

***Validation of Novel Planar Cell  
Design for Megawatt-Scale  
SOFC Power Systems***

**M.J. Day, Principal Investigator**

**12<sup>th</sup> Annual SECA Workshop**

**Pittsburgh, PA**

**July 28, 2011**

### ***NexTech News***

- Achieved ISO 9001:2008 certification for all products and processes within NexTech
- Launched hydrogen safety sensor product(s), and recently passed UL/ATEX certification tests
- Launched interconnect coating product
- Continued progress made on SOFC stack technology development

### ***Outline***

- Project Details, Objectives, Conclusions
- Introduction to *FlexCell*
- Status of NexTech's SOFC Stack Technology
- Results of SECA Project
- Future Work

***Project Details, Objectives,  
and Conclusions***

### ***Project Details***

#### U.S. Department of Energy (SECA)

- DOE Contract Number: DE-NT0004113
- Project Monitor: Briggs White
- Phase I: 1-Oct-08 to 31-Mar-10
- Phase II: 1-Apr-10 to 30-Sep-11

#### State of Ohio (Third Frontier Program)

- *Cell Manufacturing for 100+ kW SOFC Power Generation Systems*
- ODOD Contract Number: TECH 08-057

#### NexTech's Team

- Principal Investigator: Mick Day
- NexTech Contributors: Scott Swartz, Lora Thrun, Kellie Chenault
- Subcontractor: Ohio State University (Professor Mark Walter)



# ***Project Objectives***

### **Overall Project Goal**

- Validate performance, robustness, cost and scalability of NexTech's *FlexCell* planar cell design for coal-based SOFC power systems

### **Phase I Objectives**

- Demonstrate that high performance can be achieved in *FlexCells* made with YSZ as the electrolyte material
- Demonstrate that *FlexCells* have sufficient mechanical robustness for SOFC applications
- Demonstrate potential of achieving cell manufacturing cost of less than \$50/kW

## *Conclusions*

- Fabrication methods for ScSZ-based *FlexCells* were successfully transferred to YSZ-based *FlexCells*.
- YSZ-based *FlexCells* successfully scaled to 500-cm<sup>2</sup> area.
- High performance in YSZ-based *FlexCells* has been demonstrated at the single-cell (and stack) level.
- Finite element analysis is an effective design tool for mechanically robust *FlexCell* architectures.
- Cell manufacturing cost was estimated to be \$51/kW at 250 MW/year scale

