



A Portable SOFC-Based JP-8 Power System

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Altex Technologies Corporation

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Contract Number W909MY-06-C0050



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Outline

- Project Driver and Goals
- Low-Temperature Pre-Reformer (LTPR) Developmental Basis
- SOFC Developmental Basis
- System Integration and Delivery Experience
- Project Status
 - LTPR
 - SOFC
 - BOP
 - Controls
- Conclusions



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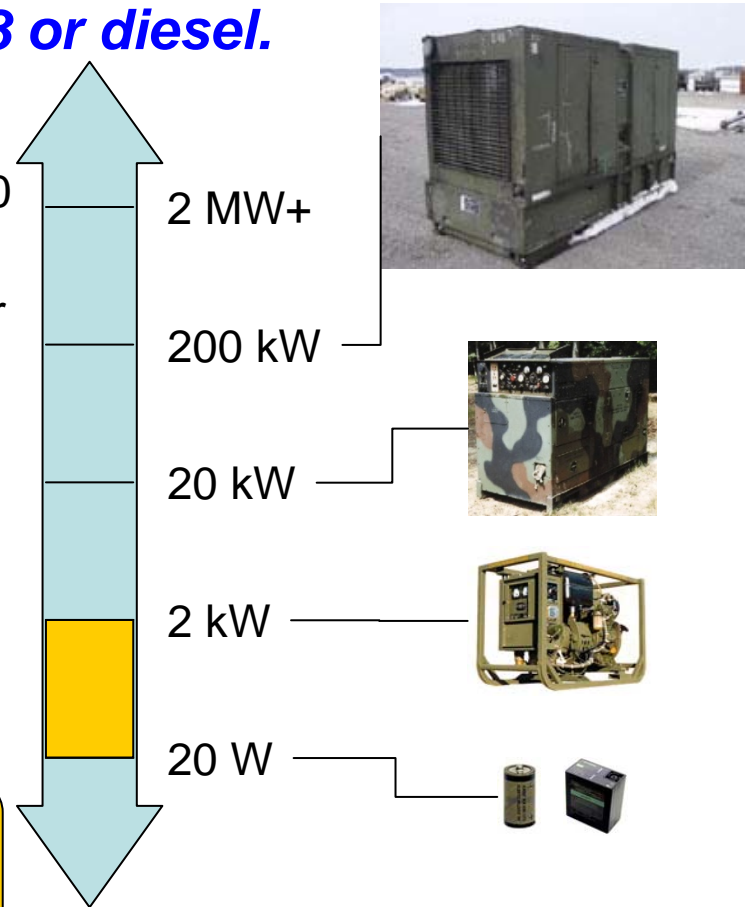


Project Driver

The DoD lacks a power-generation solution below 2 kW_e which operates on JP-8 or diesel.

- Batteries are the only power source for $< 2 \text{ kW}_e$
- Warfighter needs to either carry batteries (20-40 lbs) and limit distance from power source
- Move towards rechargeable batteries with lower specific energies than disposable batteries
- 2 kW minimum diesel genset size leaves gap between gensets and batteries

Lack of a person-portable power source tethers the warfighter to vehicle-based chargers and limits power level of equipment.



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Performance Targets

Priority Draft Specifications for Fuel Cell Battery Charger

Specification	Threshold Target	Objective Target
Size ^(a)	80 L	50 L
Weight ^(a)	30 kg	22 kg
System energy density		
72-hour mission ^(b)	225 Wh/L	360 Wh/L
Run time on 2-L fuel charge	4 hours	8 hours
Power output	250-500 We 21-30 Vdc	250-500 We 21-30 Vdc
Reliability		
Lifetime	2,000 hours	5,000 hours
Shelf Life	3 years	5 years

