Development of a Low Cost 3-10kW Tubular SOFC Power System

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FC032

This presentation contains no proprietary, confidential, or otherwise restricted information

Overview

Timeline

- Project Start: 4/1/2008
- Project End: 9/30/2012
- Percent Complete: 95%

Budget

- Project Funding
  - DOE Share=$11,692,737
  - Contractor=$3,897,579
- Funding Received
  - 2011 $0
  - 2012 $537,838

Barriers

- Cell Power Density
- Stack Power Density
- Cell Cost Reduction
- System Cost Reduction
- System Efficiency
- Lifetime

Relevance/Objectives

- Improve Cell Power & Stability
- Cost Reduce Cell Manufacturing
- Increase Stack & System Efficiency
- Prototype Testing to meet system efficiency and stability goals
- Integrate to remote power and mCHP platforms to allow short and longer term market penetrations

Technical Approach

Perfect the individual System pieces followed by optimizing their integration:

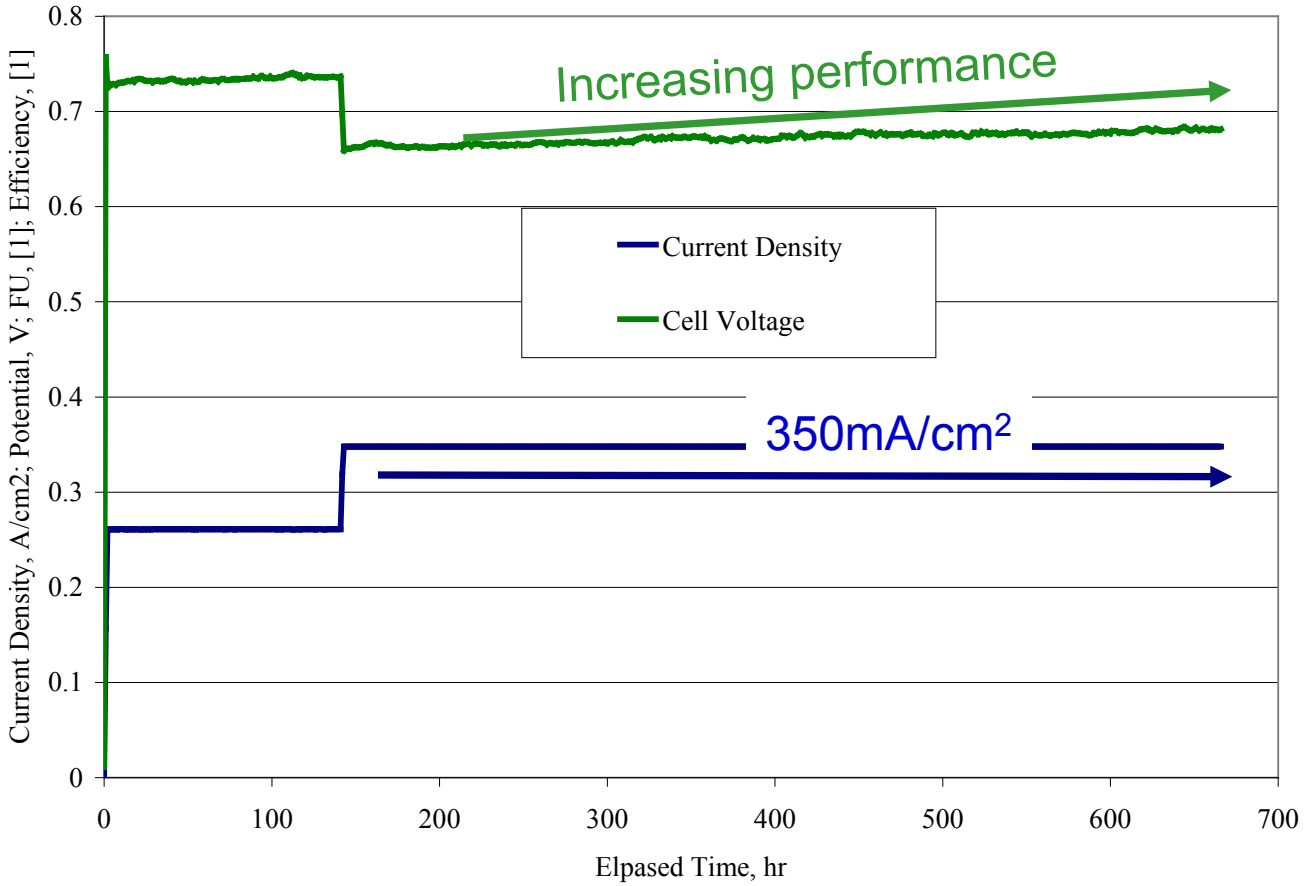
- **Cell Technology:** Improve power & stability of the cell building block
- **Cell Manufacturing:** Improve processing yield & productivity while decreasing material consumption
- **Stack Technology:** Refine stack assembly and improve heat removal and integrity while cost reducing components
- **System Performance:** Develop simplified controls and BOP to allow for a reliable, highly efficient unit.

Proposed Future Work-2011 Annual Meeting

- Assure cell stability
  - Continue testing at 250 to 400mA/cm^2 current density
  - Further demonstrate stability over thermal cycles through cell & stack testing
- Continue cost reductions on each product platform
  - Continue cell manufacturing automation-maintaining performance
  - Reduce Generator & BOP costs to levels allowable for remote power products – complete “make/buy” decisions on all major sub-assembleis
- Move from field testing of first market products to second market products
  - Continue to build on success of remote power units and accept commercial orders
  - Field demonstrate liquid fueled military units in the 1-3kW range.

