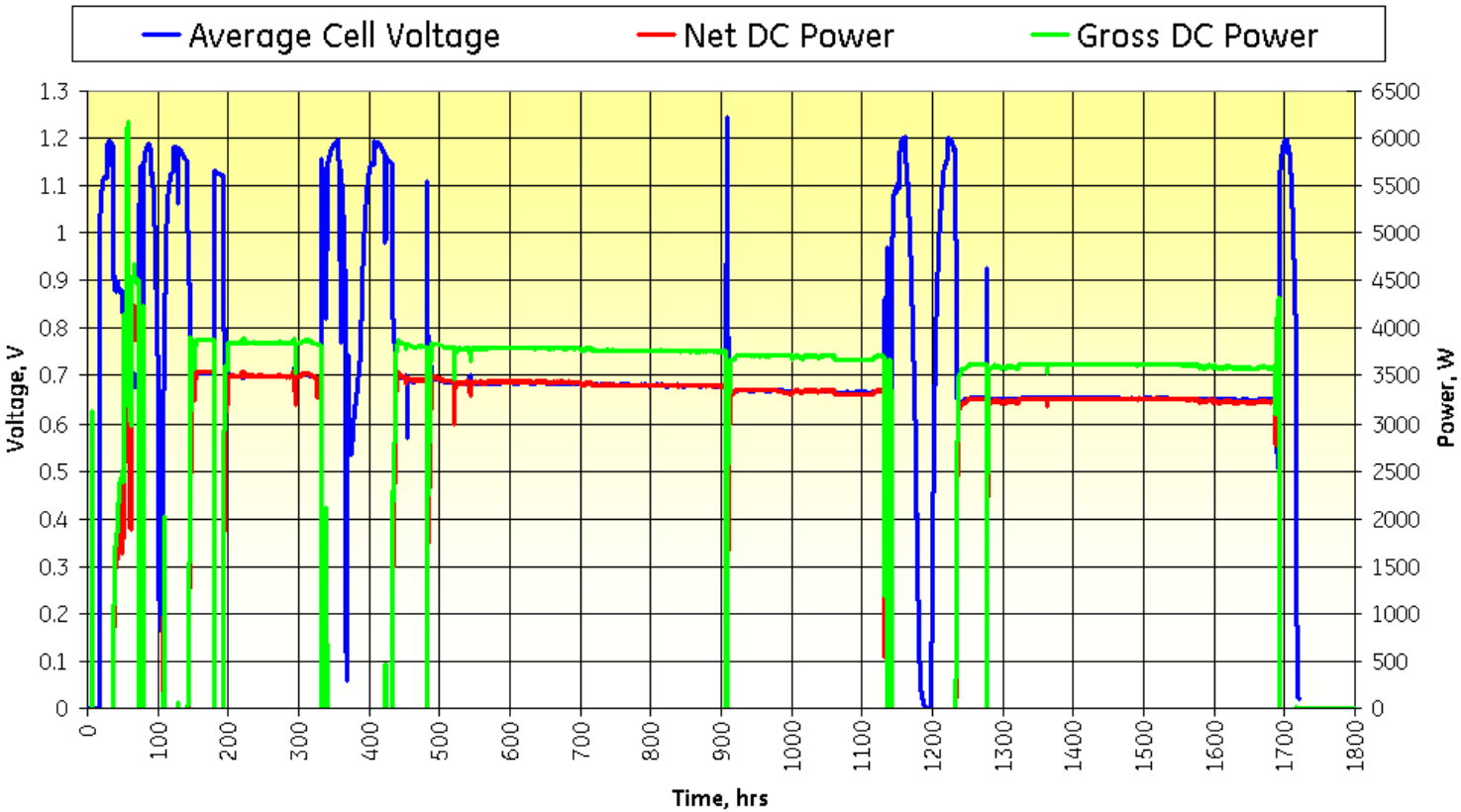
CATHODE AIR BLOWER

PROTOTYPE SYSTEM

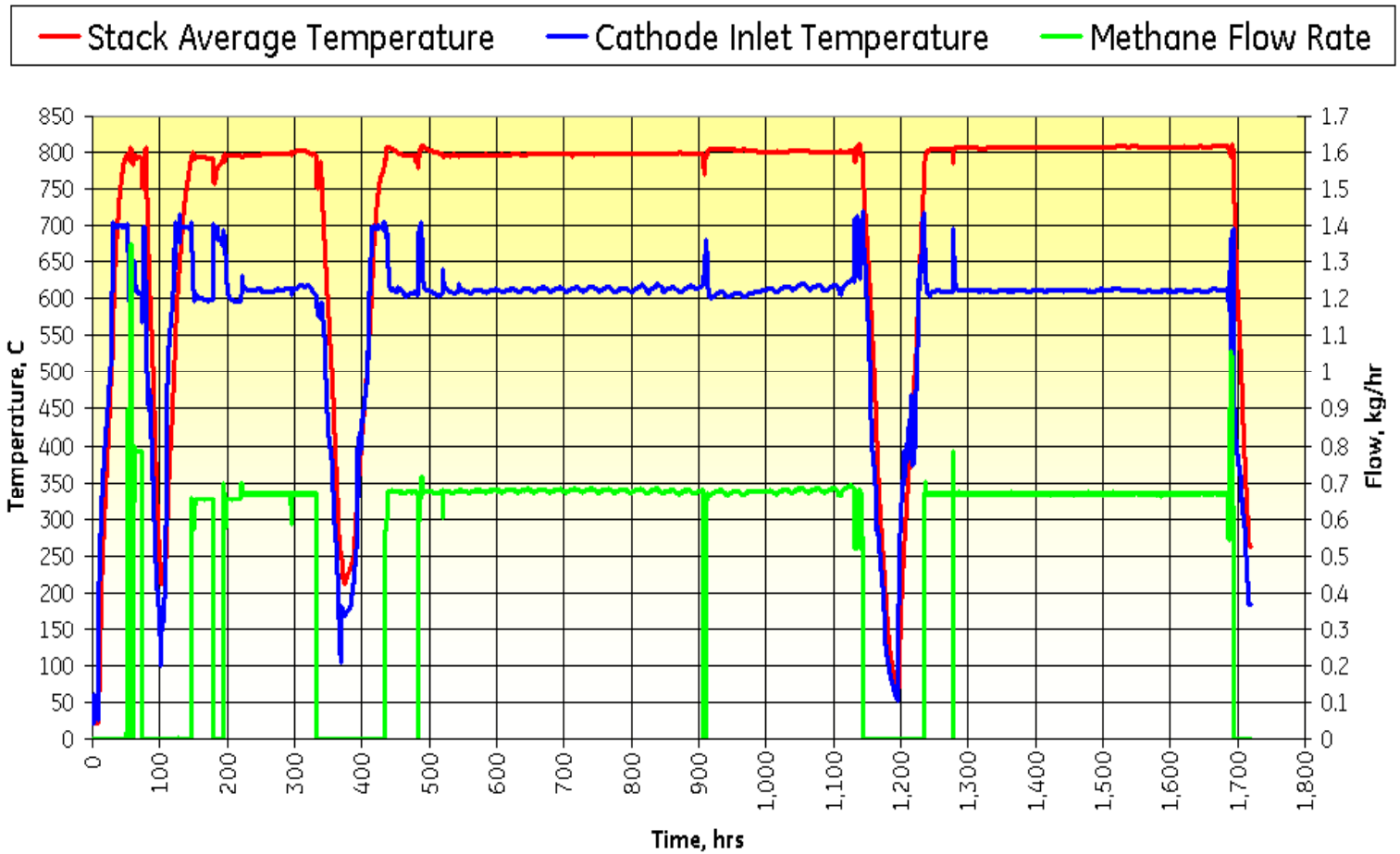
Prototype System Test Plan



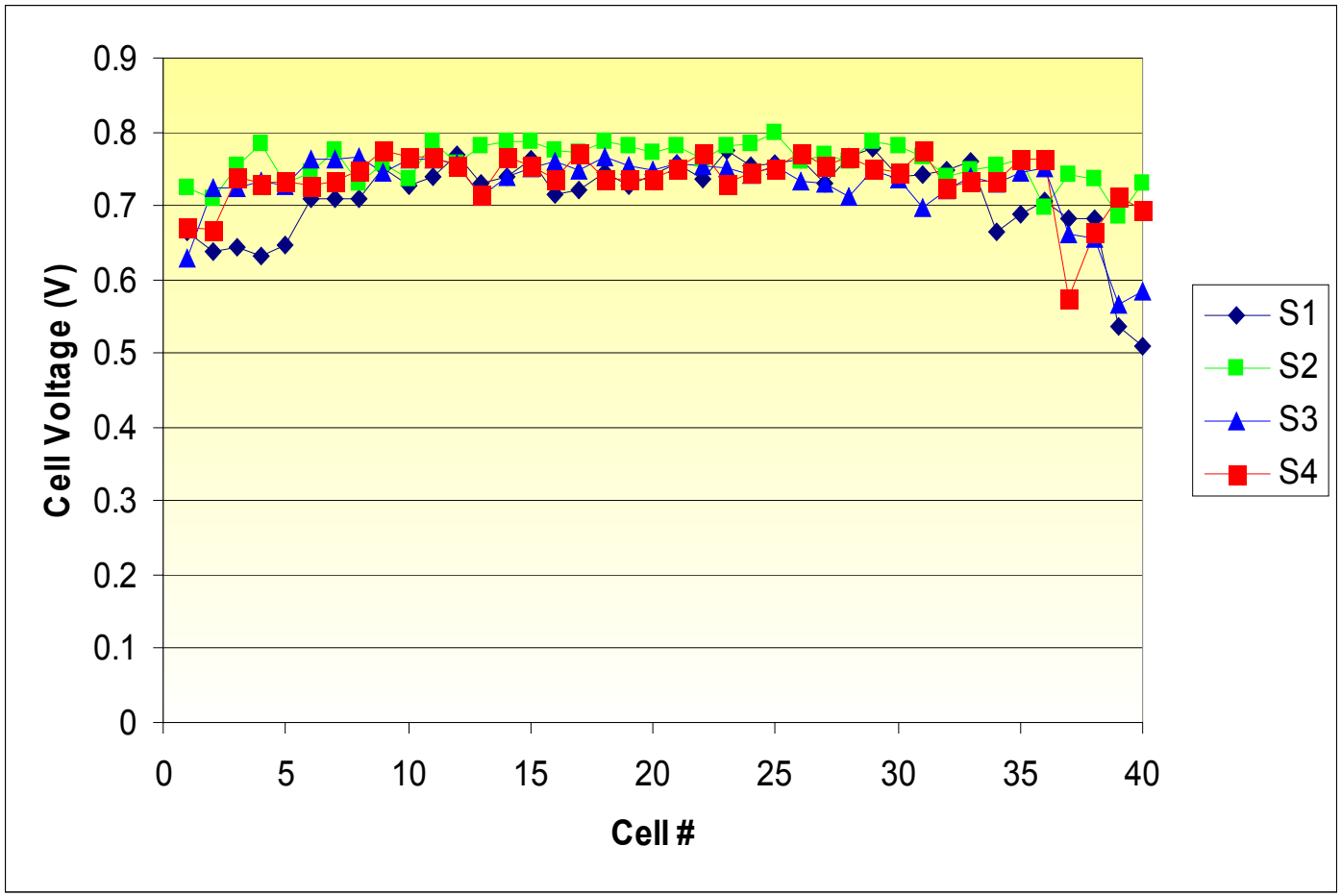
Prototype System Operation



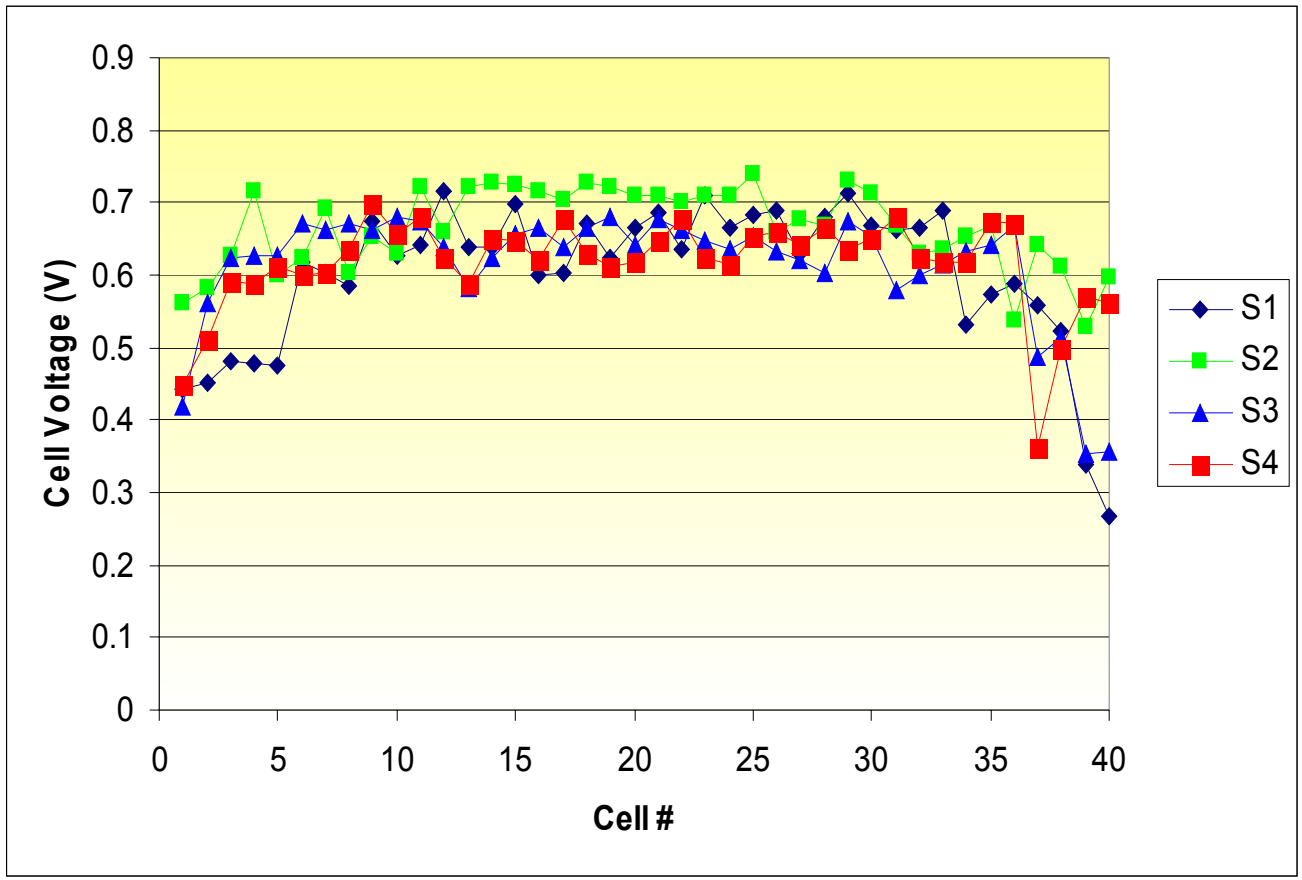
Prototype System Operating Parameters



Cell Voltages at Peak Efficiency Point



Cell Voltages at Peak Power Point