a) Including fuel for a 72-hour mission

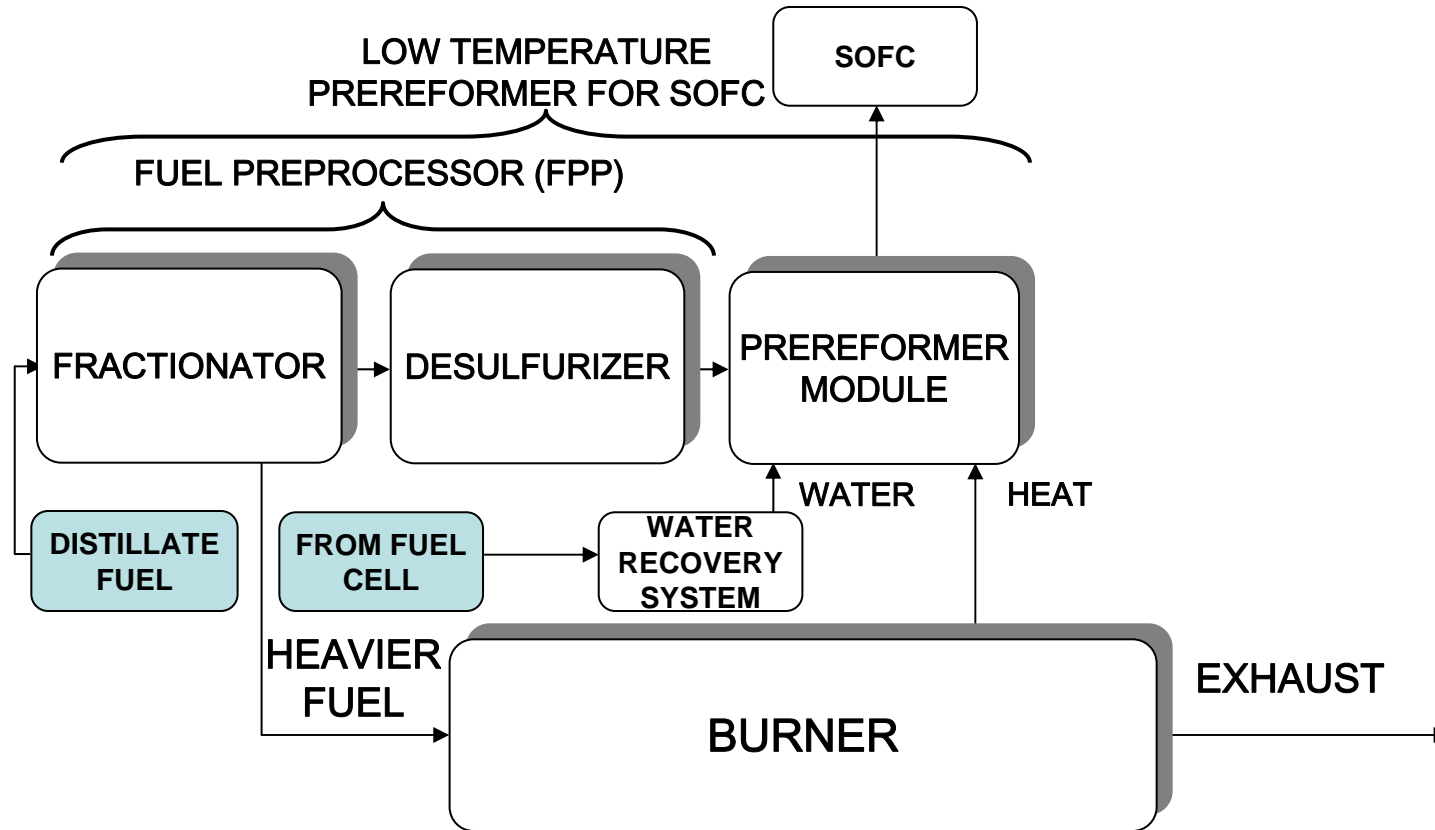
b) Calculated based on 250 W continuous power for 72 hours and size specifications