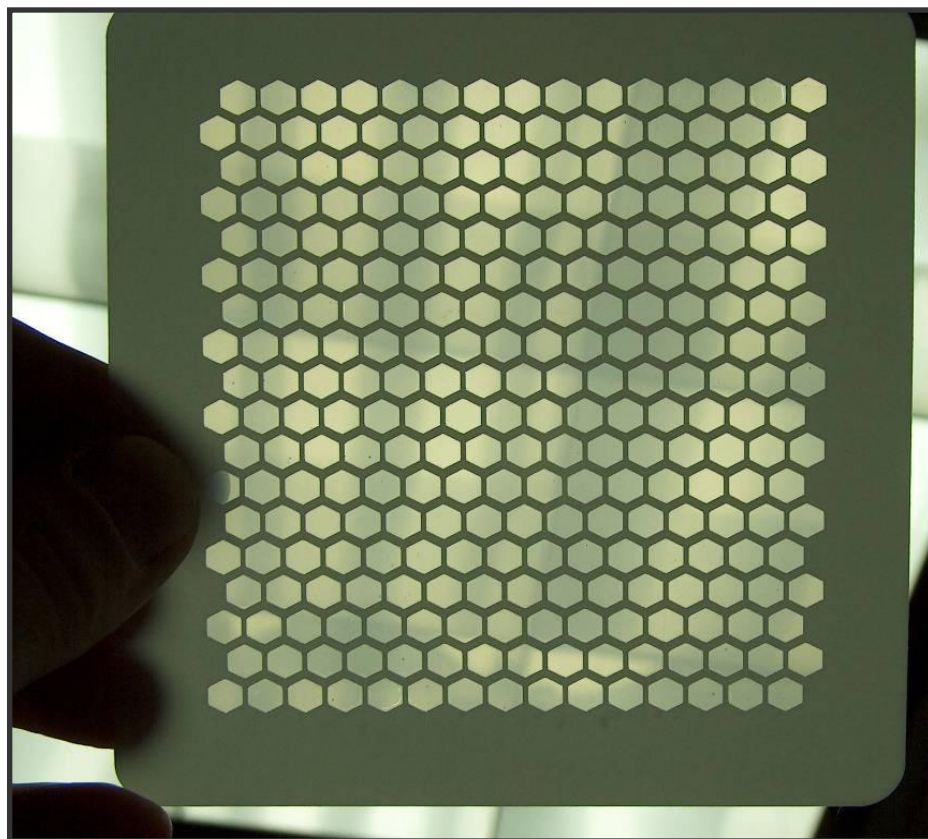
# ***Introduction to the FlexCell***



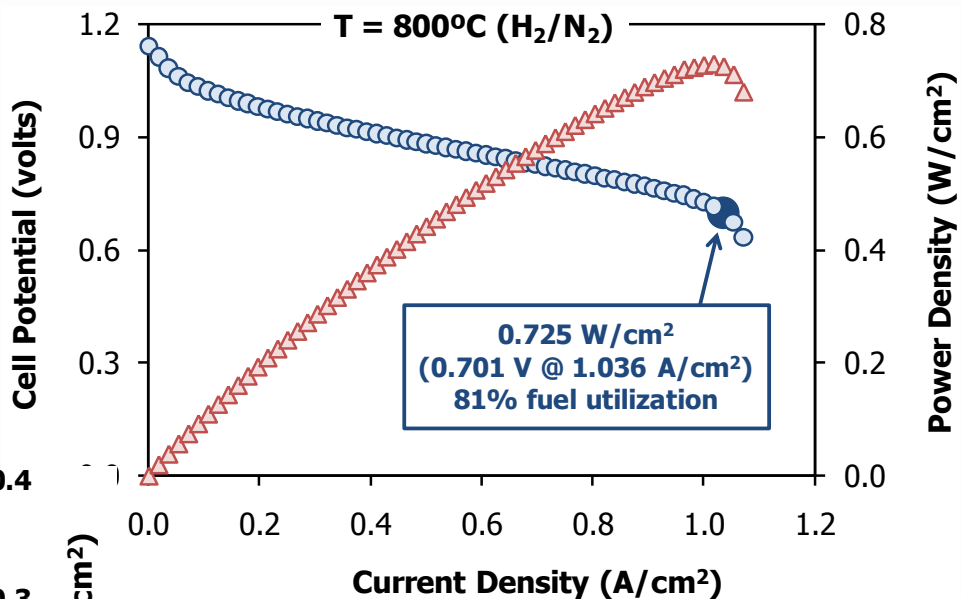
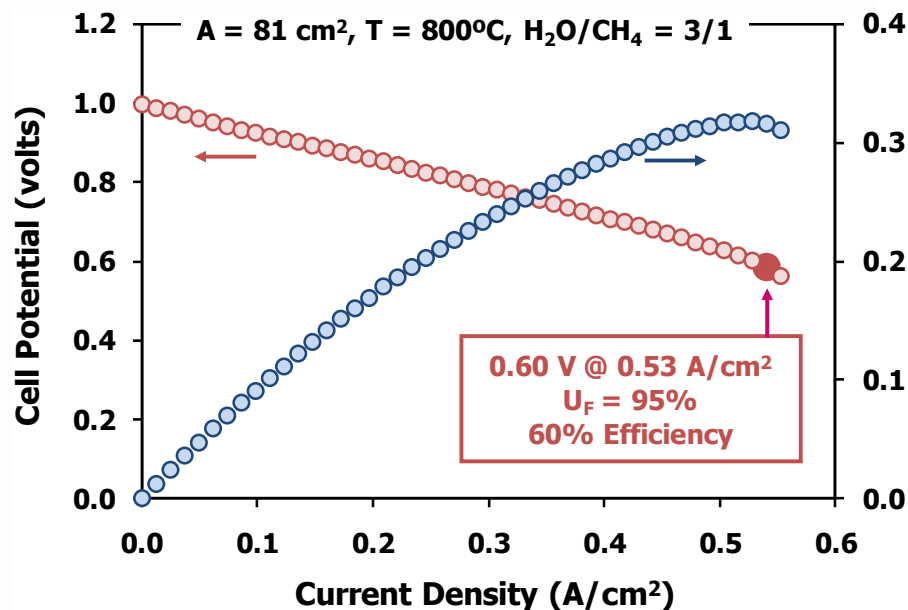
## ***Introduction to the FlexCell***

### **Attributes**

- Thin-electrolyte for high performance
- Small repeat units for high power density
- Dense perimeter for ease of sealing
- Thin electrodes to facilitate gas diffusion
- Thin anode for redox cycling tolerance
- Electrode material flexibility



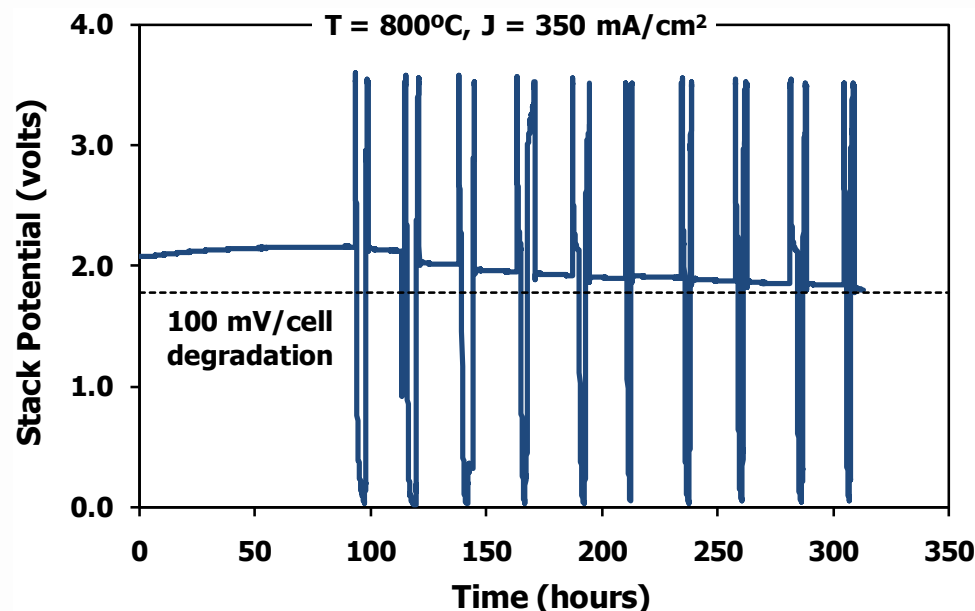
### Performance Attributes



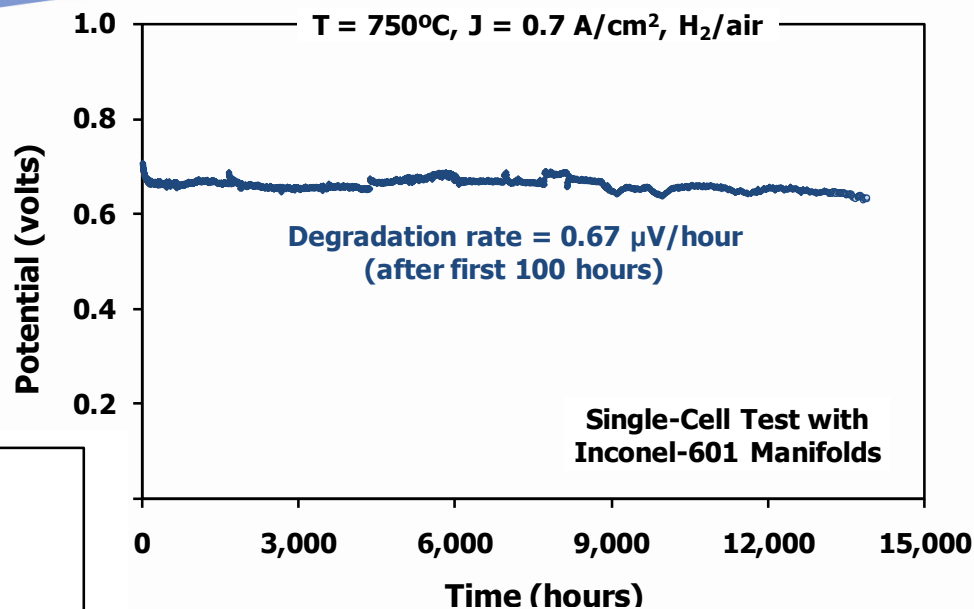
High power density  
and high fuel utilization