Prototype System Test Result Summary

PERFORMANCE PARAMETER	REQUIREMENTS	RESULTS
DC Efficiency	35%	41%
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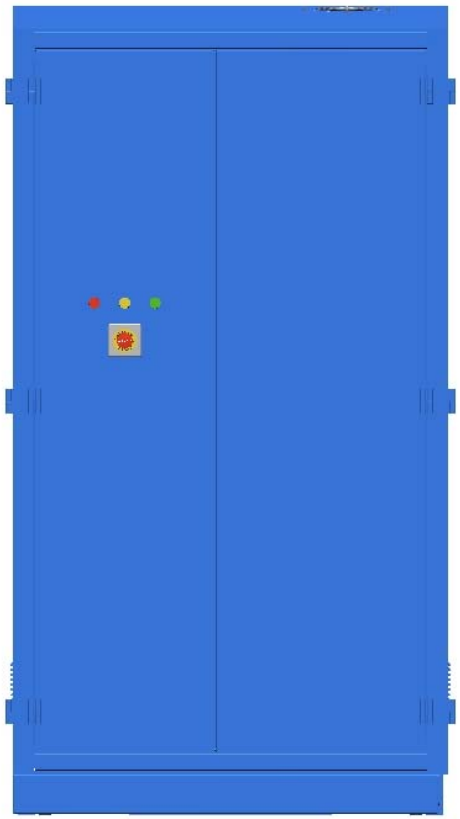
SECA Prototype System
(2006 system)



Key Features

- Single stack with 600 cm^2 active area cells
- 75% reduction in system volume

Preliminary Test Results

PRELIMINARY RESULTS

- Peak efficiency 49%