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Technical Approach





LTPR Developmental Basis

SOFC Systems

LFPPR
20 W_e

CELF
2 kW_e

HTPEM Systems

CORE
1 kW_e 2 kW_e



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LTPR Developmental Basis

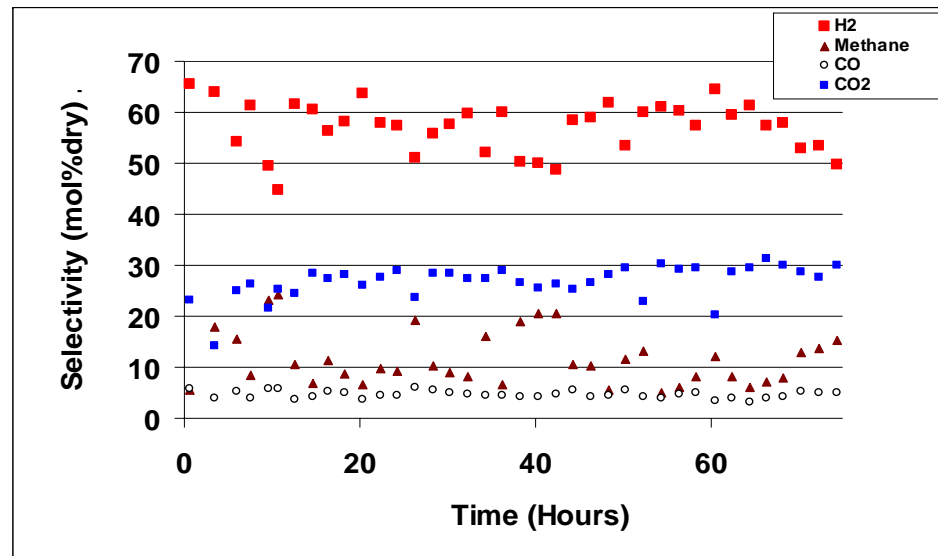
SOFC Systems

LFPPR

20 W_e

CELF

2 kW_e



LTPR Developmental Basis

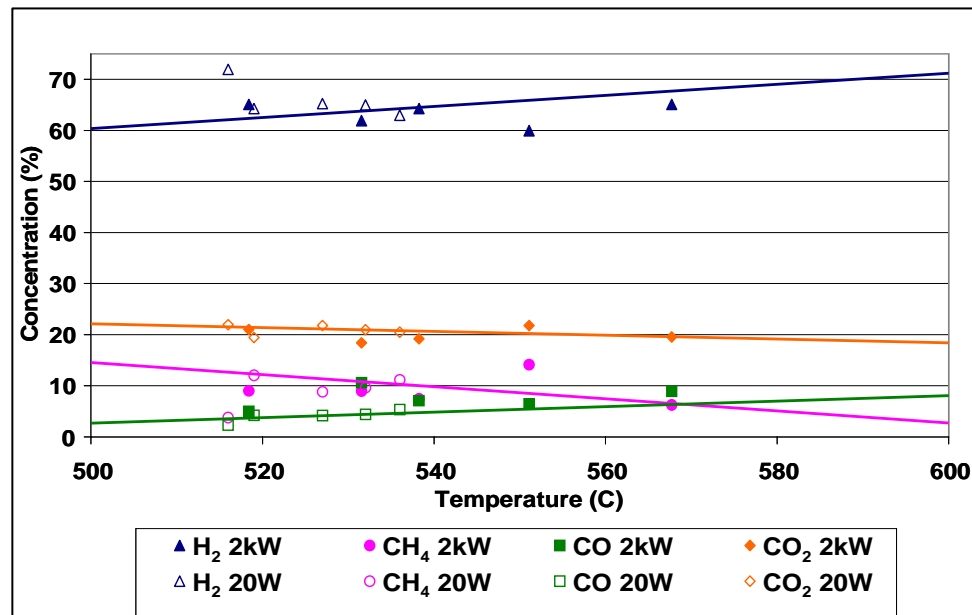
SOFC Systems

LFPPR

20 W_e

CELF

2 kW_e

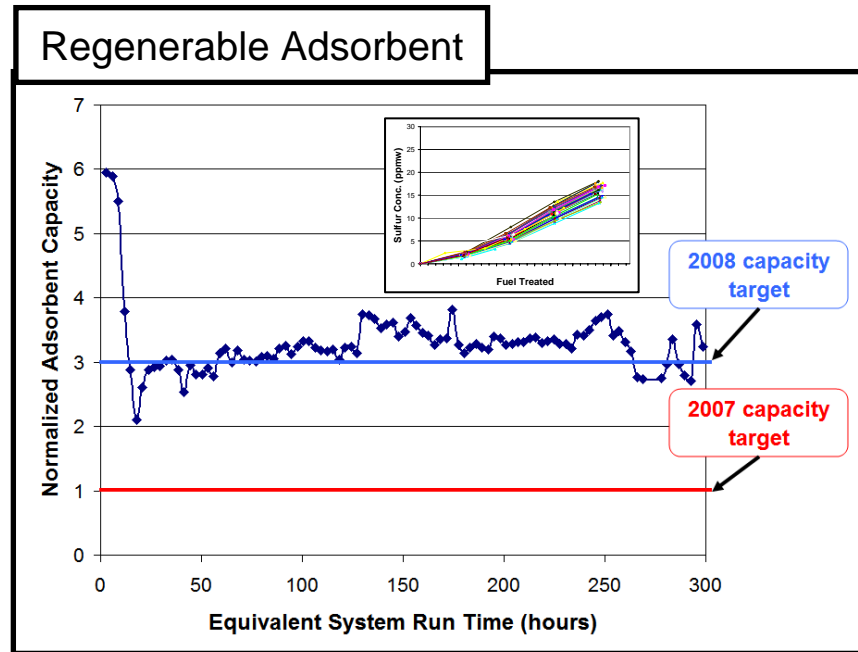
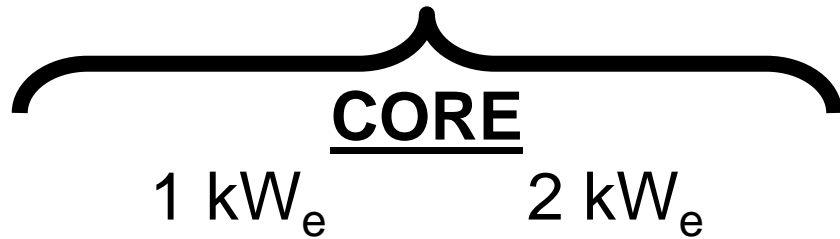


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LTPR Developmental Basis

HTPEM Systems



Regenerable Adsorbent

Exceeded 2007 capacity target, met 2008 capacity target.
300 system hours @ 30 ppmw S outlet