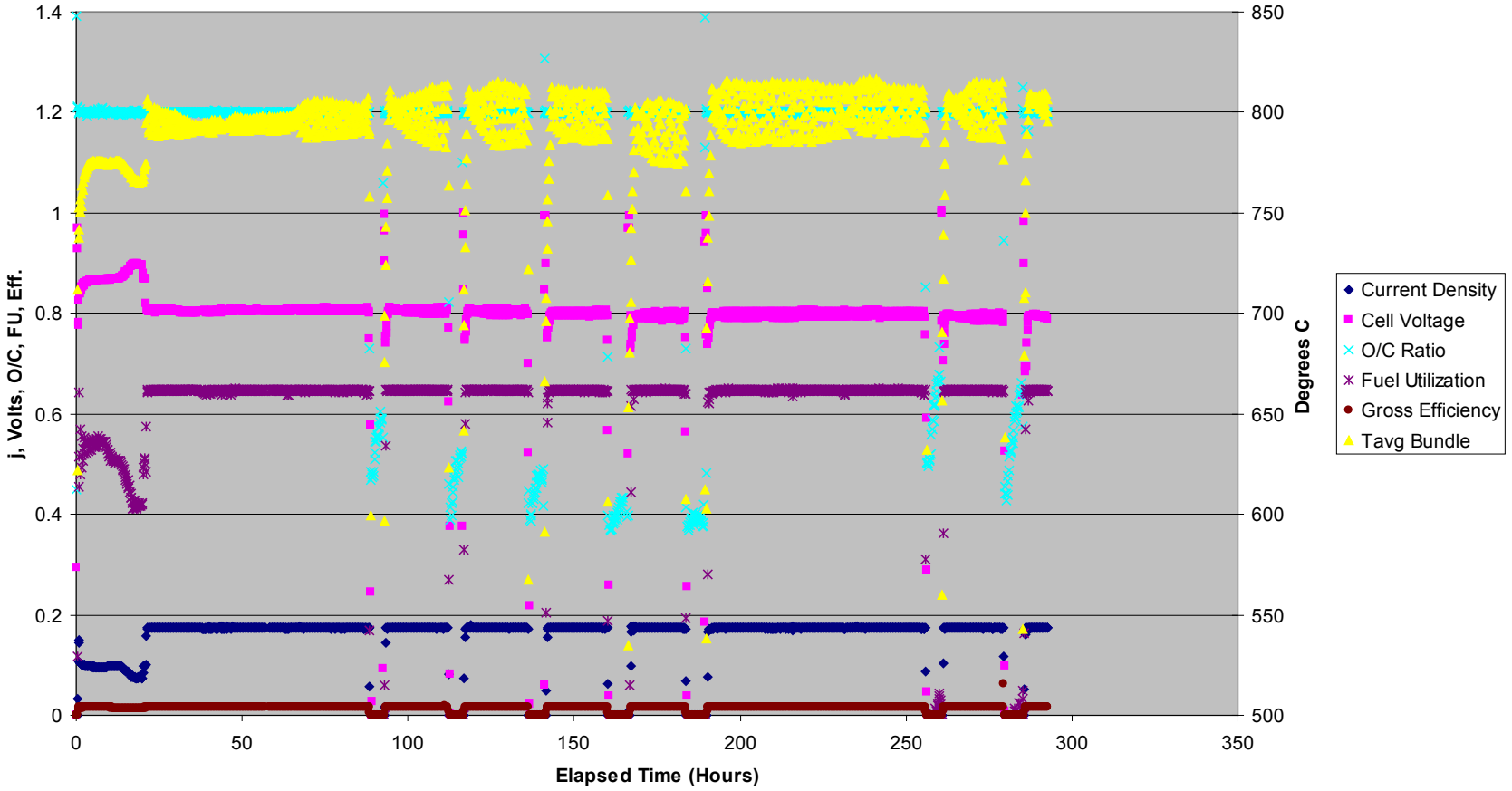
Technical Accomplishments & Progress

Maintained Voltage Stability increasing current density from 150 to 250 to 350mA/cm^2 over life of program



Technical Accomplishments & Progress

Performance Loss <2% over 20 thermal cycles on Full System Testing



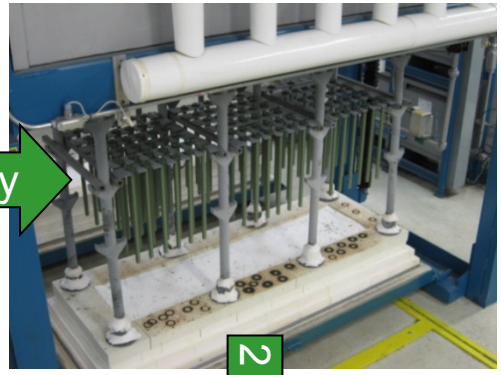
Tri-sintering development – Process Step Removal

