Honeywell

Solid Oxide Fuel Cell System Development

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Simplified SOFC System & Components

Microturbine

SOFC Stack

SOFC Fuel Cell

Turbo-Compressor

Controllers

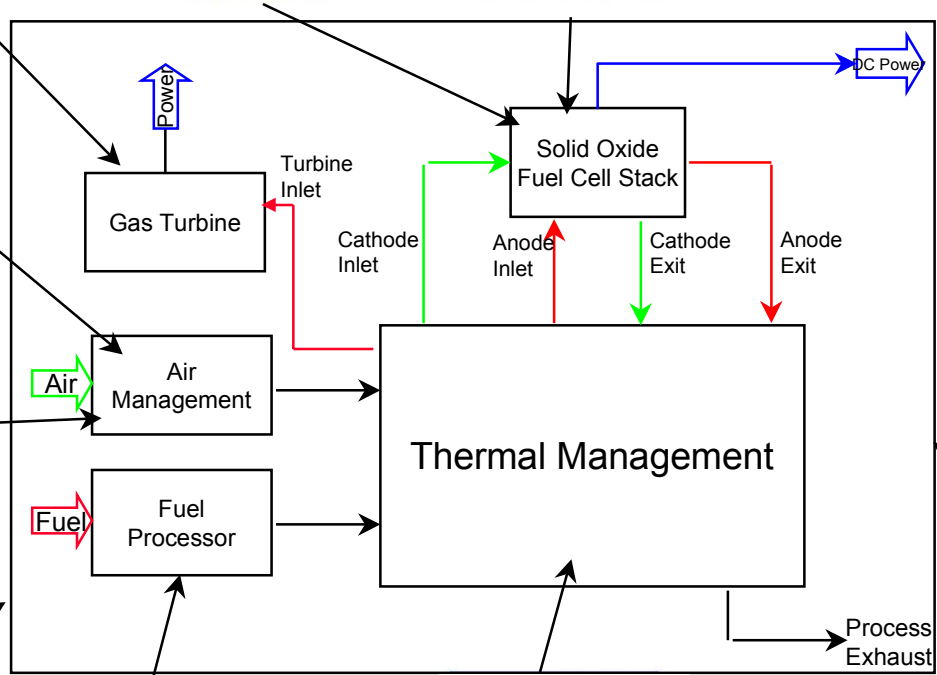
Blowers

Valves

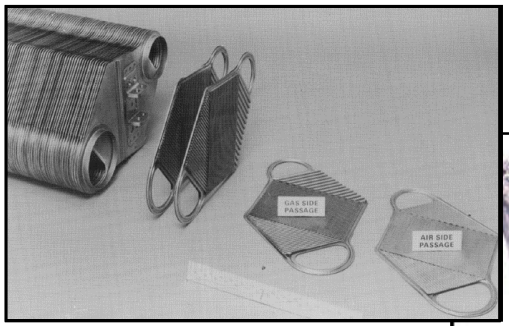
Sensors

CPOX Fuel Processor

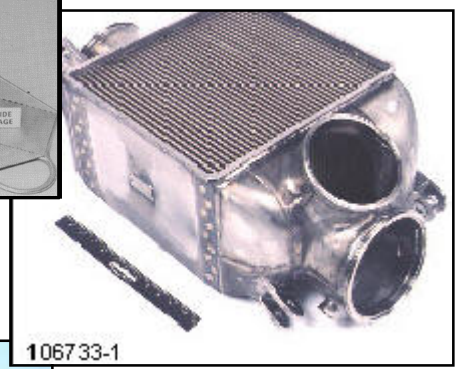
High-T Heat Exchangers



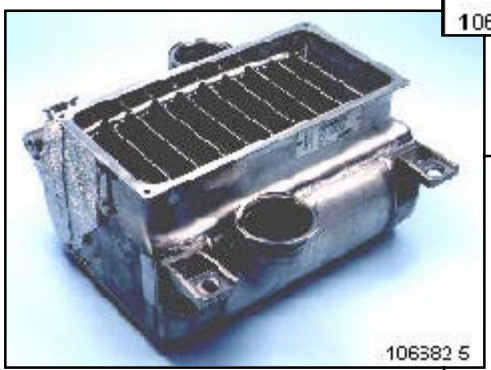
Heat Transfer/Thermal Management



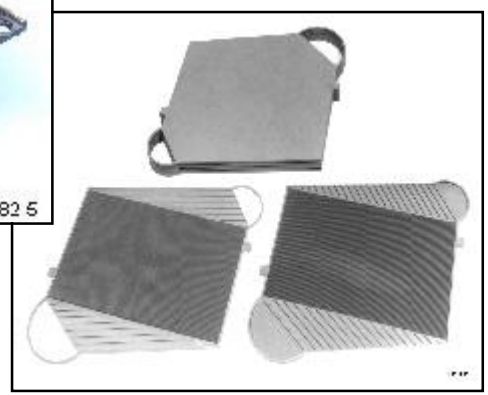
Commercial Recuperators



757-300 RR Precooler



F22 Primary Heat Exchanger