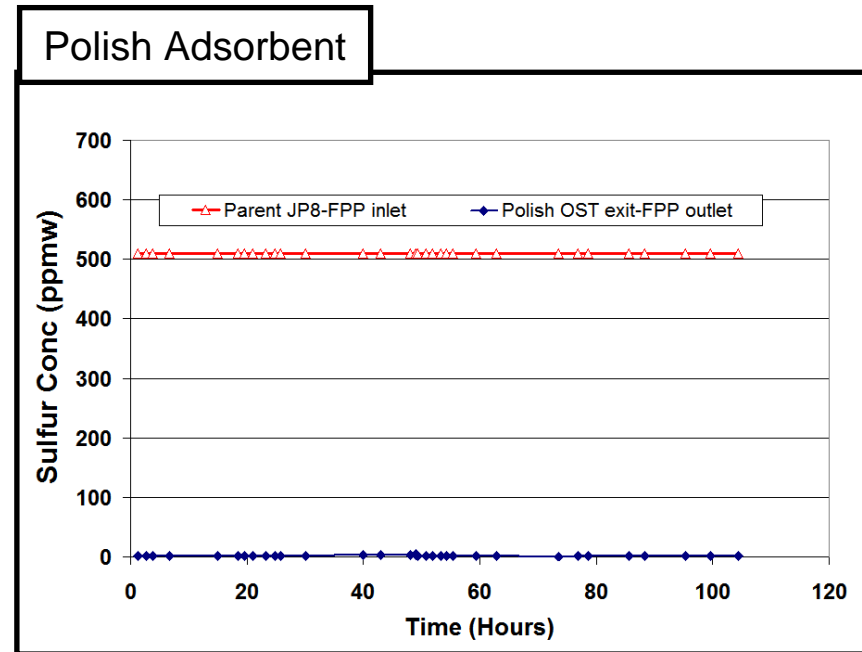
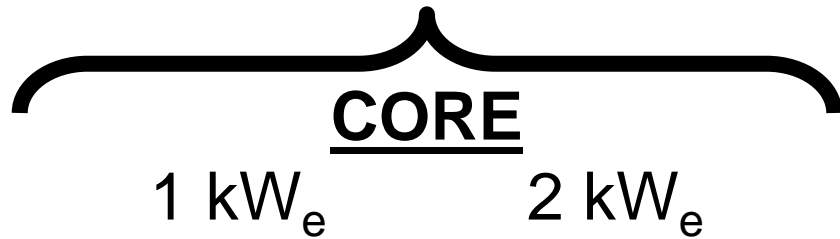


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LTPR Developmental Basis

HTPEM Systems



Polish Adsorbent
Meets system targets.
100 hours @ < 1 ppmw S outlet

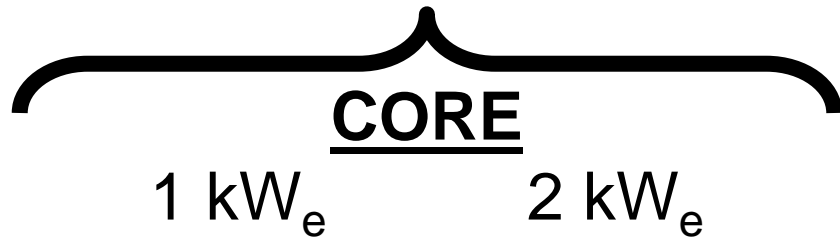


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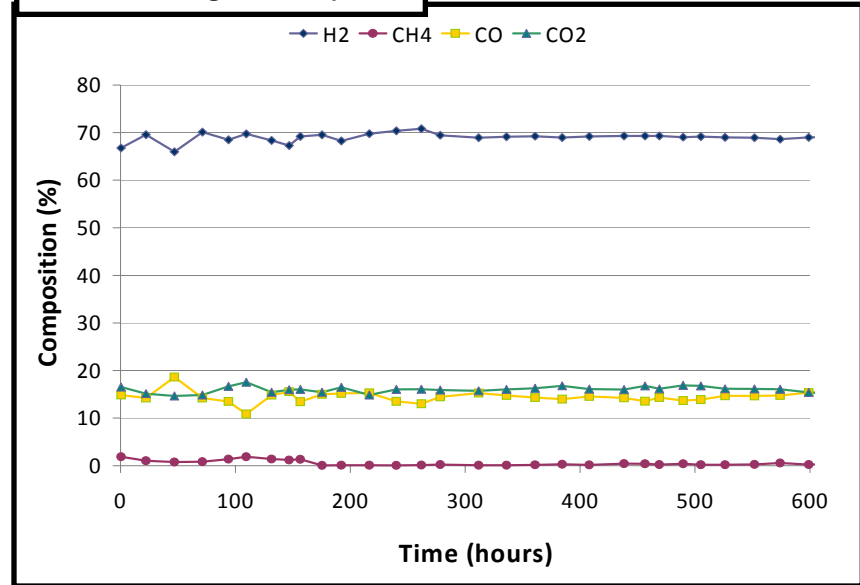


LTPR Developmental Basis

HTPEM Systems



Reforming Catalysts



Prereformer and Reformer Catalysts

Operated on desulfurized JP-8
> 600 hours @ 100% conversion

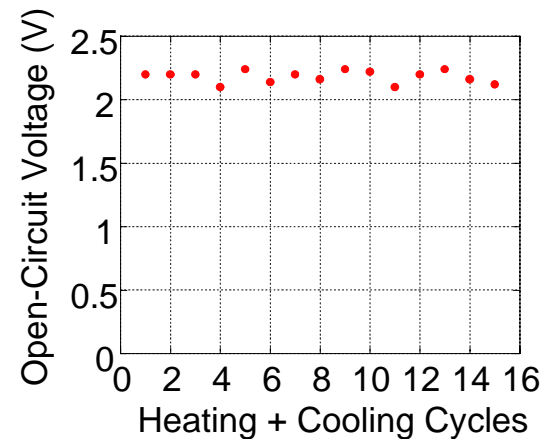
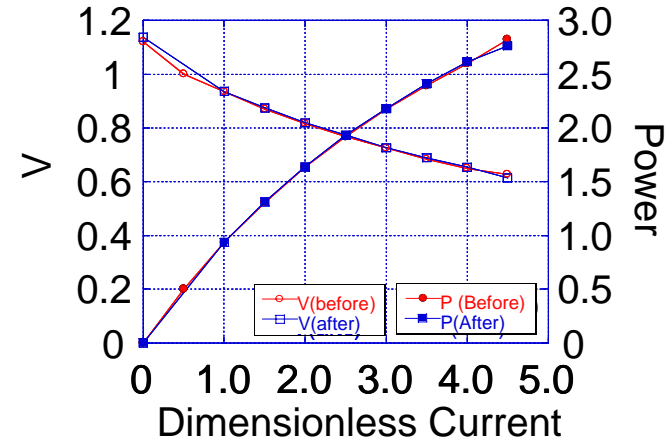