  - Net DC power 3.2 kW
  - ATR fuel
  - Fuel utilization 80%
  - Air utilization 24%
- Peak power of 5.6 kW
  - Efficiency of 32%
  - ATR fuel
  - Fuel utilization 65%
  - Air utilization 21%

SOFC Stack Technology

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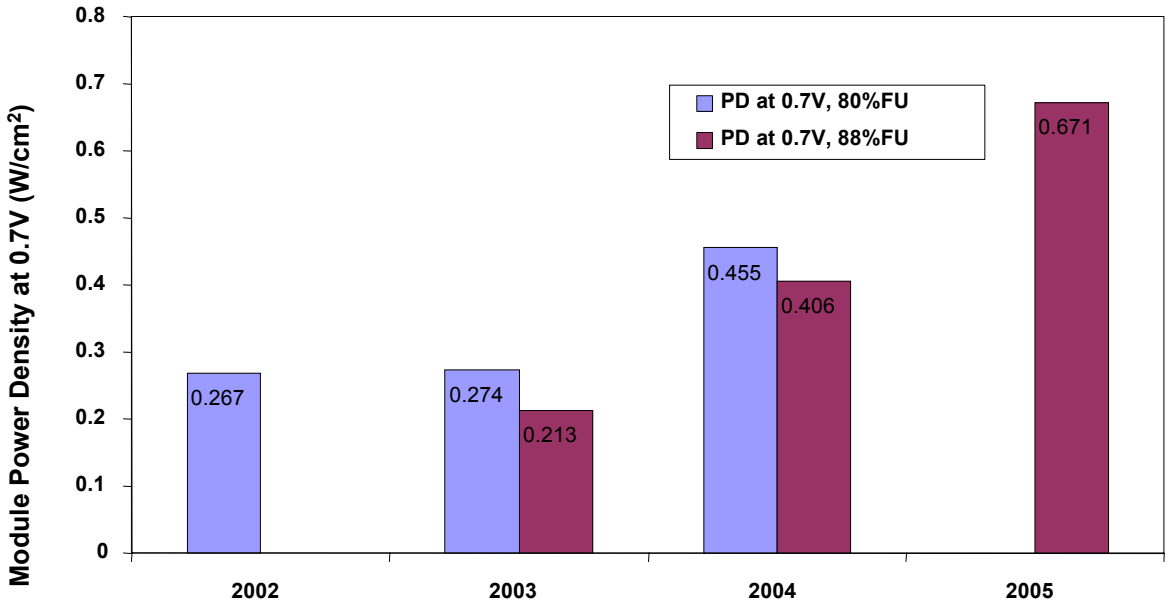
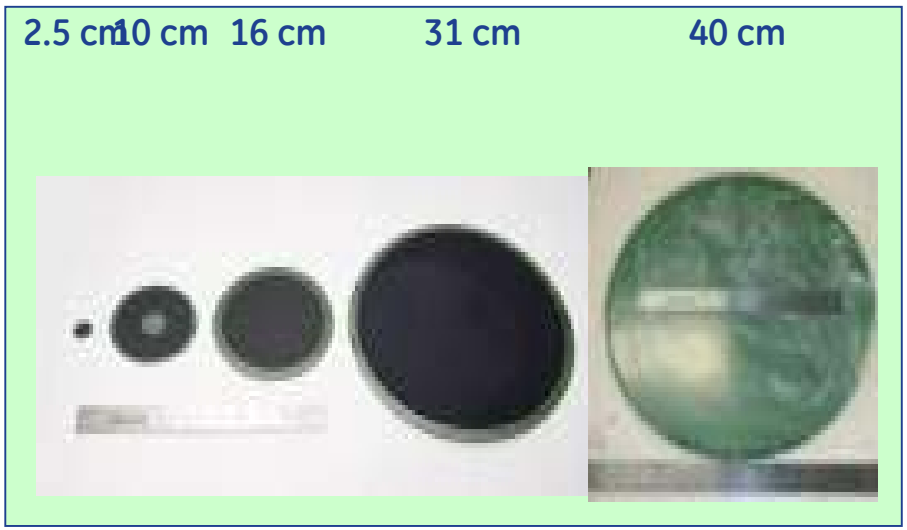
Single Cell Performance Improvement