Internal Methane Reforming

### ***Durability Attributes***

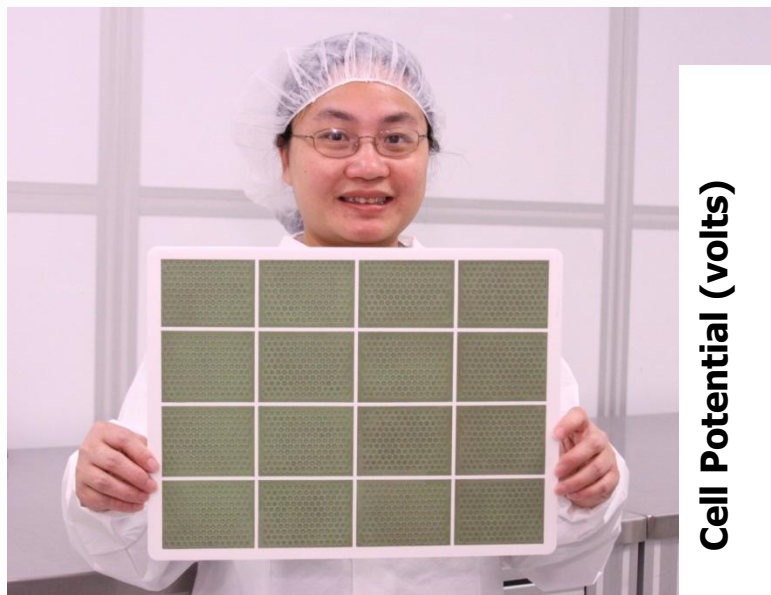


Redox Cycling Capability  
(3-cell stack, Hybrid Cells)



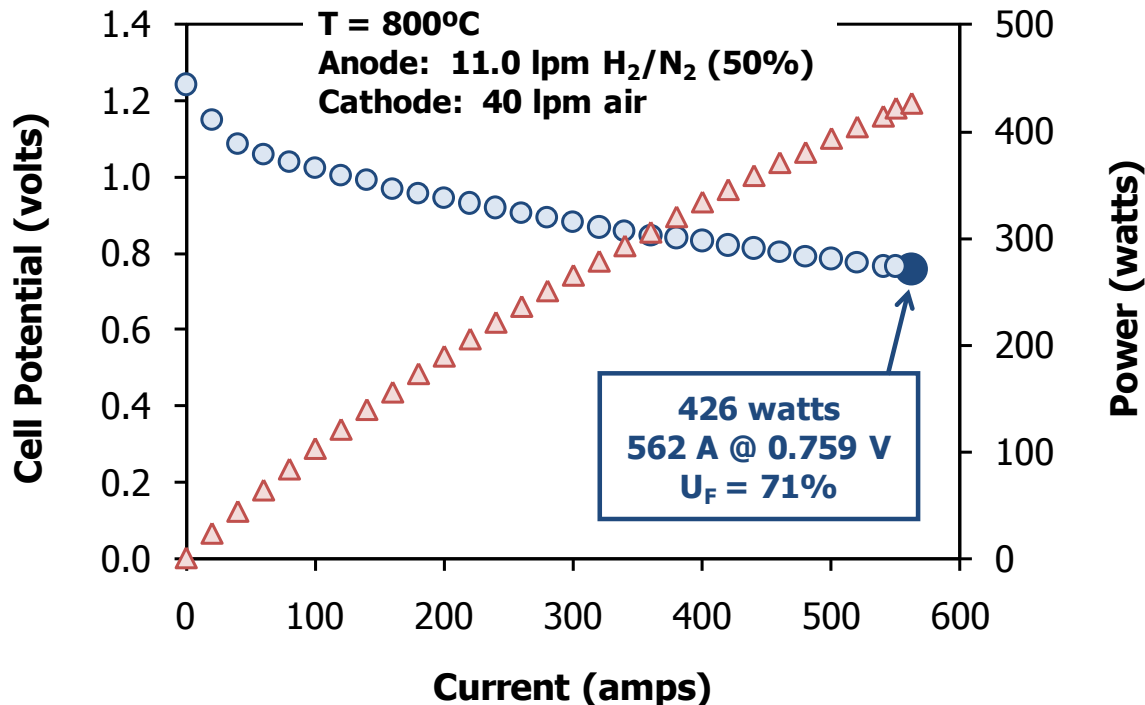
Long-Term Durability  
(Hybrid Cell)