2.5 Days

0.5 Day

2 Days

0.5 Day



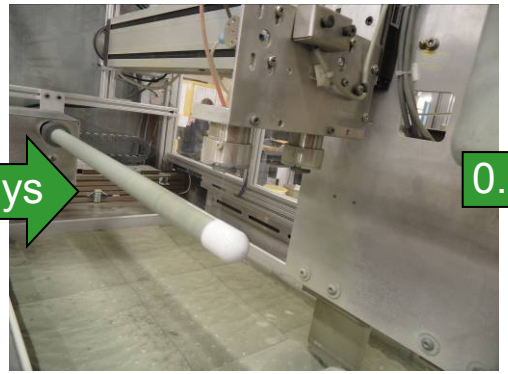
2 Days

7.5 Days to process 100 tubes through to electrolyte sinter using standard processing methodology

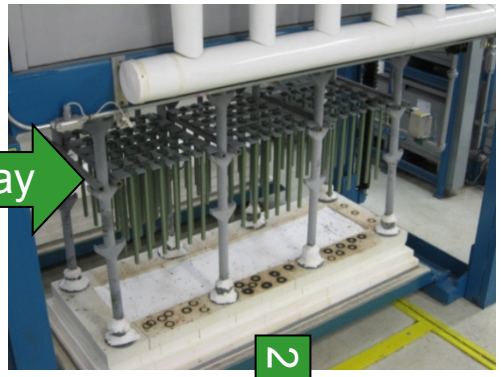
Technical Accomplishments & Progress

With the development of a tri-sinter for the tube, active anode and electrolyte, a significant time saving will be realized

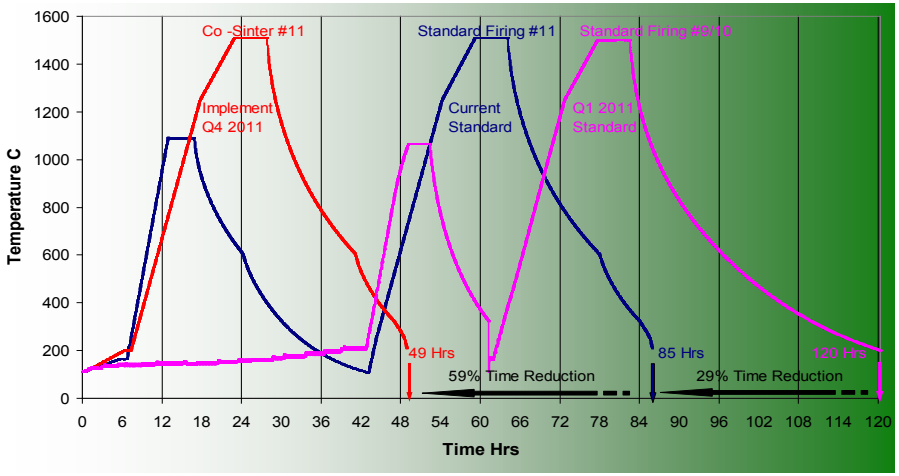
2.5 Days



0.5 Day



2 Days

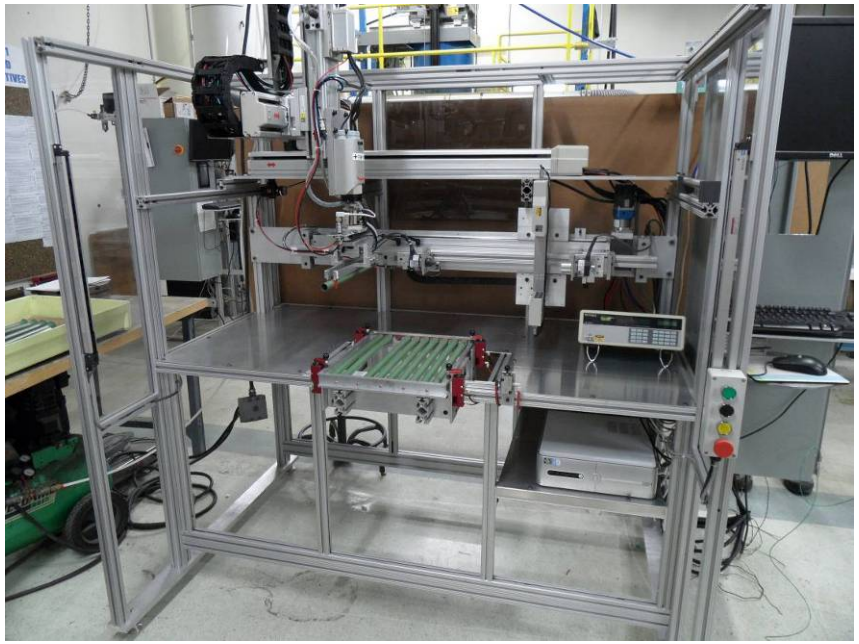


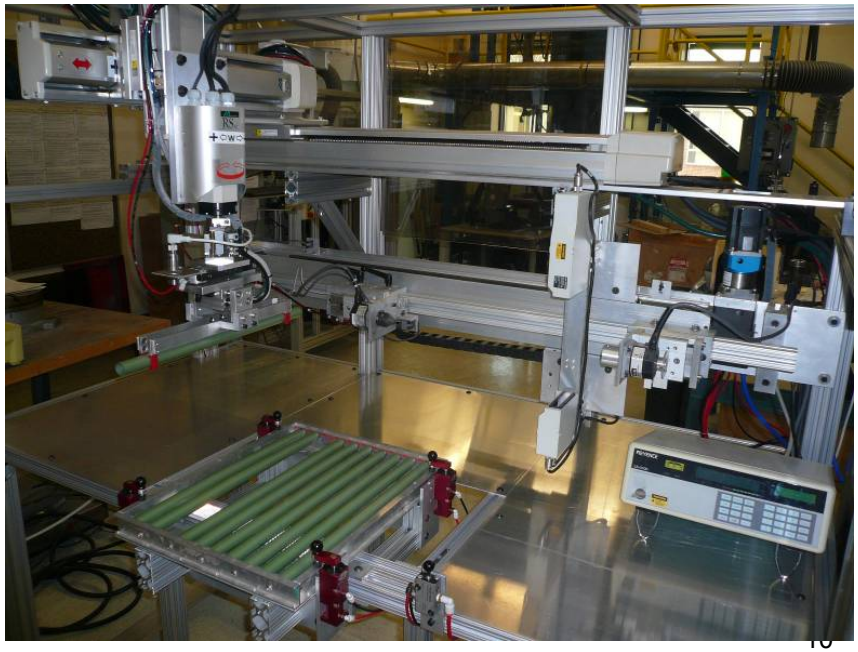
5.0 Days to process 100 tubes through to electrolyte sinter using proposed tri-sinter