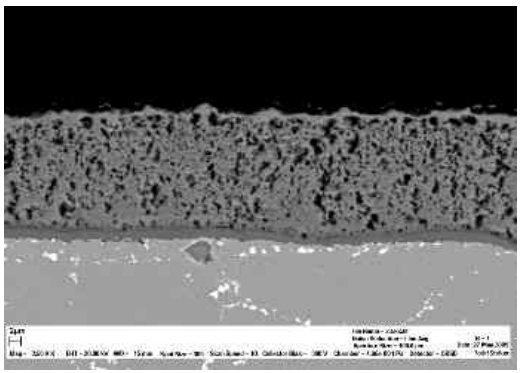
Cell Size Scaleup



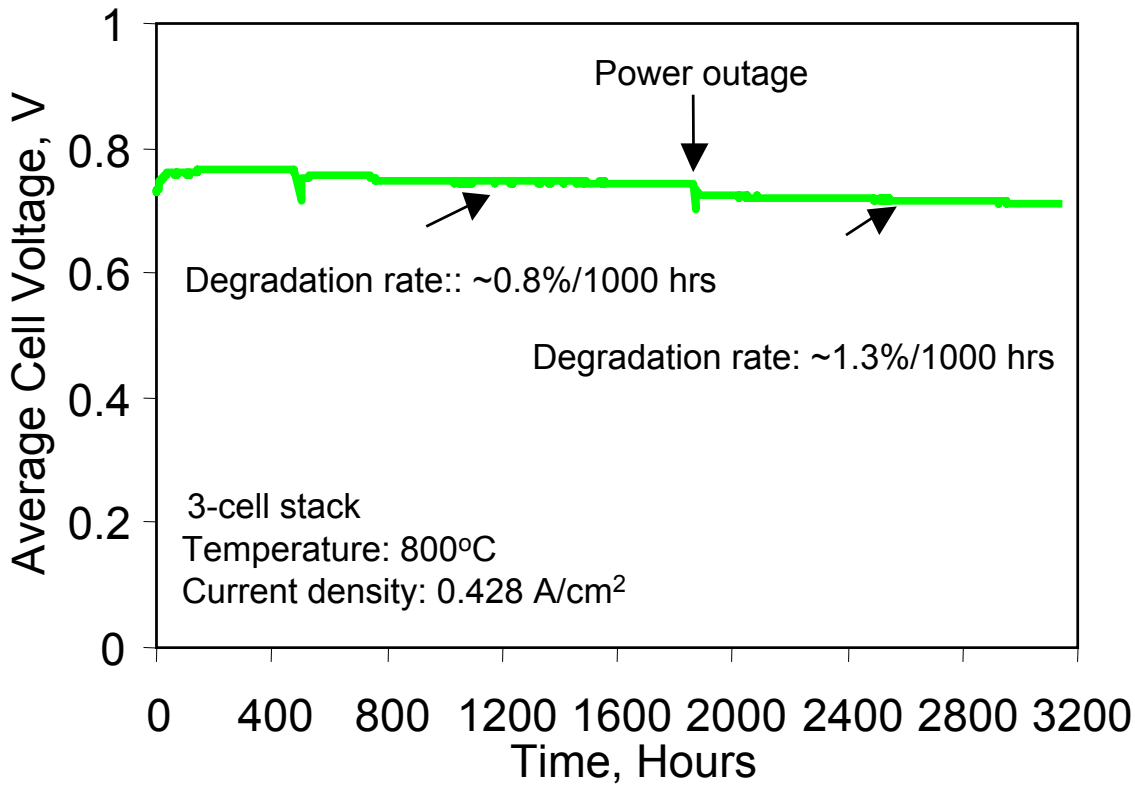
Tape Calendering

Plasma Spraying

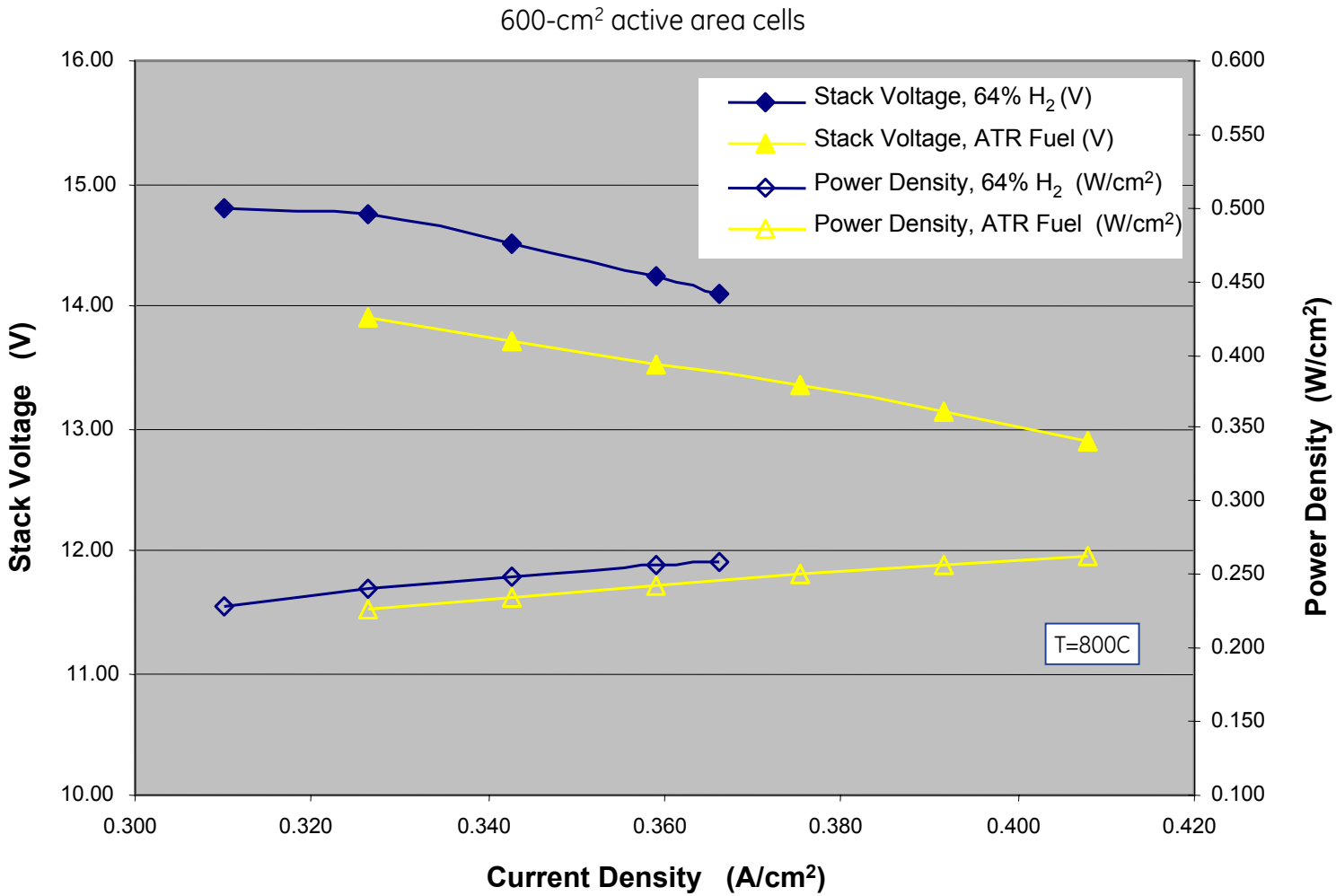
Performance Degradation



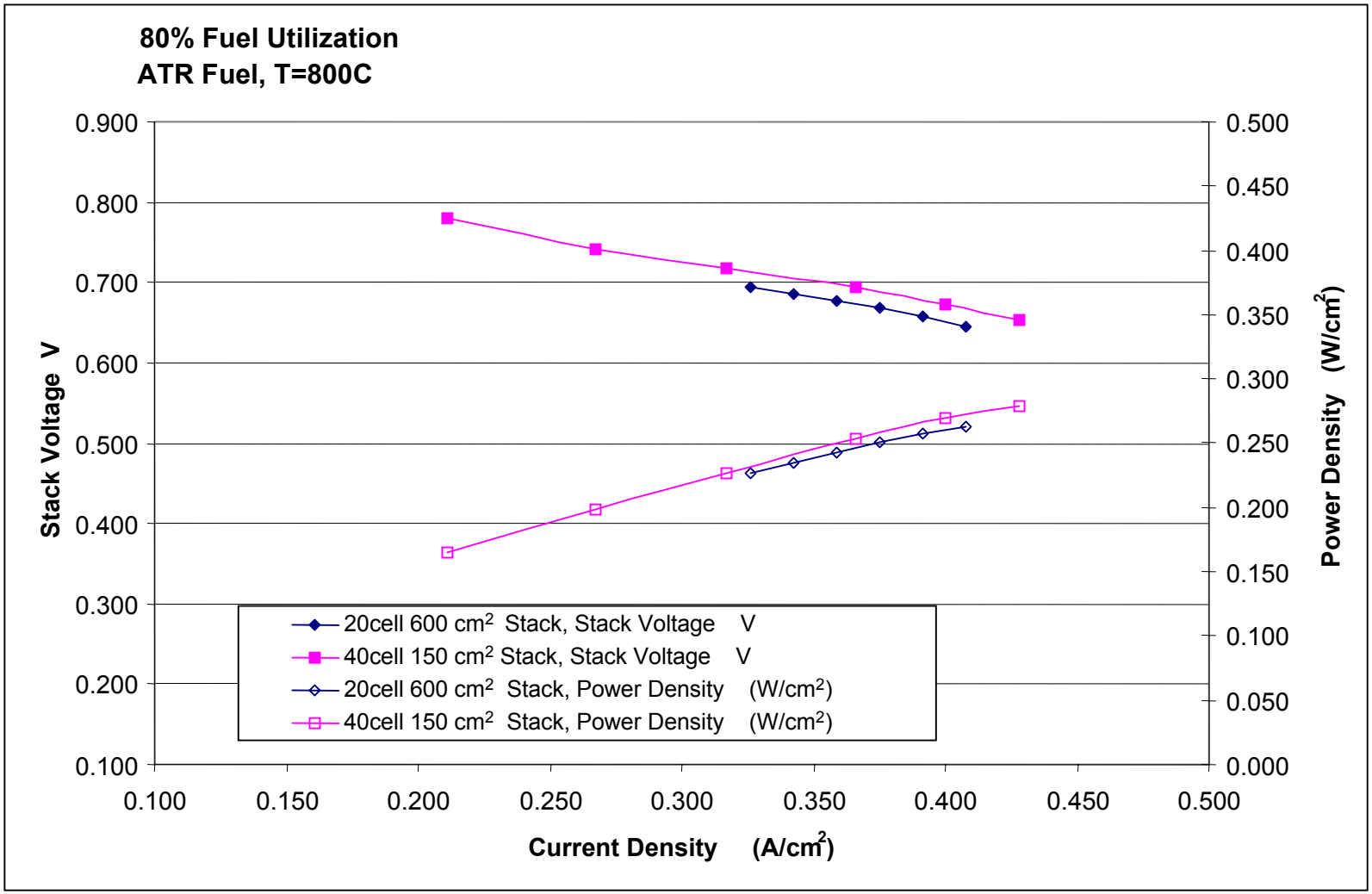
Interconnect Coating



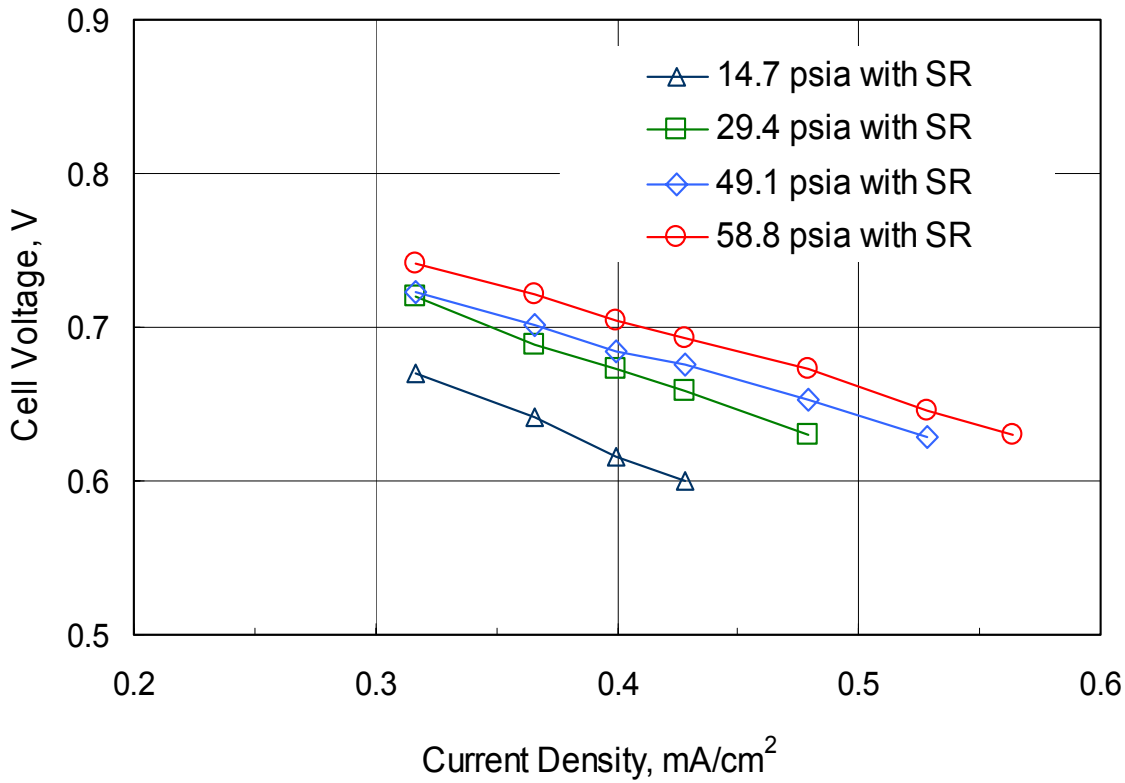
Performance of 20-Cell Stack