## *Scalability to Large Areas for Higher Power Stacks*

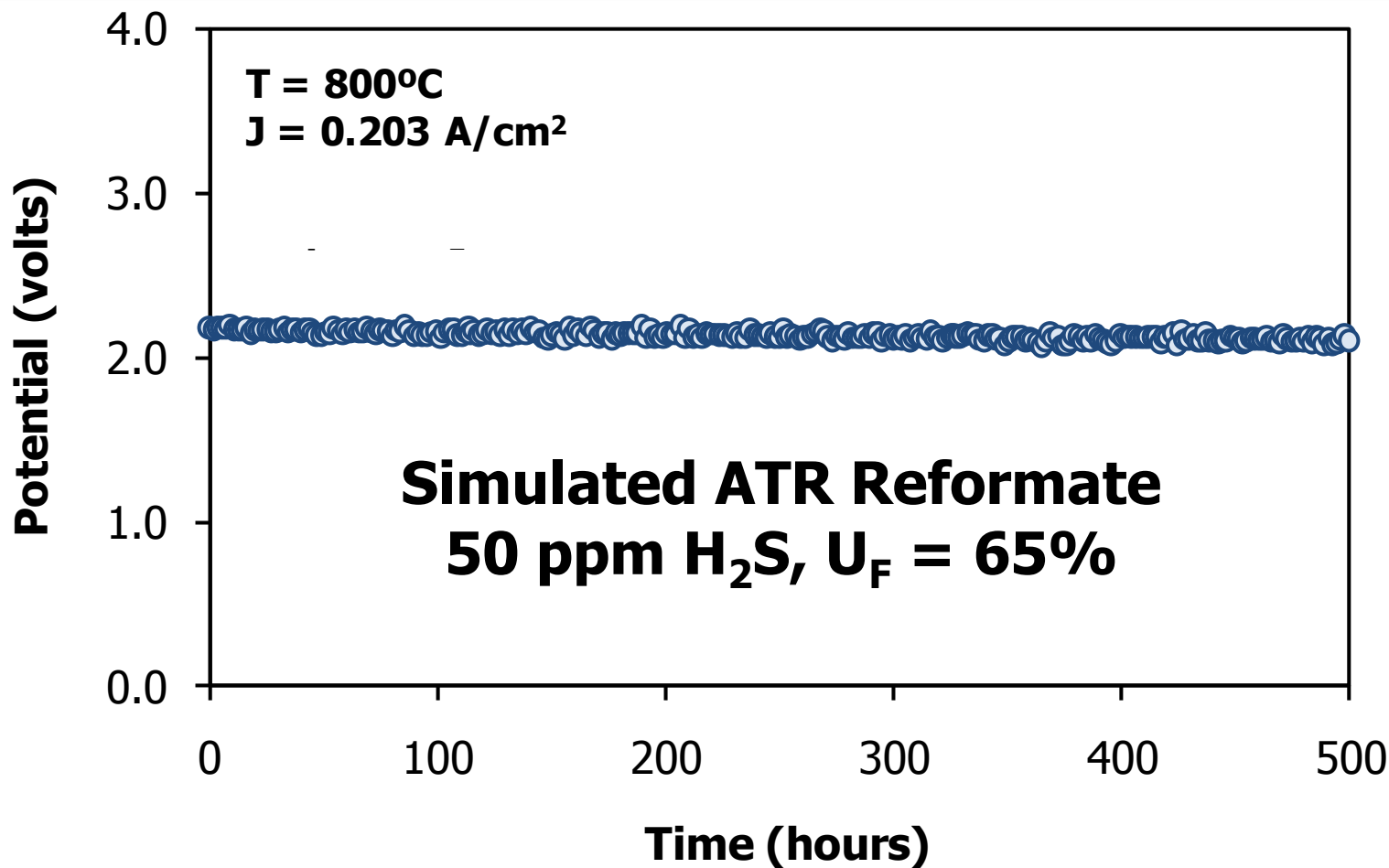


Total Cell Area: 1200 cm<sup>2</sup>

Active Cell Area: 800 cm<sup>2</sup>



## *Sulfur Tolerant Stack Operation (3-Cell Stack)*



***Status of NexTech's  
SOFC Stack Technology***