2.5 Day improvement

Technical Accomplishments & Progress
Pick & Place Robot – Straightness Measurement

- Removes labor from tube straightness and coating thickness QC measurements.
- Enabled QC data to be collected on larger sample sizes without additional labor – set baseline for quality
- Developed load/unload robotics for many future automation projects
- Common part holder utilized





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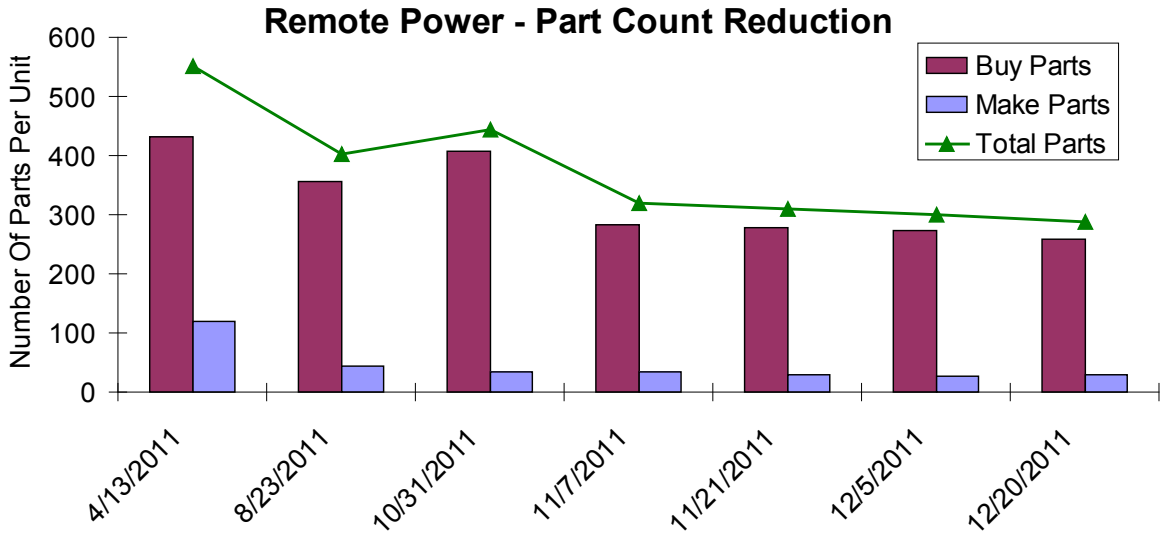
Technical Accomplishments & Progress
Pick & Place Robot – Cathode Spraying

- Fully automated cathode and barrier layer spraying
- Slurry management system implemented – improved coating uniformity
- Elimination of all masking
- Slurry utilization near 100%
- Common part holder utilized