Multicell Stack Performance



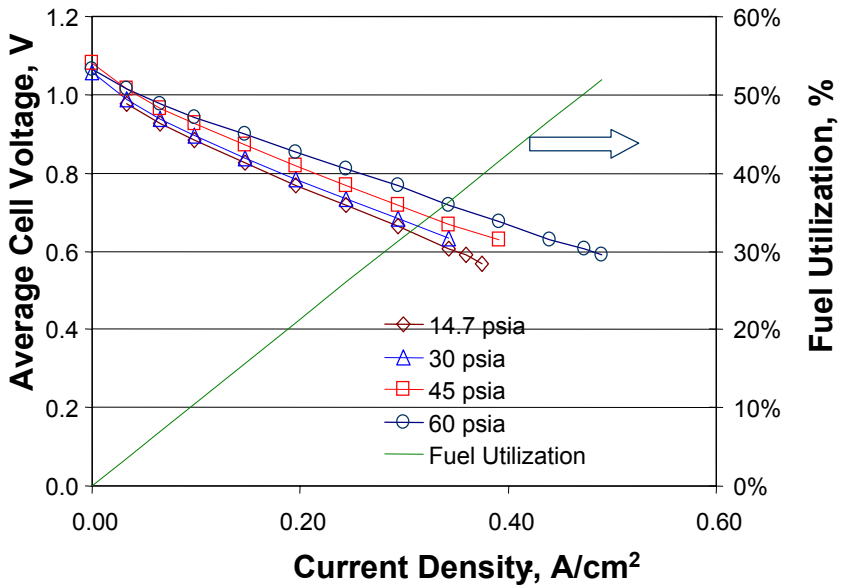
Pressurized Stack Testing

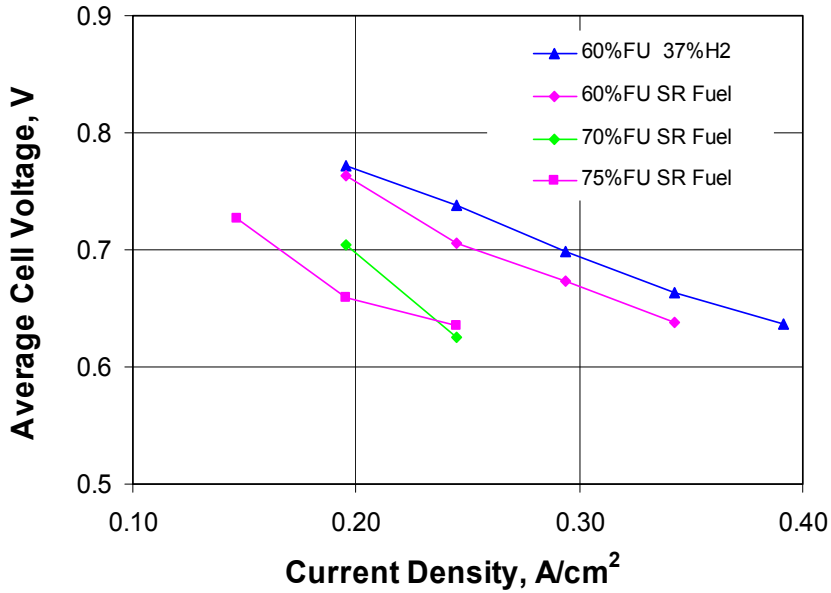


T=800^{0}C
SR=Simulated steam reformate
Cell active area= 150 cm^2

Pressurized Operation

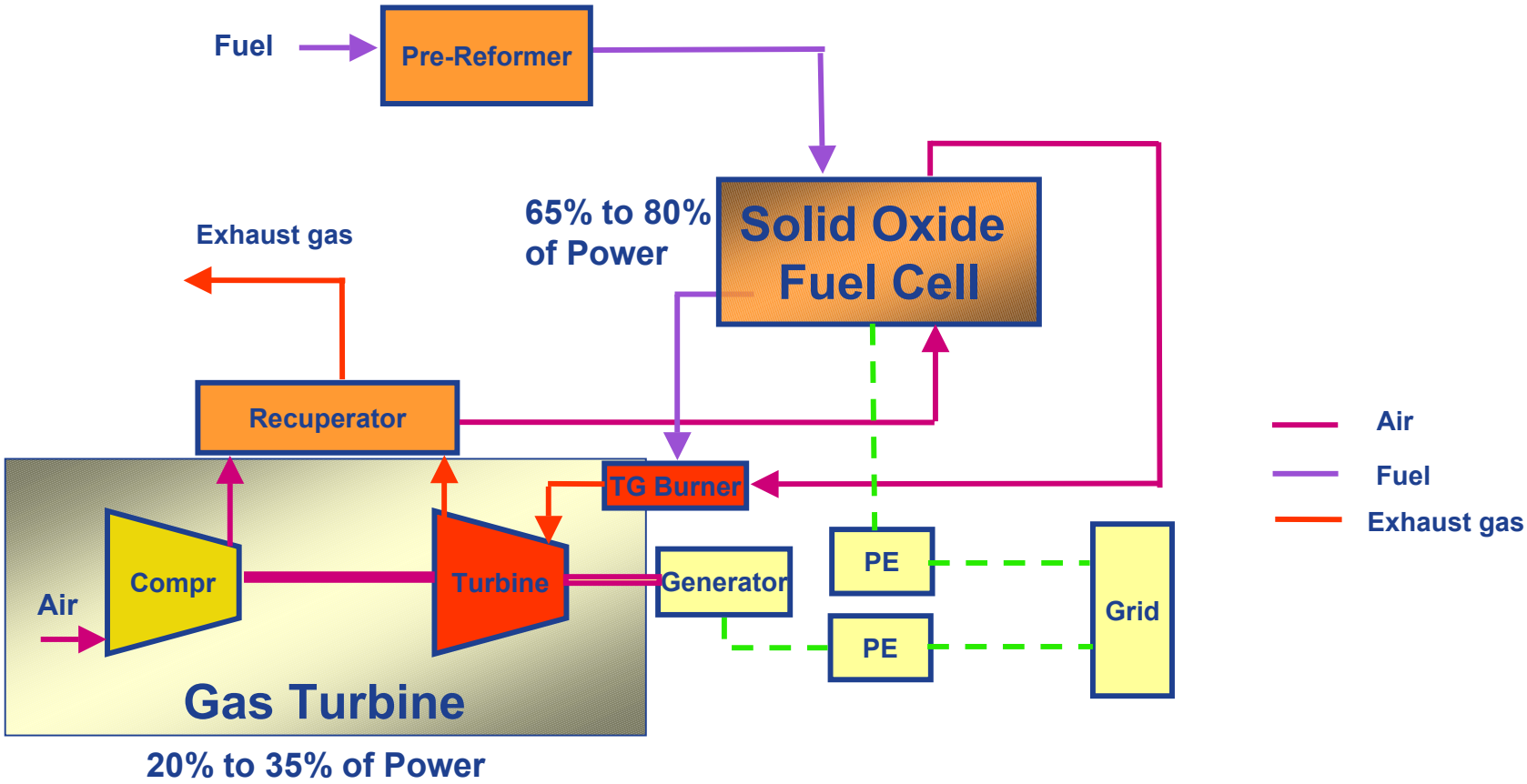
Stack with 600 cm^2 active area cells





System Concept Development