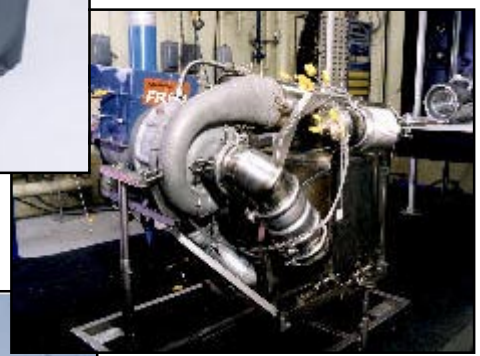


Si_3N_4 Ceramic Heat Exchanger

- Extensive experience with thermal management of complex systems
- Broad spectrum of heat exchanger products
- Thermal management systems for a wide range of operating environments

Turbomachinery

RAH-66 Fan



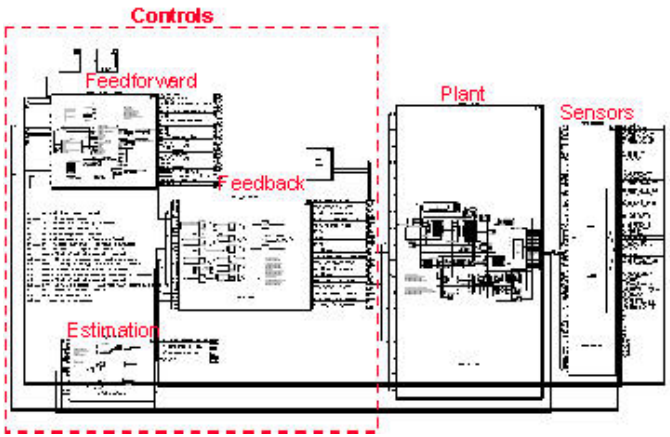
50 kW
Turbogenerator

Trident Gas
Hydraulic Assembly
Turbopump

PEMFC Turbocompressor

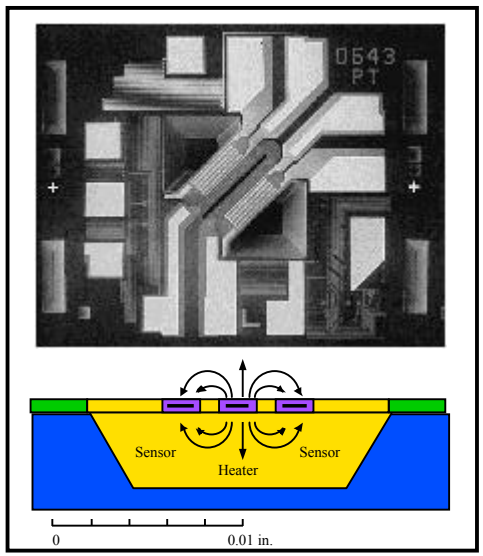
- Expert knowledge in positive displacement and dynamic pumps, compressors, and turbines
- Wide range of turbomachinery products
- Development of turbocompressor for PEMFC systems