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SOFC Developmental Basis

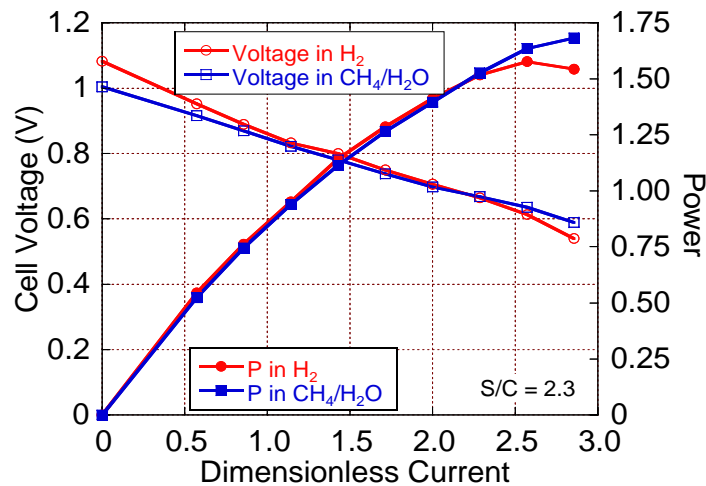
- Stable to redox and thermal cycling
 - Anode exposed to air at operating temperature
 - Thermally cycled in air
 - No noticeable decay in performance