SOFC – GT Hybrid System Schematic



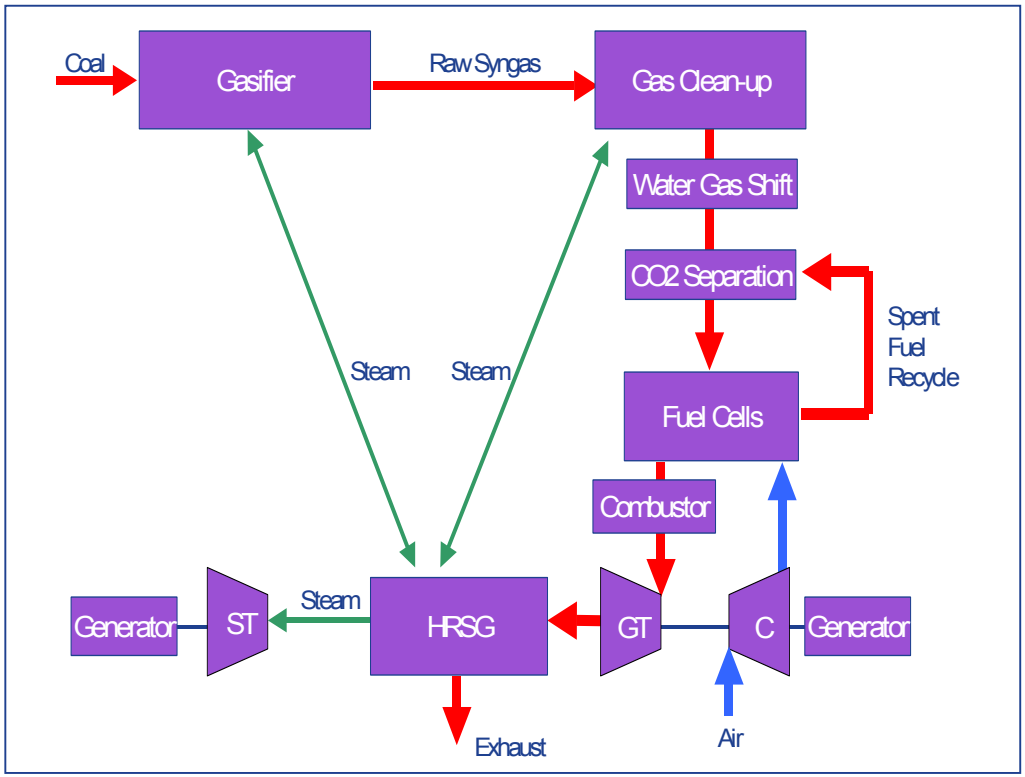
Efficiency Improvements with Hybrid Configurations

	Simple	Hybrid	Hybrid with Recycle
Efficiency (%)	44.8	61.1	71.0
SOFC Power* (kW)	3709	3709	4099
GT Power* (kW)	0	976	1447
Parasitic Power	(389 kW)	(100 kW)	(288 kW)
Net Plant Power	3320 kW	4585 kW	5258 kW