Controls and Sensors



Control Schematic

Hydrogen Sensor



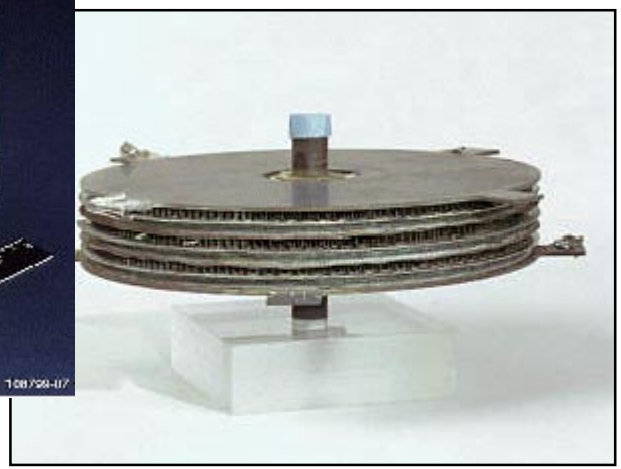
Top view and cross section of Mass Air Flow Sensor

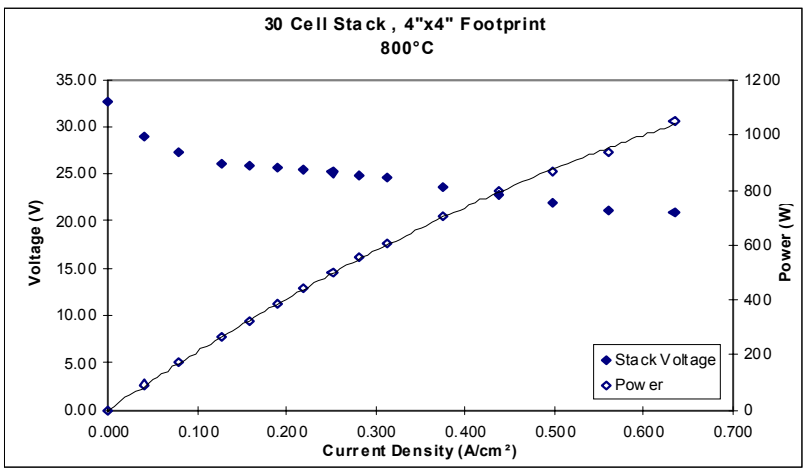
- **Controls**
  - Model-base control and optimization algorithms including Fuel Cell Dynamics Component Library
  - Rapid prototyping
  - Load following control system for PEMFC systems
- **Sensors**
  - Relative humidity
  - Mass air flow
  - Hydrogen
  - Carbon monoxide

System Development Approach

- **Low-cost fabrication processes and materials along with compact, lightweight component designs**
  - **SOFC:** Tape calendering fabrication process, stack designs incorporating thin-electrolyte cells and thin-foil metallic interconnects
  - **Fuel processor:** Catalytic partial oxidation (CPOX)
- **Component designs based on system requirements and other design methodologies (e.g., design-for manufacturing, design-to-cost)**
- **Focus on lessons learned from small (50 W to several kW) system operation**