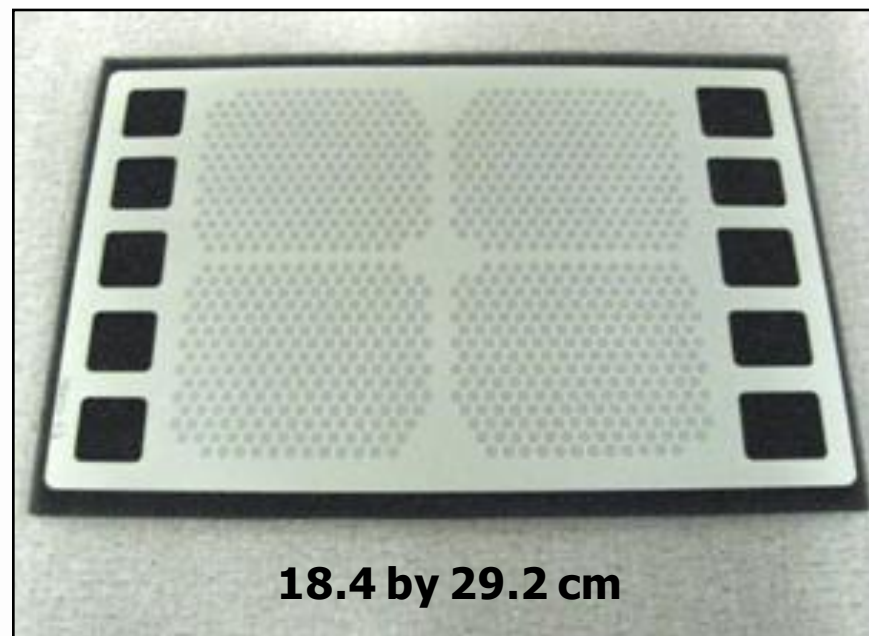


## *Stack-Intent FlexCells*

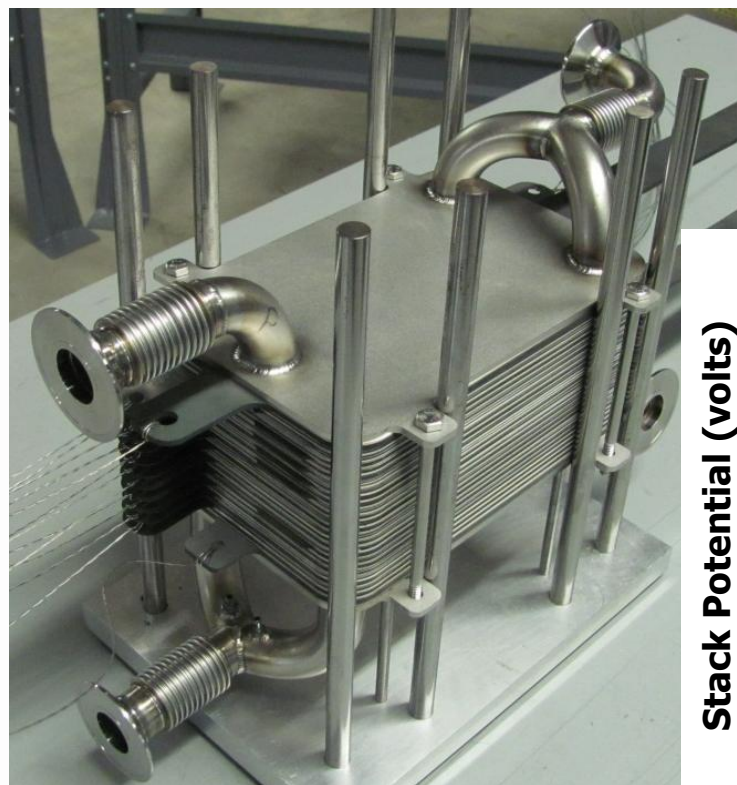
### FlexCell for 1-2 kW stacks



### FlexCell for 5-10 kW stacks

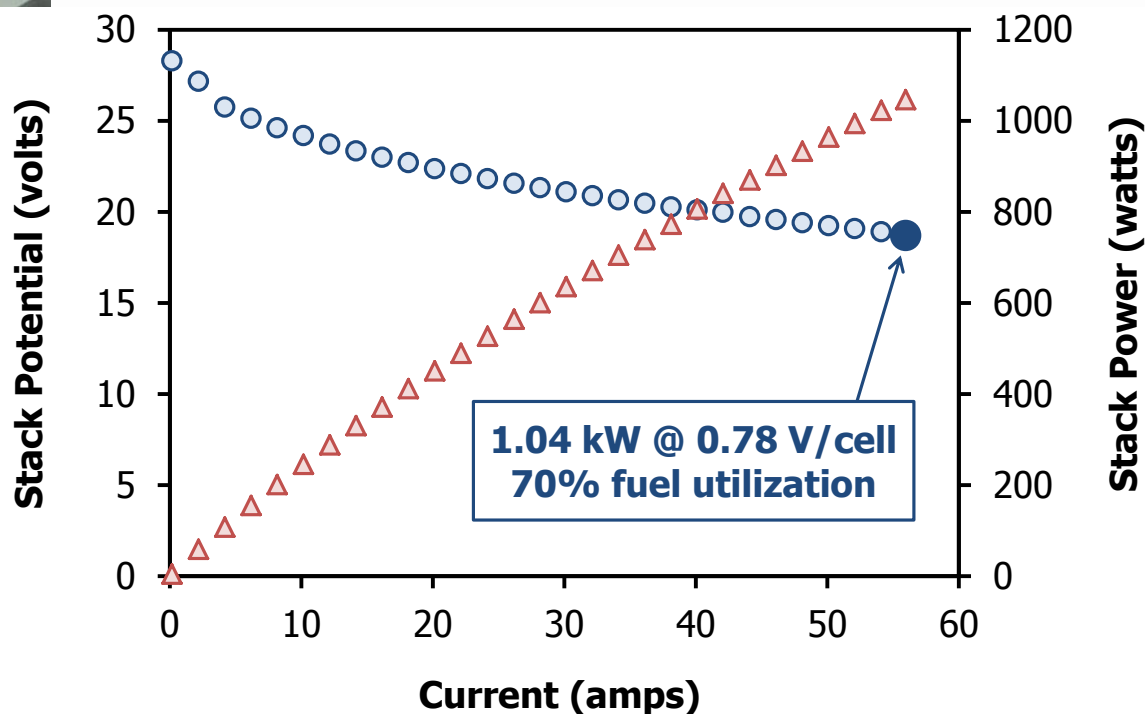