SOFC Pressure	1.3 atm	4.6 atm	4.6 atm

*After power conversion

- Natural gas
- 800C planar SOFC

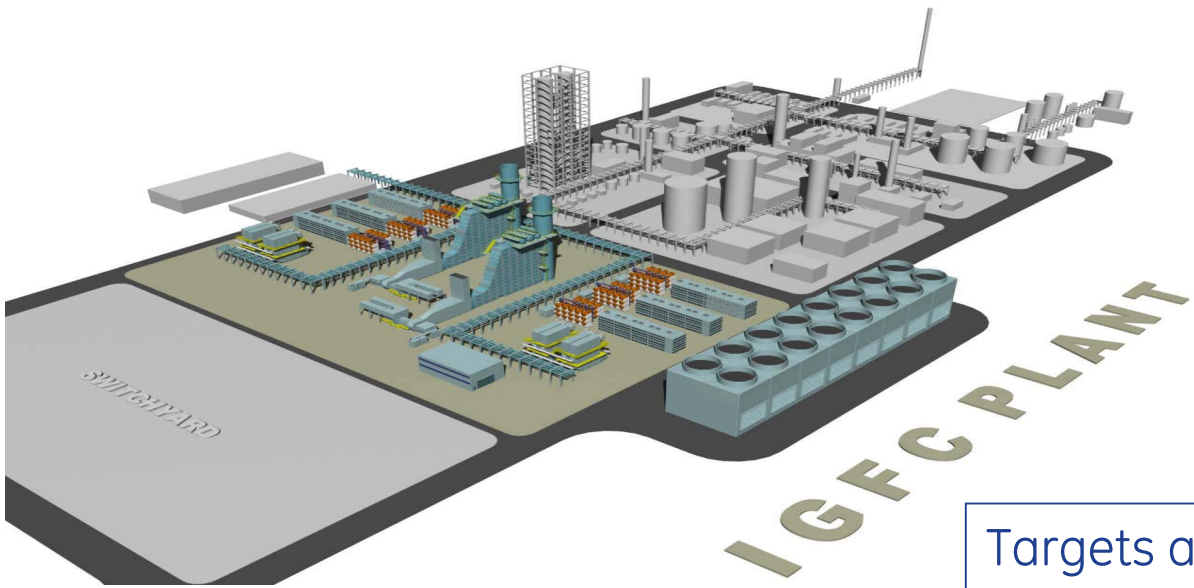
IGFC System



IGFC System

- System feautres
  - SOFC/gas turbine hybrid
  - CO_2 separation (with or without
- Key system components
  - SOFC
  - Gasifier
  - Gas turbine and steam turbine