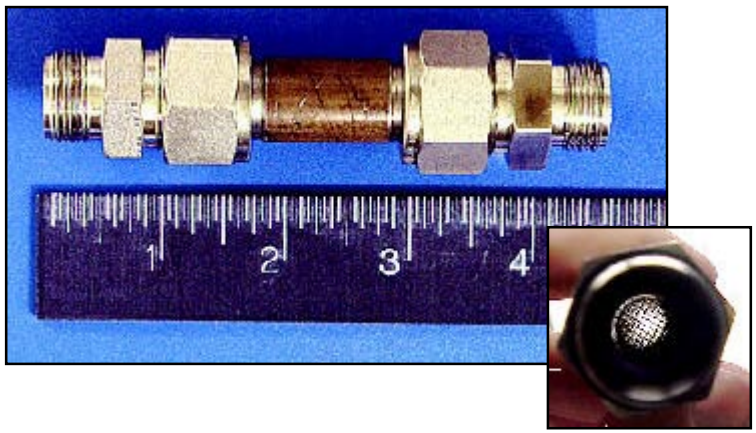
SOFC Stack Metrics

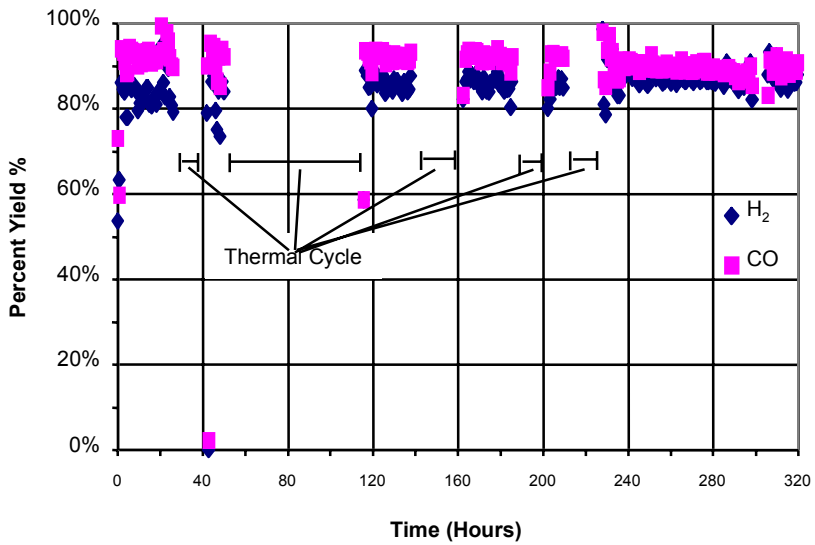




- Fabrication and operation of multi-cell stack of various sizes (up to kW size)
- 800°C operation at ambient pressure and up to 3 atm
- Thermal cycling
- Start-up and shut-down
- Power density:
  - 0.6 W / cm² with hydrogen
  - 0.4 W / cm² with syngas from JP-8