## ***1-kW Scale Stack Platform***



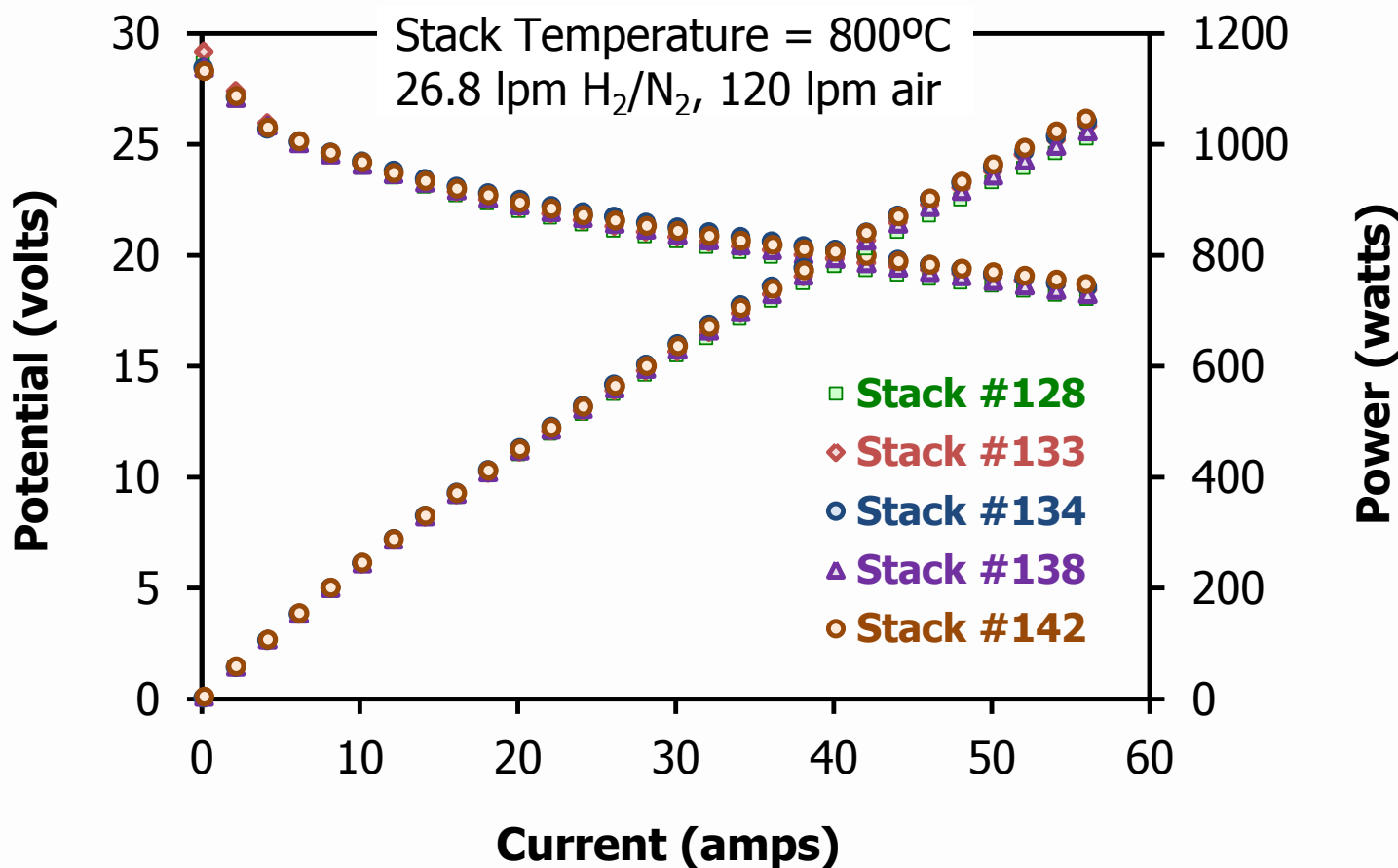
24-Cell Stack

Total Cell Area: 320 cm<sup>2</sup>  
Active Cell Area: 160 cm<sup>2</sup>

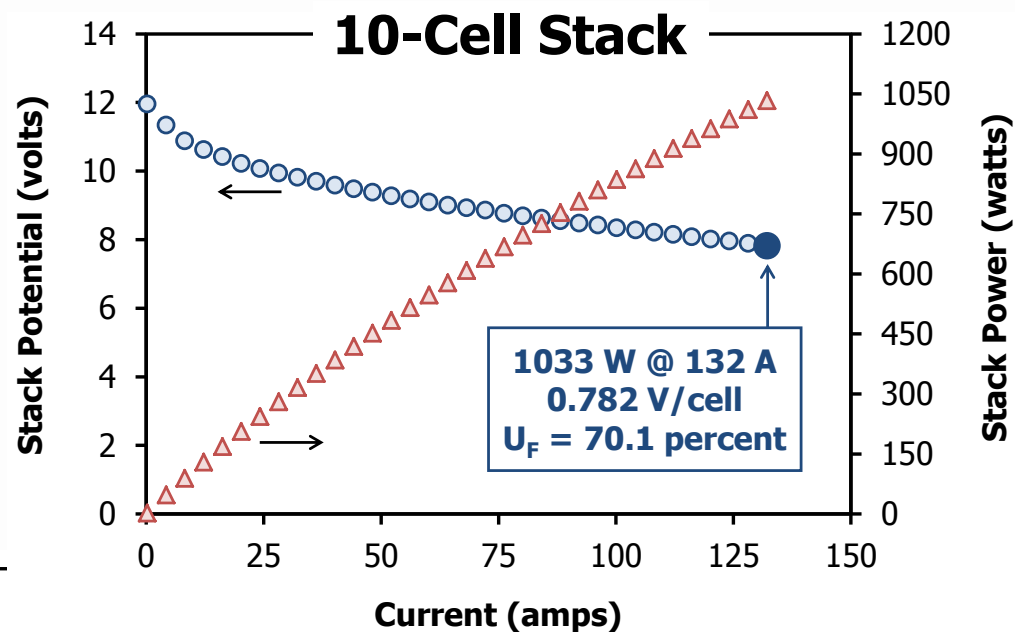
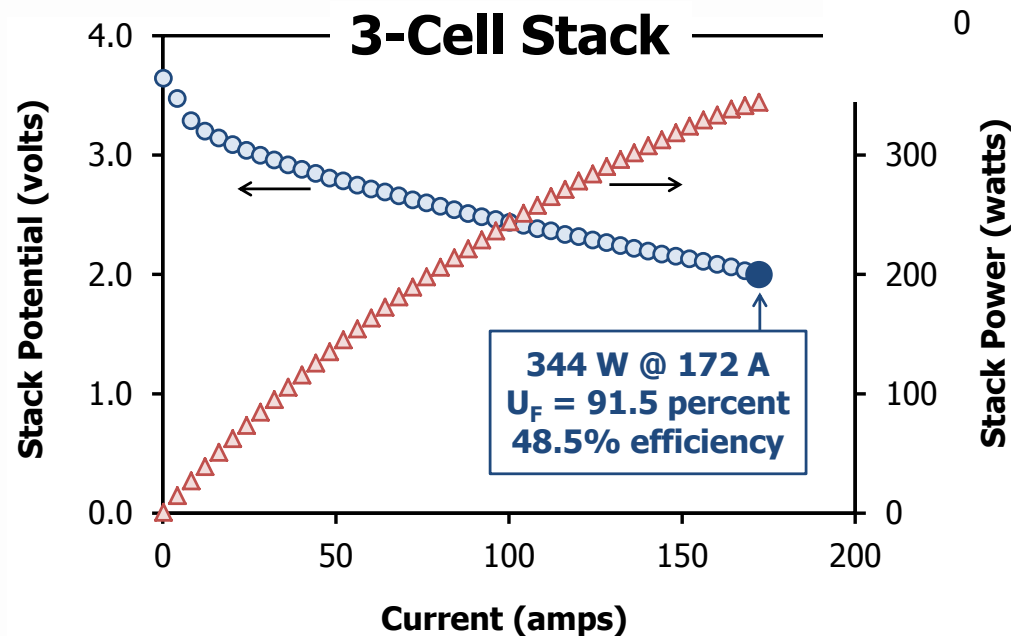