IGFC Plant Concept

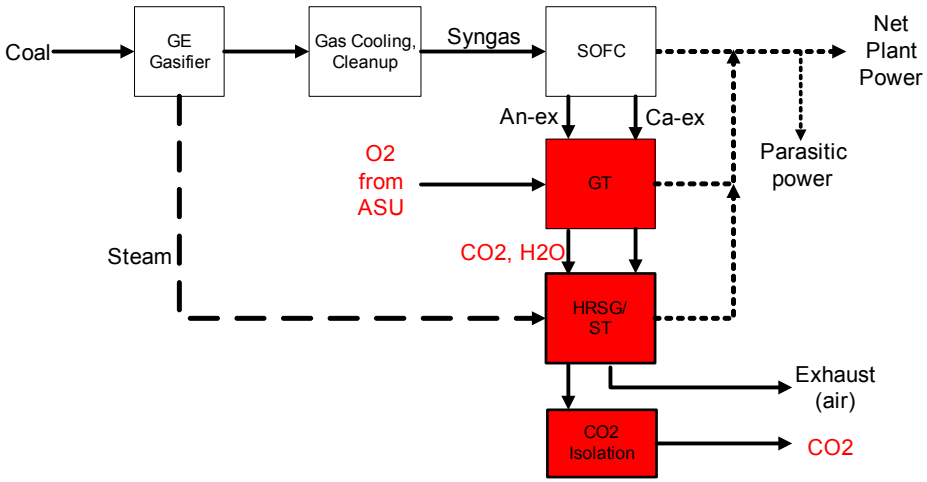


Targets and Features

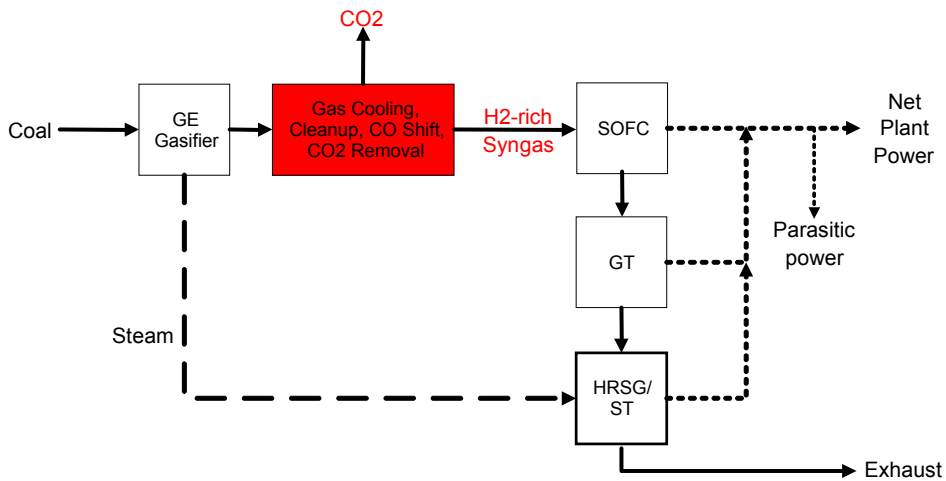
- 500+ MW
- 50% Efficiency (HHV)
- ~$400/kW mfg cost (power block)
- 5-10% CoE advantage over IGCC
- Low emissions
- CO_2 sequestration capable

IGFC Concepts

IGFC-CO2 Isolation after SOFC



IGFC-CO2 Isolation before SOFC



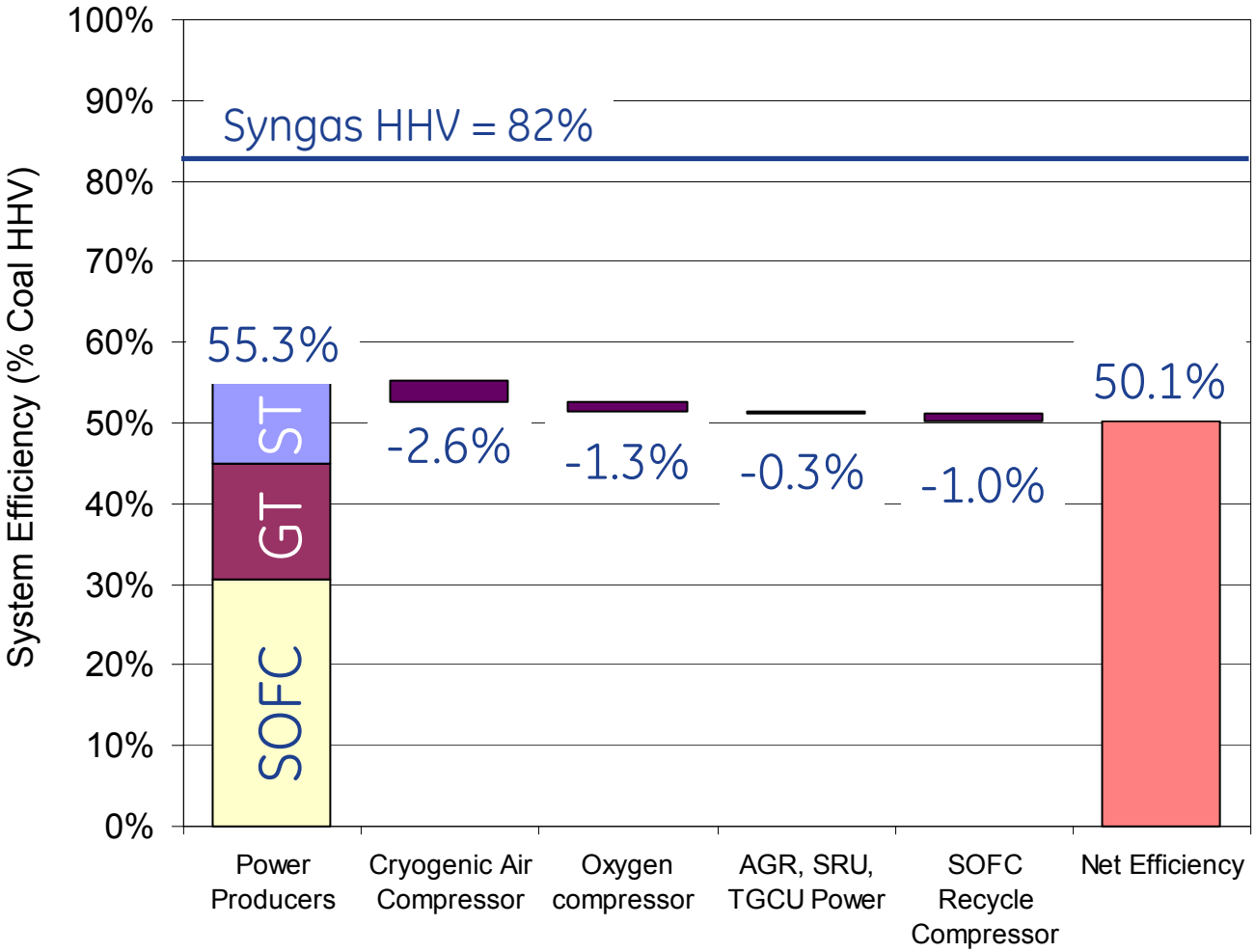
BASELINE CONFIGURATION

- Potential efficiency >50%
- 90% of gasified carbon isolated after SOFC
- CO_2 isolated @ P = 1 atm

ALTERNATIVE CONFIGURATION

- Syngas to SOFC via CO-shift and removal before SOFC (like H_2 from coal plant)
  - Conventional shift CO_2 removal
  - Advanced shift CO_2 membrane
- Potential efficiency ~50%
- 90% of gasified carbon isolated pre-SOFC
- High H_2 content to SOFC allows for high cell voltage and conversion efficiency
- CO_2 isolated at P >> 1 atm

IGFC System Performance Preliminary Results



Baseline SOFC settings:

- 0.75 V/cell
- 150° ΔT
- 80% U_f (fuel utilization)
- Air outlet T <800°C

AGR: acid gas removal, SRU: sulfur removal unit; TGCU: tail gas cleanup unit

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Concluding Remarks

- Successful SECA prototype system demonstration
- Significant progress on stack technology development for hybrid SOFC/GT systems
- Focus on IGFC system development

Acknowledgments

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