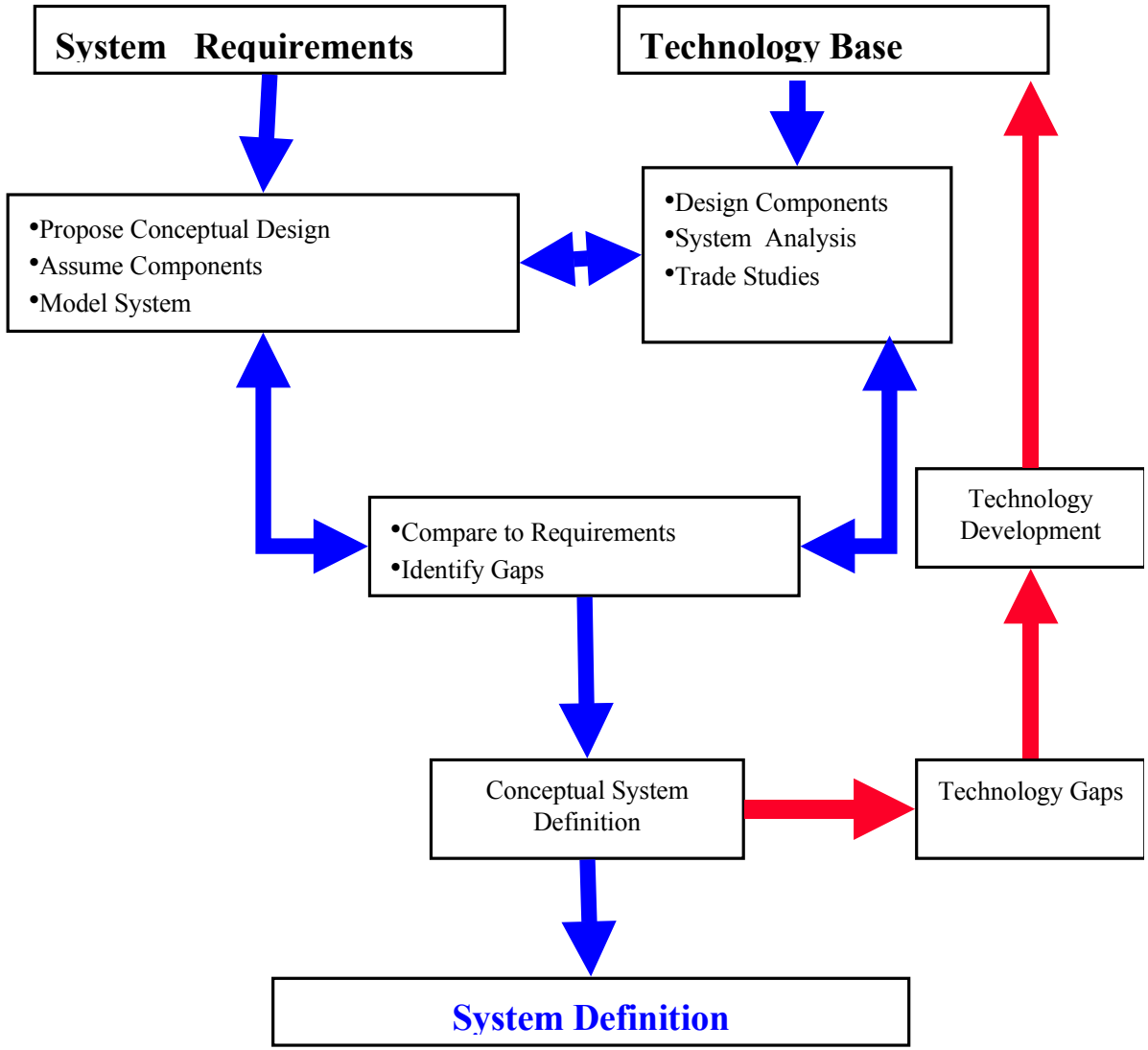
CPOX Performance Metrics



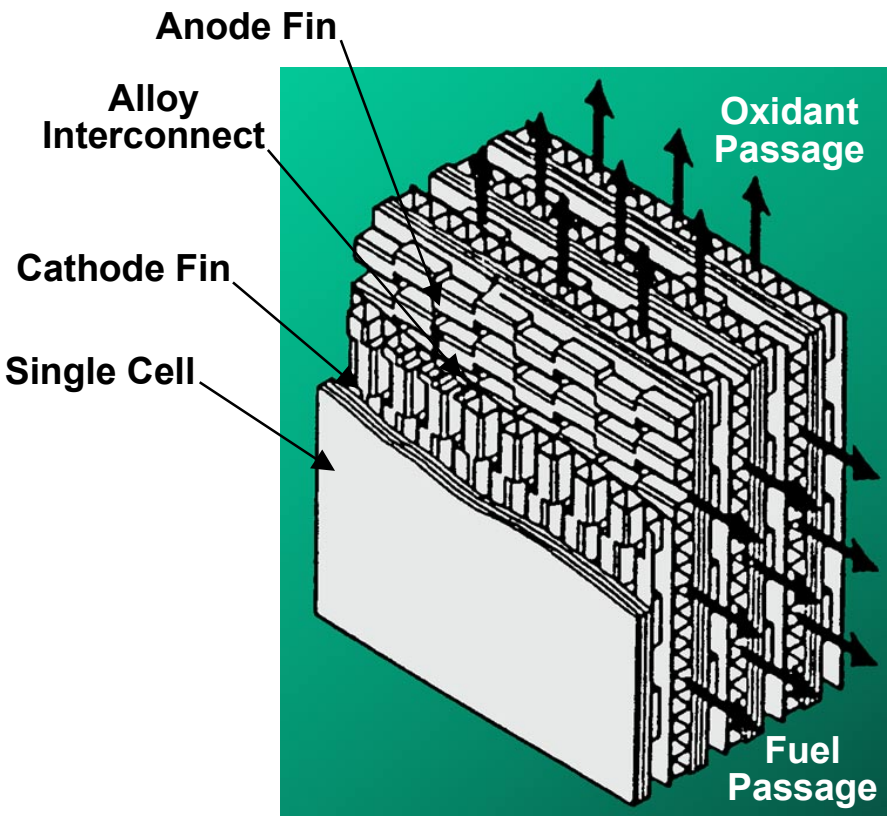


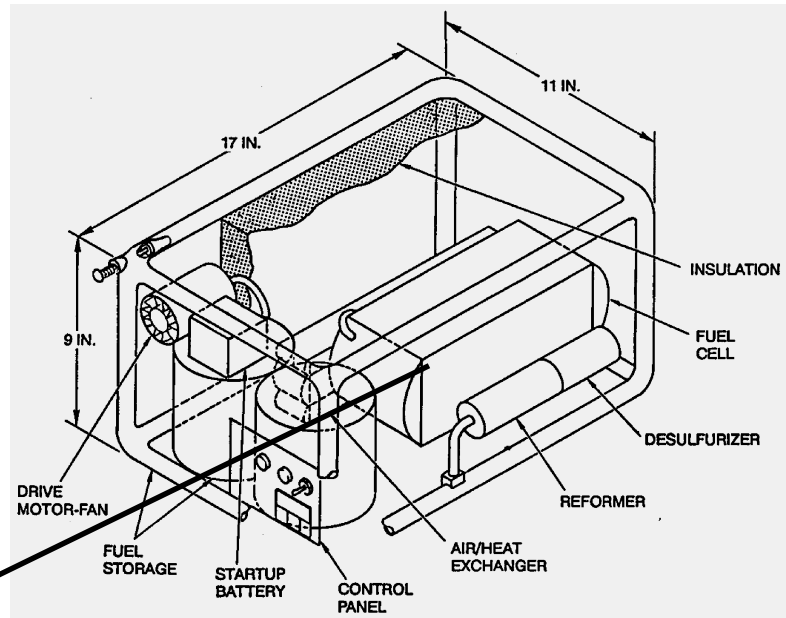
- **Duration: 700 hours to date**
- **Thermal cycles: 10**
- **Sulfur tolerance: 1000 ppm dibenzothiophene in JP-8**
- **Yield: 70-80% of LHV in JP-8**