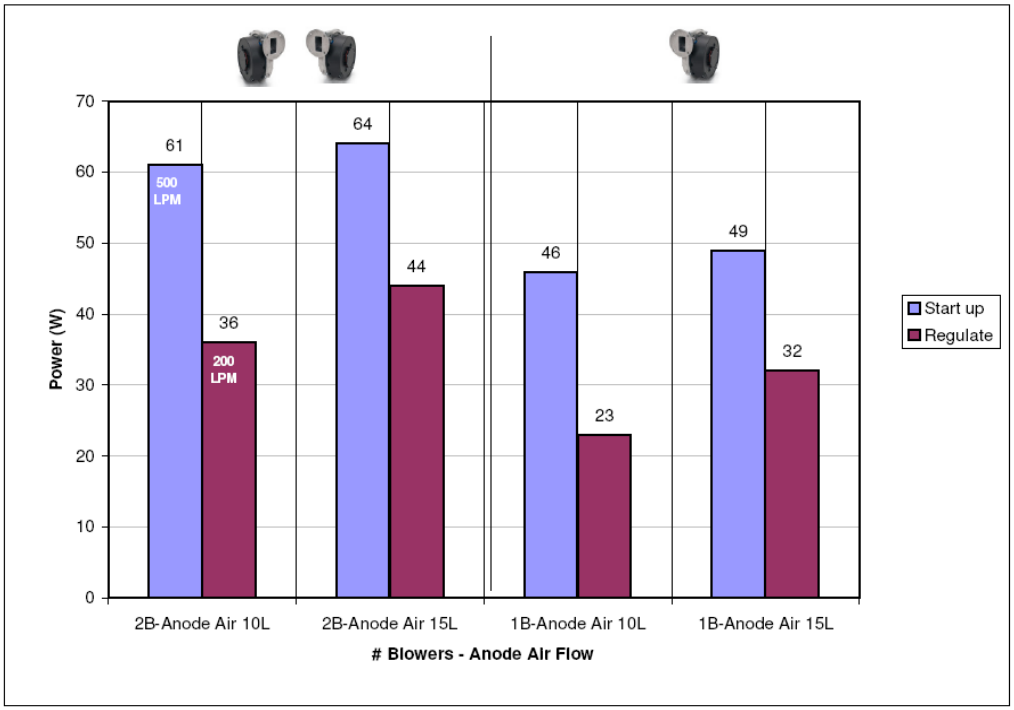
Manufacturing Development Activities

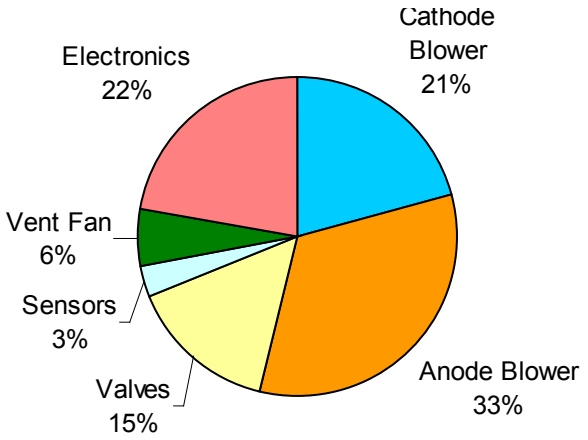
- Established 4 assembly lines leading to final assembly area

- Part count has been reduced from 551 to 287 since April 2011



Simplified BOP- Parasitic Power Reduction

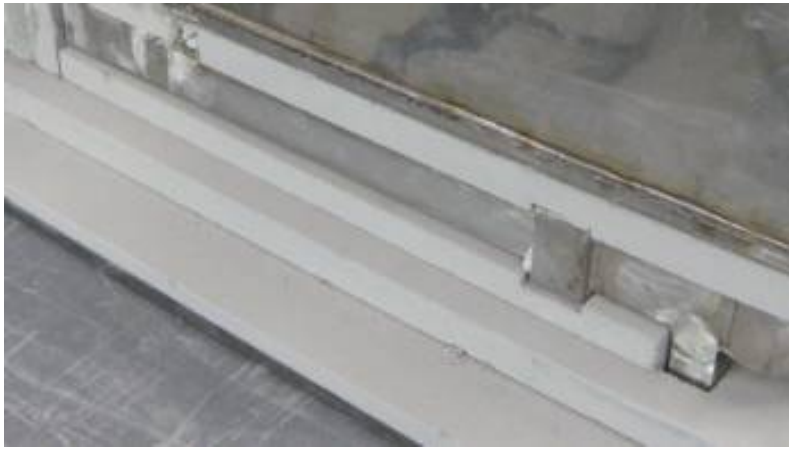




	Power (W)
Cathode Blower	17
Anode Blower	27
Valves	12
Sensors	3
Vent Fan	5
Electronics	18
	81

Cost Reduction of Fuel Cell Module

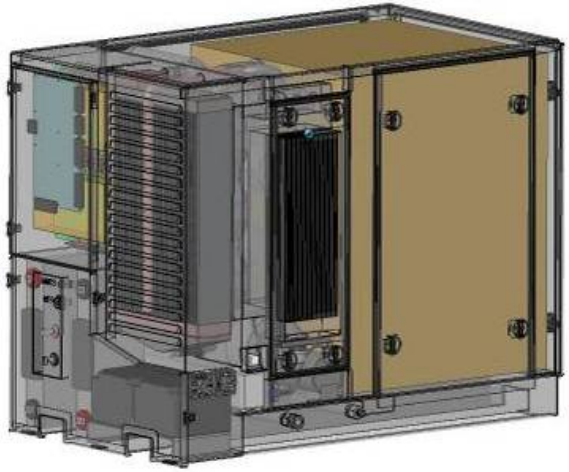
- Simplified metal forming and welding
- Outsourced routine fabrication
- Thermal Insulation cost reduced by 65%, 85% potential
- Recuperator cost reduced by 45%