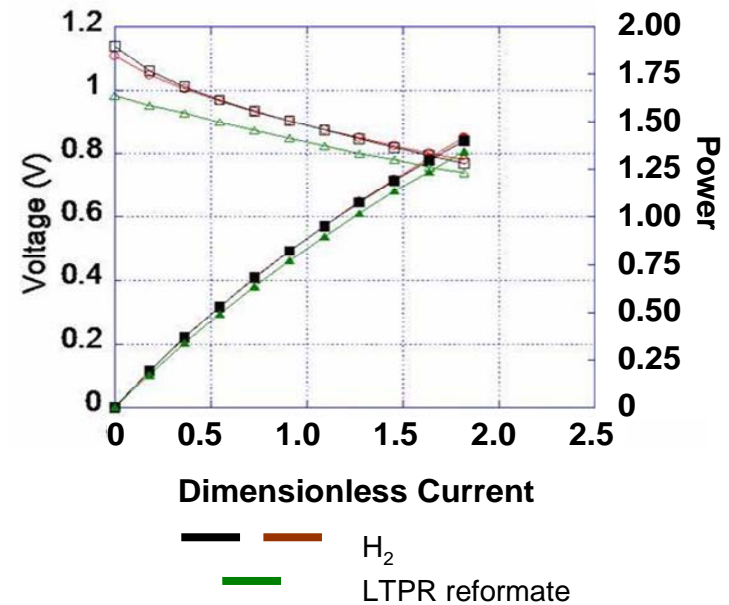
SOFC Developmental Basis

Performance on fuels other than hydrogen

30% CH₄, 70% H₂O



JP-8 Reformate from Altex reformer

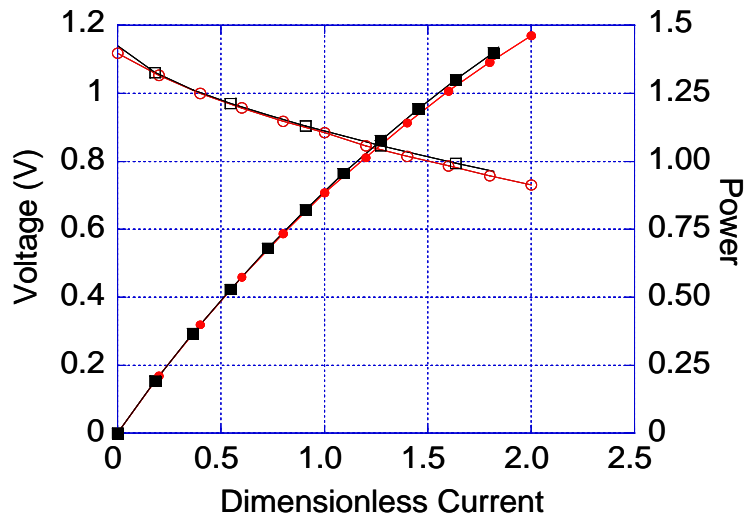


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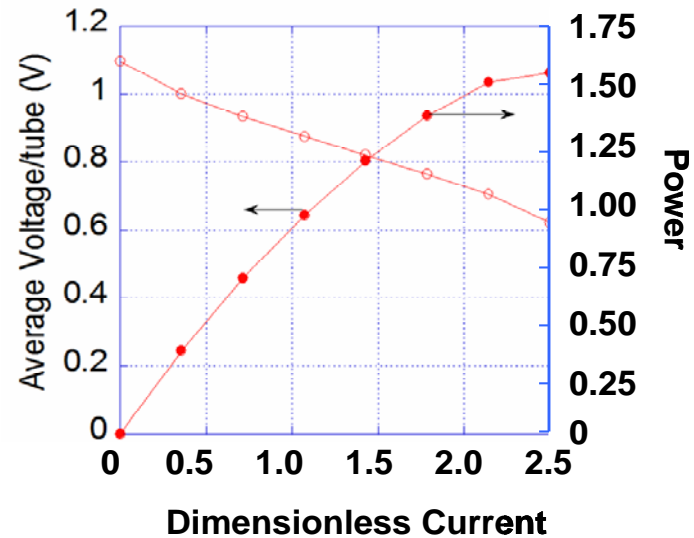


SOFC Developmental Basis

Single-cell performance is maintained in sub-scale stacks



Performance of single cell.



Average cell performance in the sub-scale stack.



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Altex System Integration and Delivery Experience

Stand-alone logistic Fuel Preprocessors.



ONR
JP-5



AFRL
JP-8

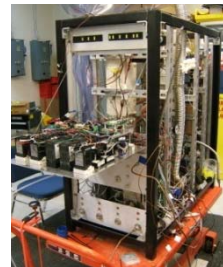


ONR
NATO-F76

Logistic-fuel reformers

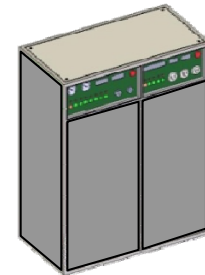


ARL
2 kW_e



CERDEC
2 kW_e

Logistic-fuel power systems



TARDEC, EPA, NAVAIR, ONR
CORE (HTPEM)



CERDEC
LTPR-SOFC

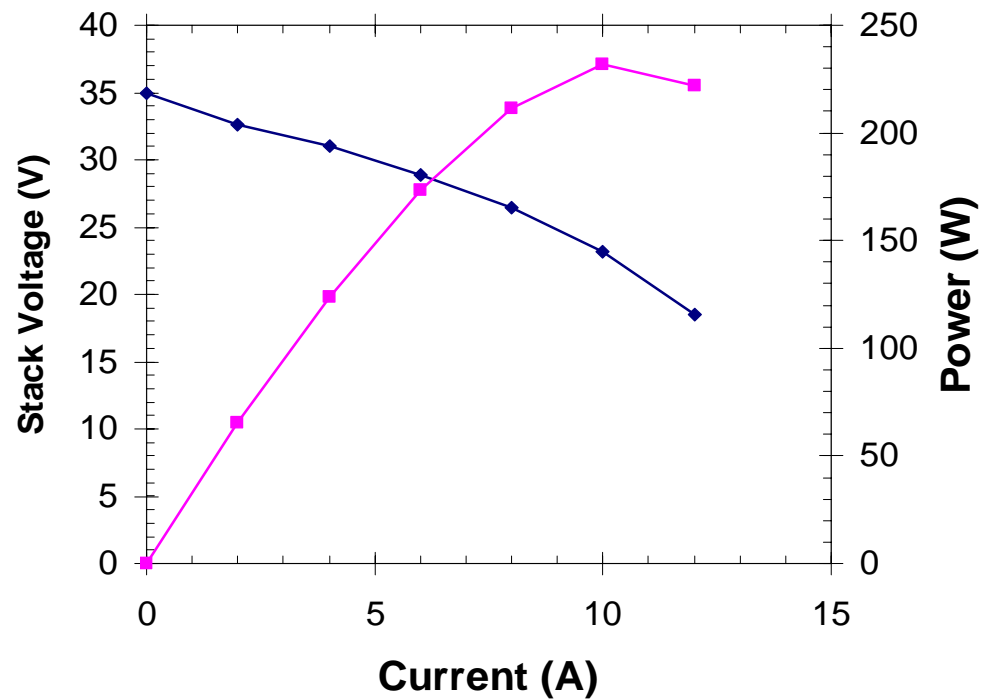


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Full-Scale LTPR-SOFC Testing