System Design Methodology



Solid Oxide Fuel Cell Battery Charger

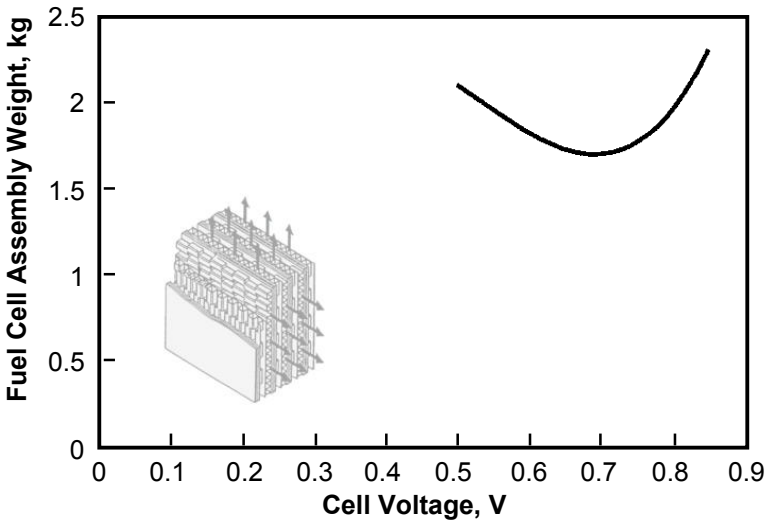


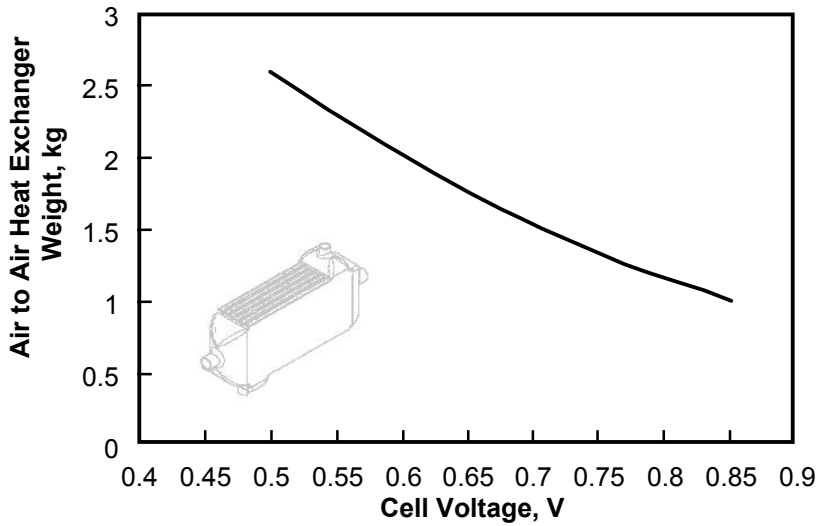


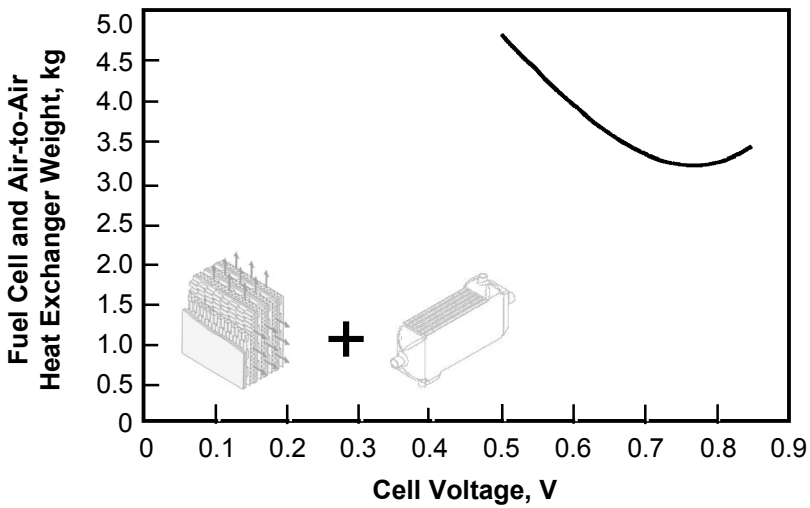
Requirements

- 7 kg
- 500 W at 28 VDC
- Operation on logistic fuels (JP and diesel)