Product Portfolio

Remote Power

Military Generators



mCHP

Remote Communication Applications

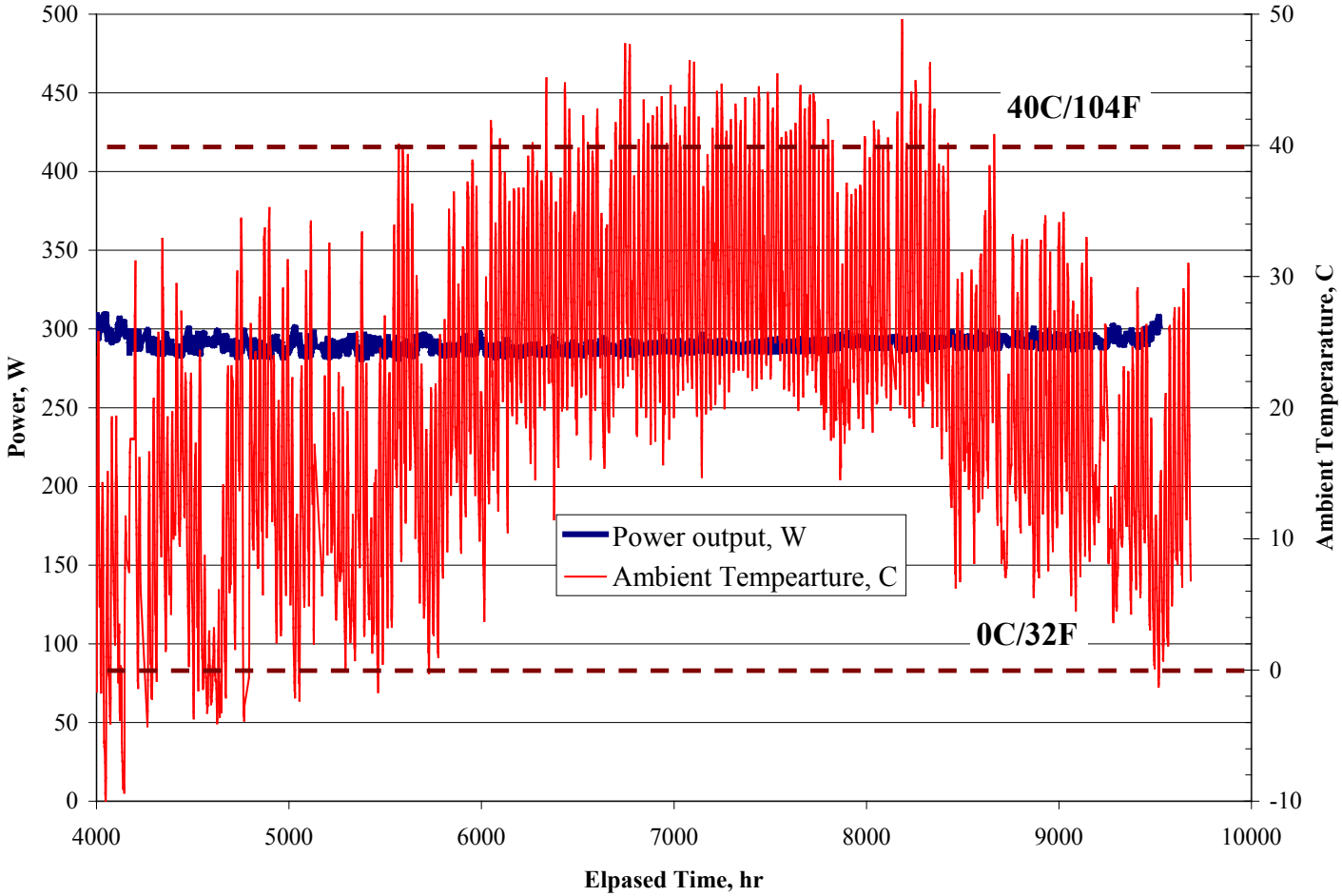
- Powering Communication systems where solar not applicable
- Reciprocating engines not applicable due to low MTBF
- Powers ranging from few 100W to kW's

Remote DC Power Installations

- Three Units Initially Installed
- Follow on order for 25 units
- Operating with multiple DC outputs
- Longest units in field for 9 months with high 90's reliability

System Experience –Ambient Extremes

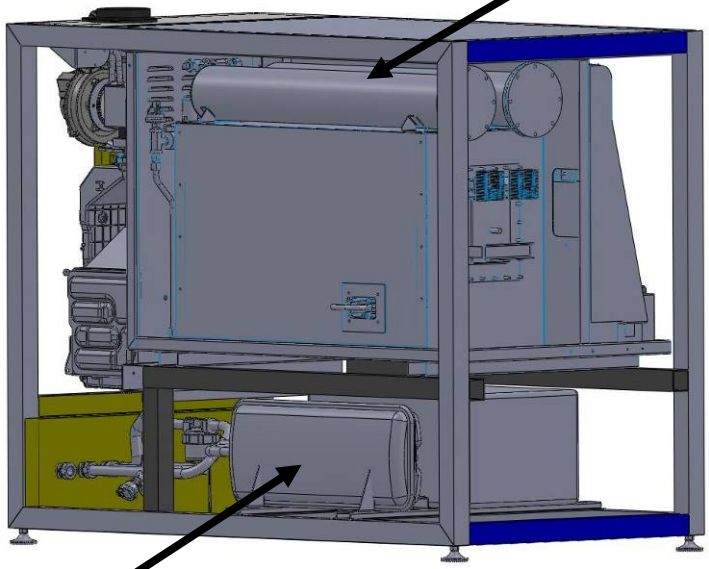
Long term internal testing at 40-45C (104-113F) has shown no negative impact on life

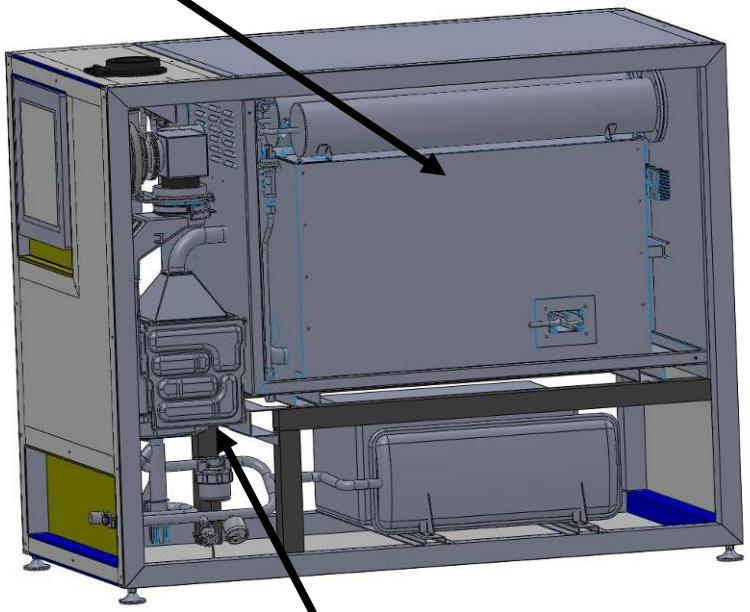


Rollup Statistics

- Alpha Units (11 units)
  - 72,250 operational hours
  - 36,074kW-hr produced
  - 73.4% availability
- Beta Units (15 units)
  - 34,379 operational hours
  - 12,568kW-hr produced
  - 91.2% availability

mCHP – RP-20 Integration





Testing in Italy & Switzerland late 2012/early 2013

1kWe, 20kWt

Certified to European Standards

Proposed Future Work

- Complete RP-20 mCHP integration
- Continue cost reductions on each product platform
  - Continue cell manufacturing automation-maintaining performance
  - Reduce Generator & BOP costs to levels allowable for remote power products – complete “make/buy” decisions on all major sub-assembleis

Summary

- Increased power output and thermal cycle capability of system from cell level
- Significant cost reductions in cell and overall system to allow for market introduction
- Improved reliability of overall system exceeding that available for power generation in the field
- Continue to make steady progress into short, medium, and long term markets for fuel cells.