Gen-1 stack used for thermal integration tests



Gen-2 stack to be tested in box

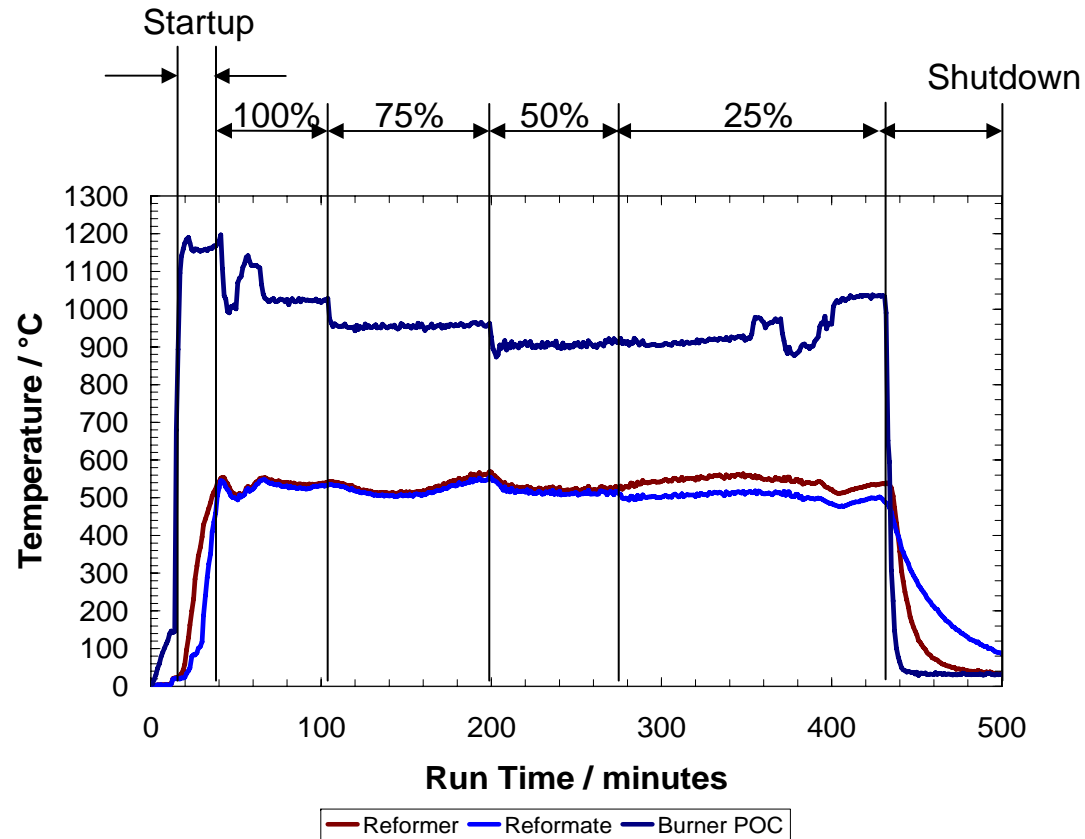


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Full-Scale LTPR-SOFC Testing

Reformer Load Variation Testing

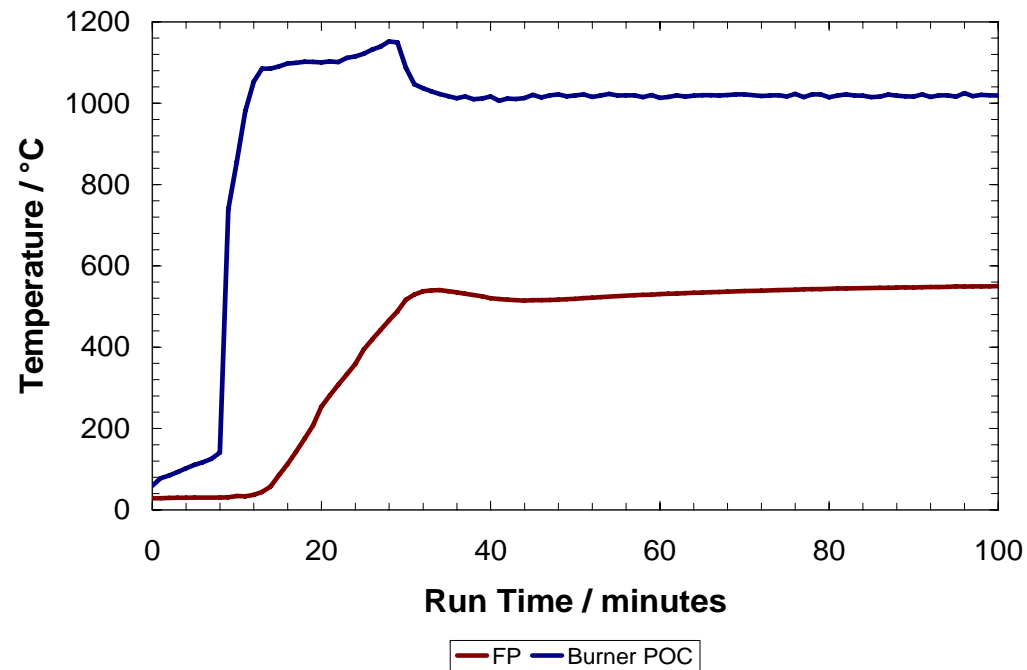


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Full-Scale LTPR-SOFC Testing