System Weight Optimization





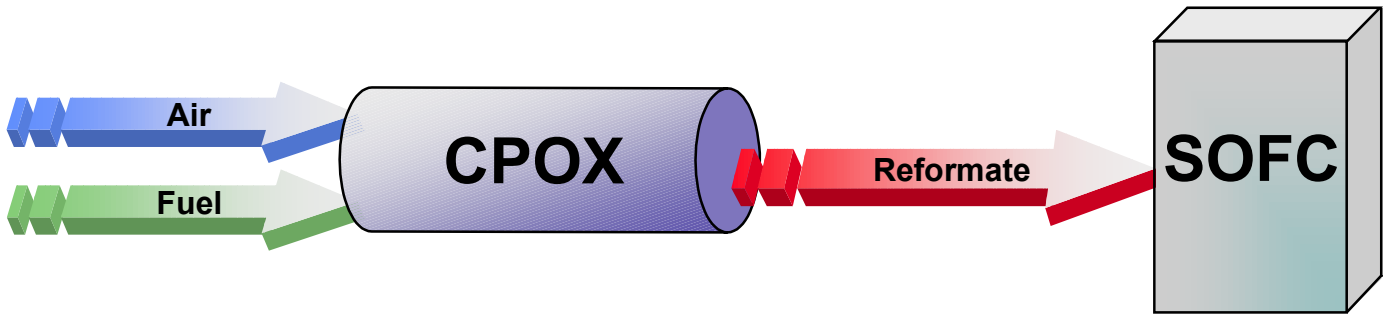


- **500 W, 28 VDC output**
- **Hydrogen utilization of 0.8**
- **Minimum weight at cell voltage of 0.75 V**

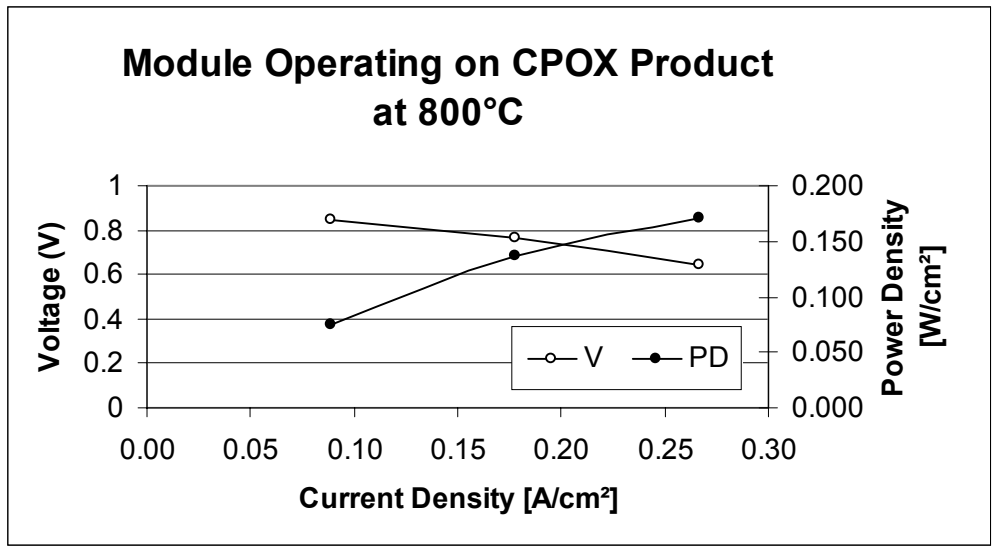
CPOX/SOFC Integration - Key Parameters

- Start-up and shut-down procedures
- Range of operating parameters
- Pressure drop
- Thermal management
- Transient characteristics

Integrated CPOX-SOFC Operation



CPOX	
Input	Output
JP-8	17.3% H_2
Air	21.0% CO
	0.7% CO_2
	11.0% H_2O
	50.0% N_2



Demonstration of multicell SOFC operation on JP-8 syngas

System Demonstration

- Demonstration of key component integration
  - Integration of system components, especially CPOX fuel processor and SOFC stack
- Operation characteristics
  - Startup
  - Thermal integration
  - Propane and JP-8 fuels

Concluding Remarks

- Low-cost fabrication processes and materials along with compact, lightweight components developed for SOFC systems
- Demonstration of component integration and operation of small systems
- Near-term activities consistent with SECA plan