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Back-up Slides

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Sumitomo Corporation

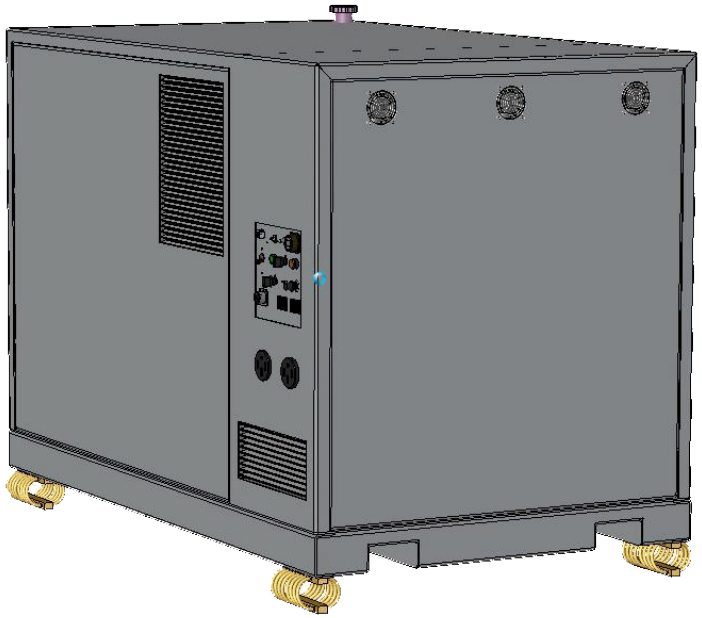
MiSource

Northeast Utilities System

- *~ 85 Employees*
- *Manufacturing since 1994*
- *Based in Westwood, Mass.*
- *~40,000 sq. ft facility*
- *Critical disciplines in-house*
  - Electrical Engineering
  - Mechanical Engineering
  - Chemical Engineering
  - Thermal Modeling
  - Ceramics Processing
  - Manufacturing
  - Sales & Marketing
  - Automation
  - Finance

10kW SOFC Tactical Quiet Generator

- Efficiency: >30%
- Noise: <55 dB @ 7 m
- Shock/Vib: Mil Std 810F
- MTBO: 5000 hrs
- Startup: Full power in 30 mins
- Oper. Temp: -30 to +60 C