## *Reproducibility of 24-Cell Stacks*

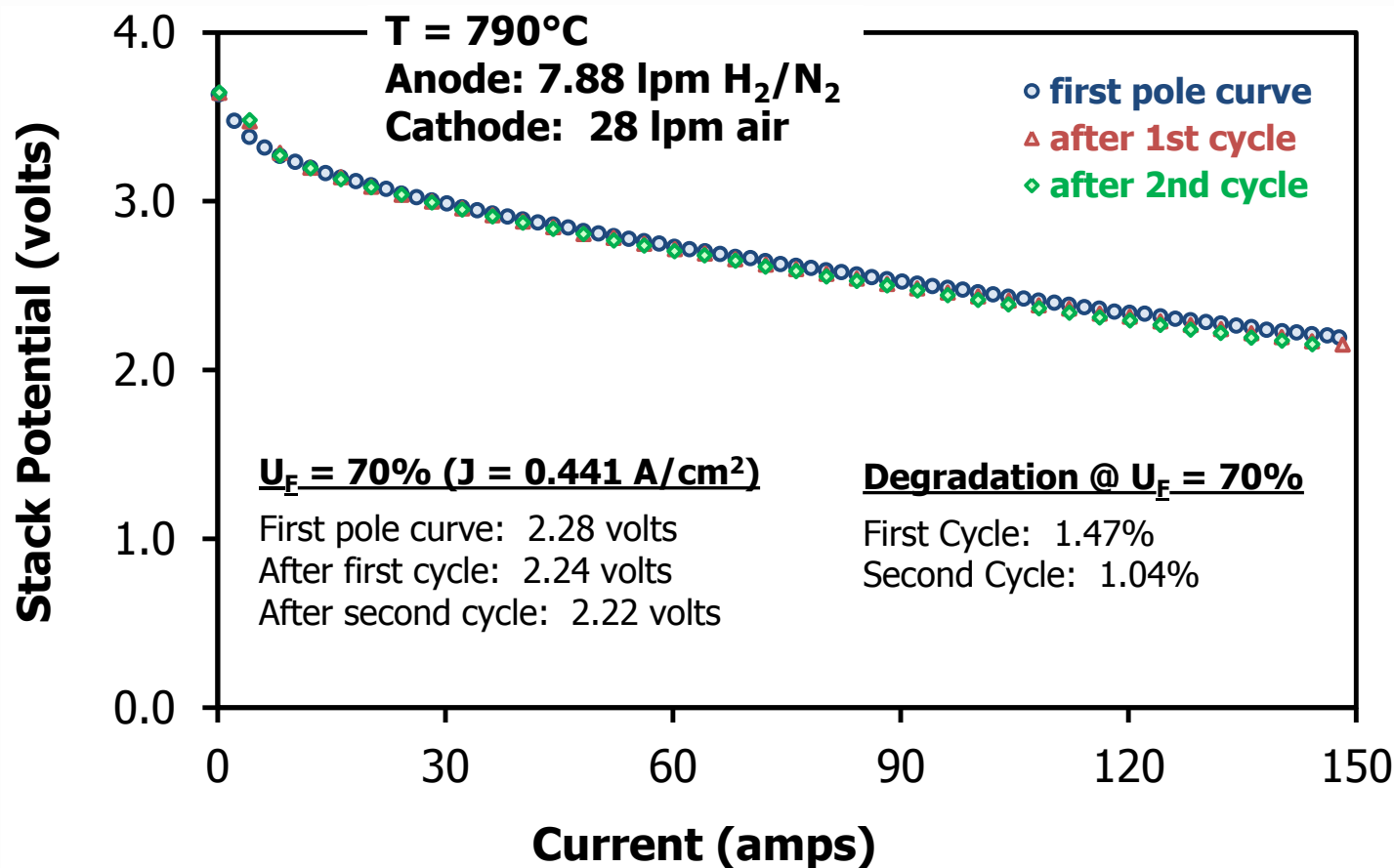


### 5-10 kW Scale Stack Platform

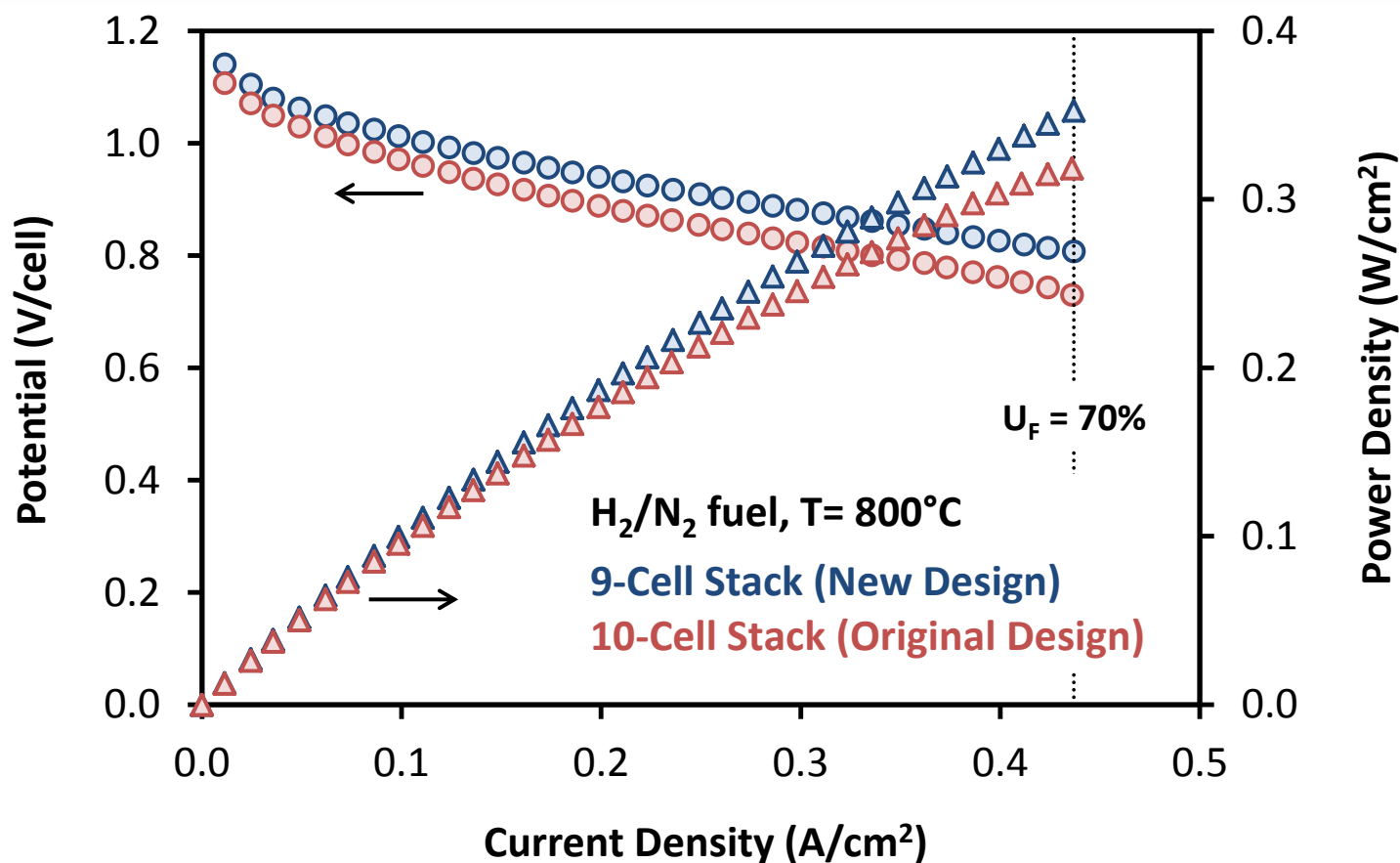


**Total Cell Area: 540 cm<sup>2</sup>**  
**Active Cell Area: 300 cm<sup>2</sup>**

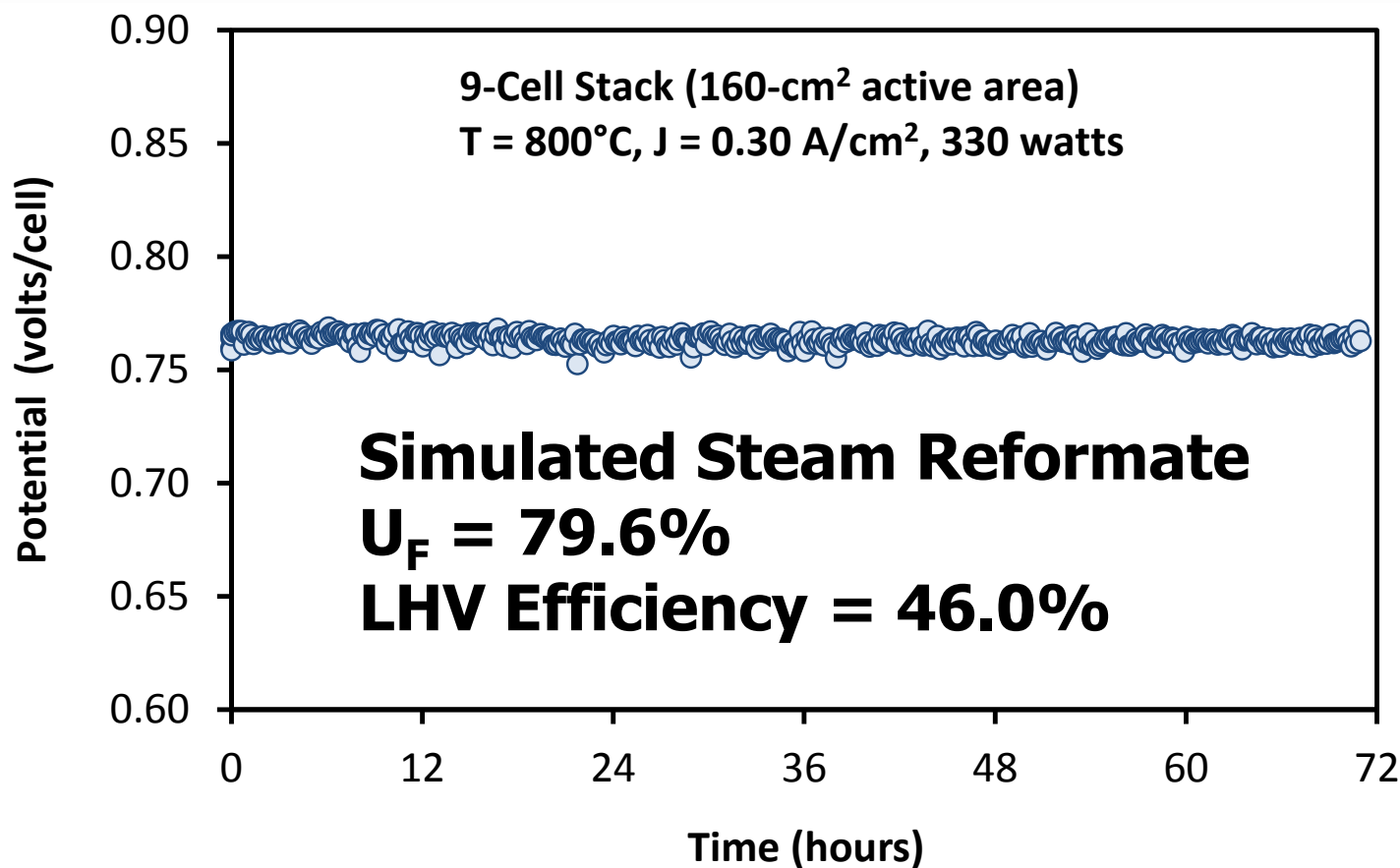
## *Thermal Cycling (large-area 3-cell stack)*



## *New Stack Design (higher efficiency)*



## *High Efficiency Stack Operation*



## ***Ongoing Stack Development Activities***

- Developing interconnect coating technology to enable long-term durability and thermal cycling