Reformer Startup 20-30 min

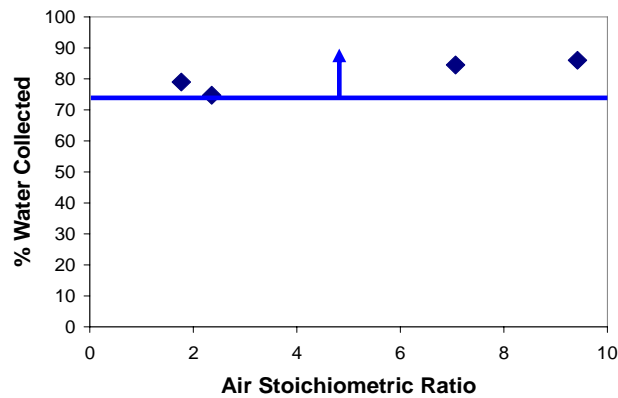


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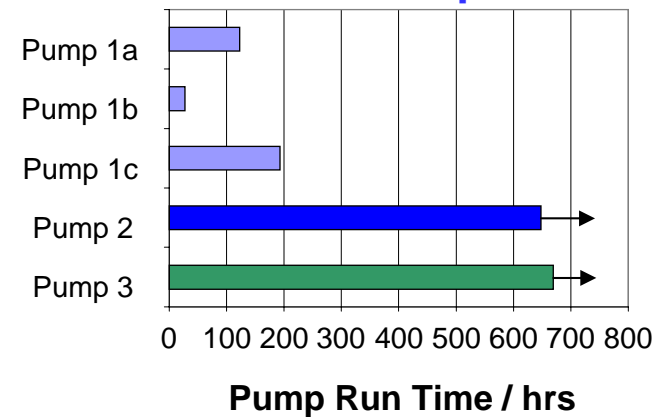


BOP Components

Condenser performance meets water-neutrality requirements



Pumps identified and tested for over 600 hours of operation



Power-conditioning components integrated and used for BOP power



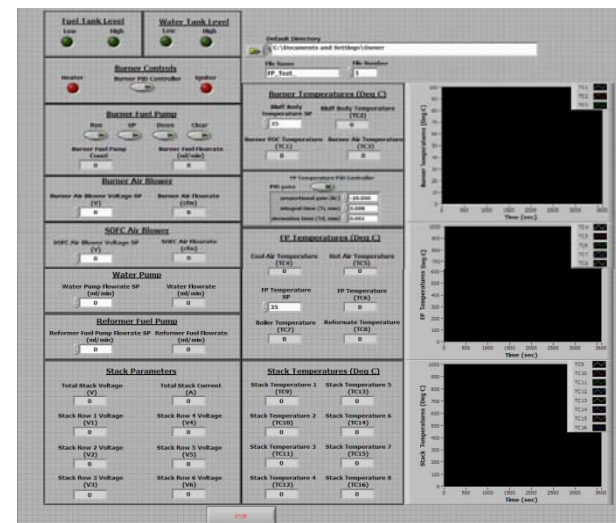
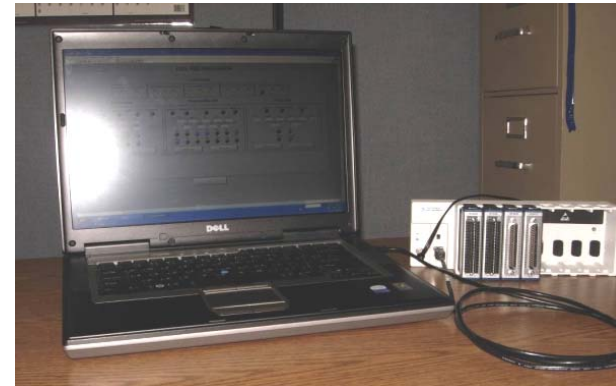
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DAQ and Control Systems

Control-system development leveraged from CORE programs

- PC-based automated control system being developed for CORE-10 system
- 8-slot chassis with analog and digital I/O modules interfaced with a laptop
- I/O modules interface with signal conditioning hardware (developed by Dewey) to control the BOP
- LabVIEW-based Virtual Instruments (VIs) developed to control the operation of the system based on programmed sequence and user defined set points.



LTPR-SOFC Prototype System

Photograph of the system being constructed



- Two NEMA-1 standard enclosures
- 20 in x 20 in x 17 in (113 L)
- BOP, blower and pump controllers, and power conditioning all included



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LTPR-SOFC Status

Priority Draft Specifications for Fuel Cell Battery Charger

Specification	Threshold Target	Objective Target	LTPR-SOFC Status (TRL4+)	Final Product Goals (TRL9)
Size ^(a)	80 L	50 L	~115 L	30 L
Weight ^(a)	30 kg	22 kg	~30 kg	15 kg
System energy density				
72-hour mission ^(b)	225 Wh/L	360 Wh/L	~140 Wh/L	500 Wh/L
Run time on 2-L fuel charge	4 hours	8 hours	>15 hours	> 20 hours
Power output	250-500 We 21-30 Vdc	250-500 We 21-30 Vdc	250 We 24 Vdc	250 We 24 Vdc
Reliability				
Lifetime	2,000 hours	5,000 hours	TBD	10,000 hours
Shelf Life	3 years	5 years	TBD	5 years

a) Including fuel for a 72-hour mission

b) Calculated based on 250 W continuous power for 72 hours and size specifications



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Size and Weight Reduction Strategies

- LTPR and SOFC
 - Physical size $\sim 500 W_e$
- Control System
 - Replace controllers, DAQ, PC w/cRIO then custom PCB w/power conditioning
- Packaging
 - Custom box to reduce unused space





LTPR-SOFC Future Plans

- SBIR Phase II Completion
 - Test integrated system in box
 - Deliver to CERDEC for independent testing
- With follow-on funding
 - Size and weight reduction
 - Customized ergonomic box
 - TRL advancement



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Acknowledgements

Altex	Mehdi Namazian, Guha Venkataraman, Siva Sethuraman, Evan Elder, Archana Bhalerao, Carlos Stephenson, Thuy Maw
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