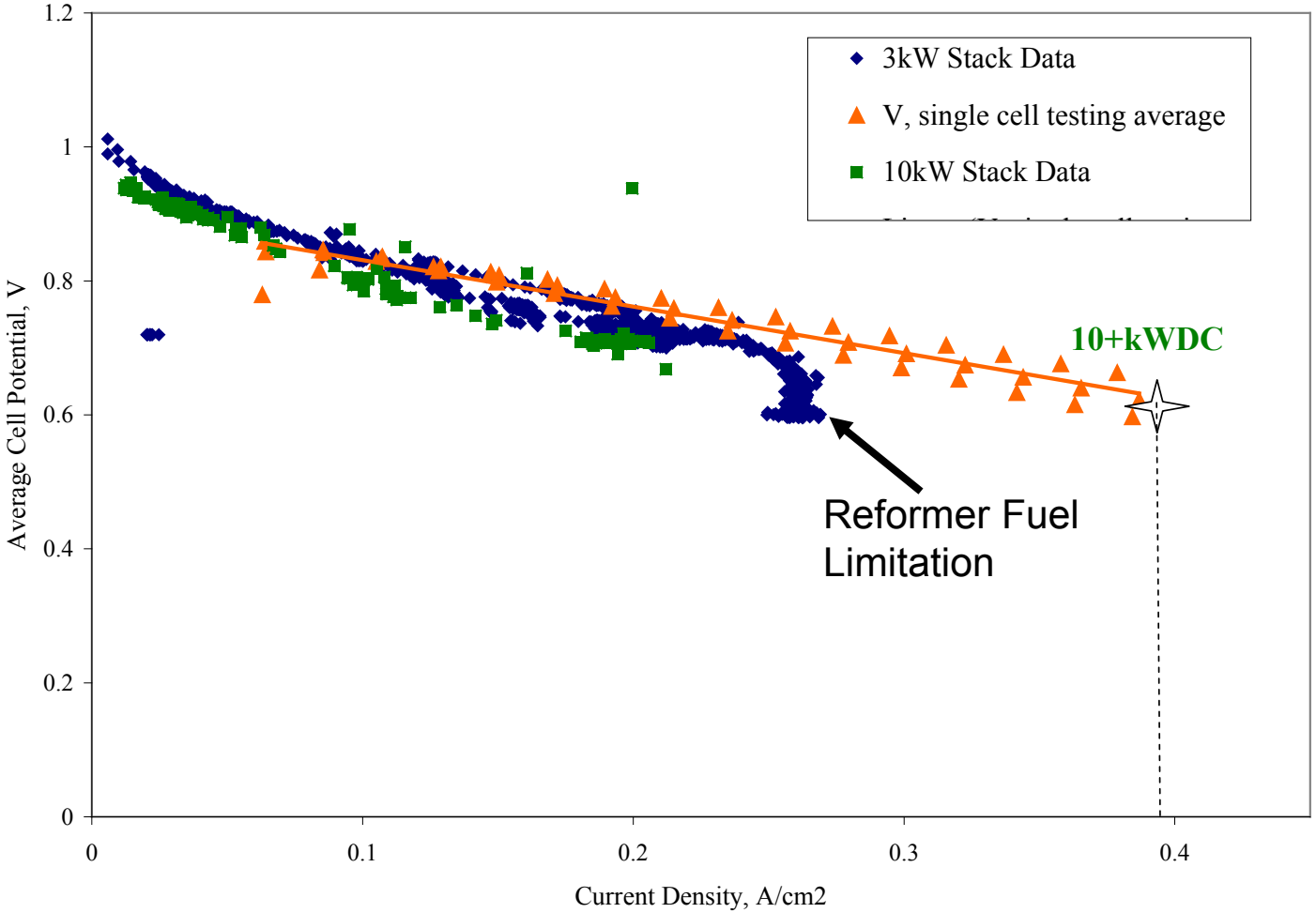


Versus Present TQG

>50% gain in power Density

>50% gain in efficiency

Comparison of Single Cell & Liquid Fuel System Performance



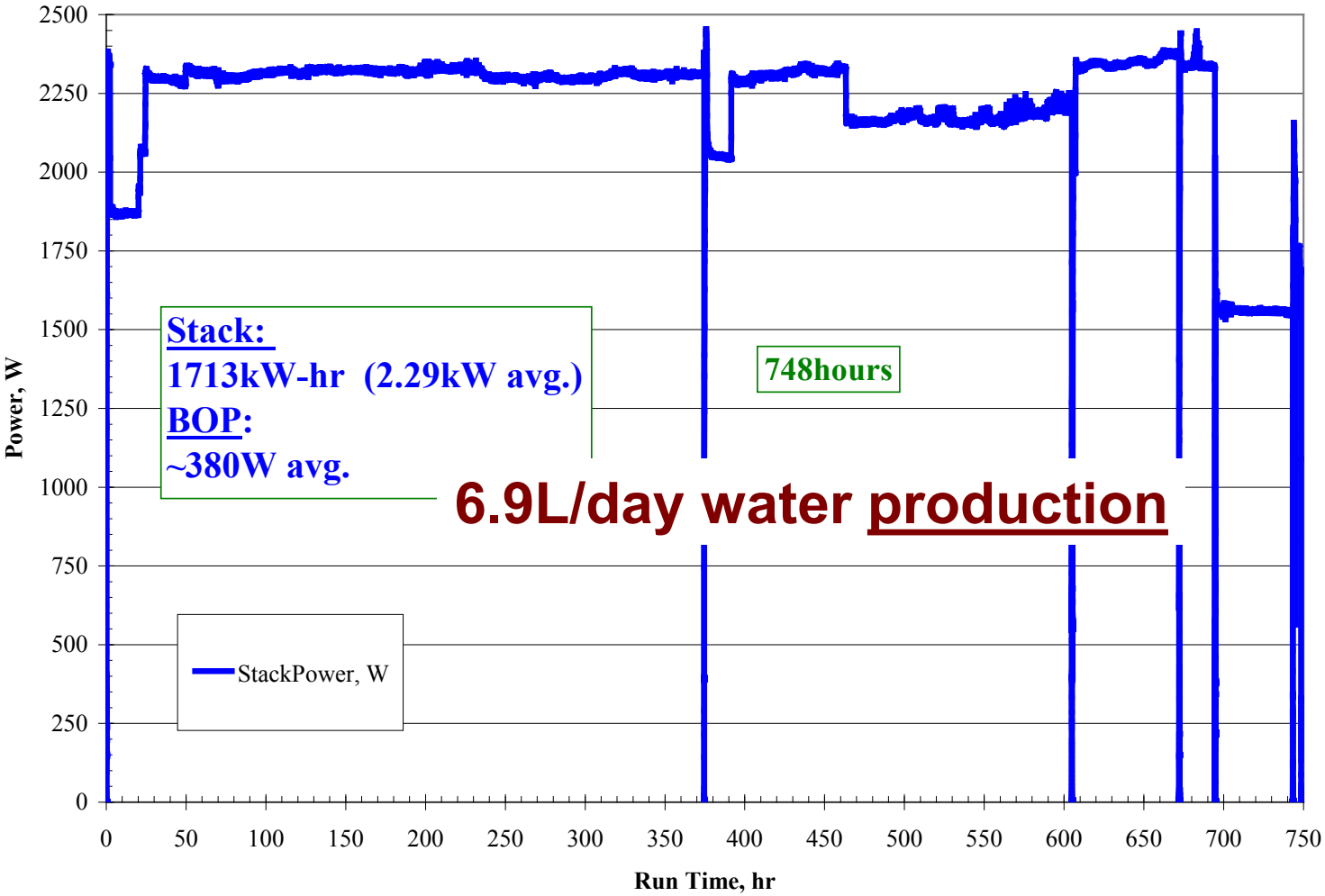
Liquid Fueled 3kW Unit

Unit mounted on Trailer 45A

Exhaust

Water Gauge

Liquid Fueled System validation



Thanks to

- Reginald Tyler of the DOE-Golden Office
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- Technical Staff at Acumentrics