- Completing 1-2 kW stack platform, focusing on efficiency, durability and thermal cycling
- Breadboard demonstrations of SOFC power generation using military logistic fuels
- Continuing development of 5-10 kW stack platform
- Offering 1-kW scale stacks for evaluation by potential partners

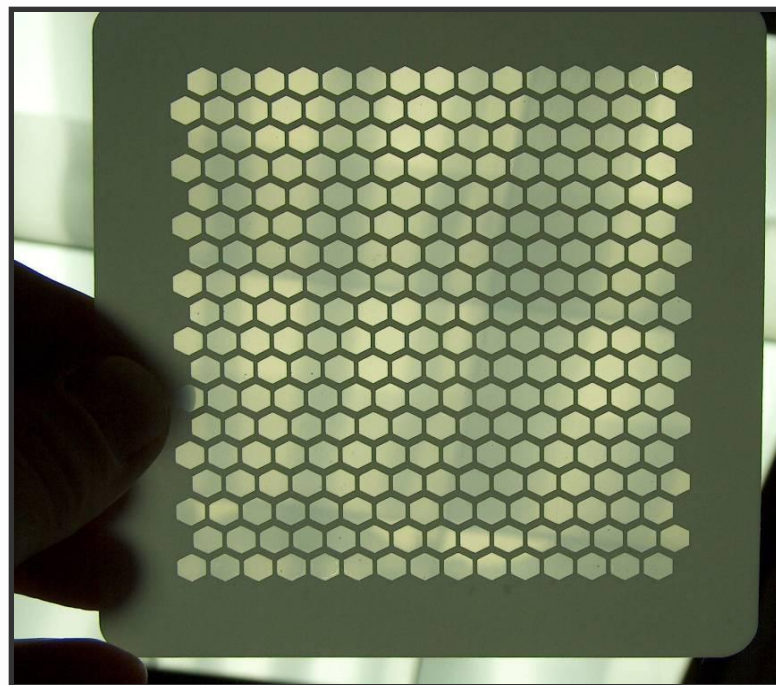
***Fabrication and Testing  
of YSZ-Based FlexCells  
(SECA Project)***



## ***Fabrication of YSZ-Based FlexCells***

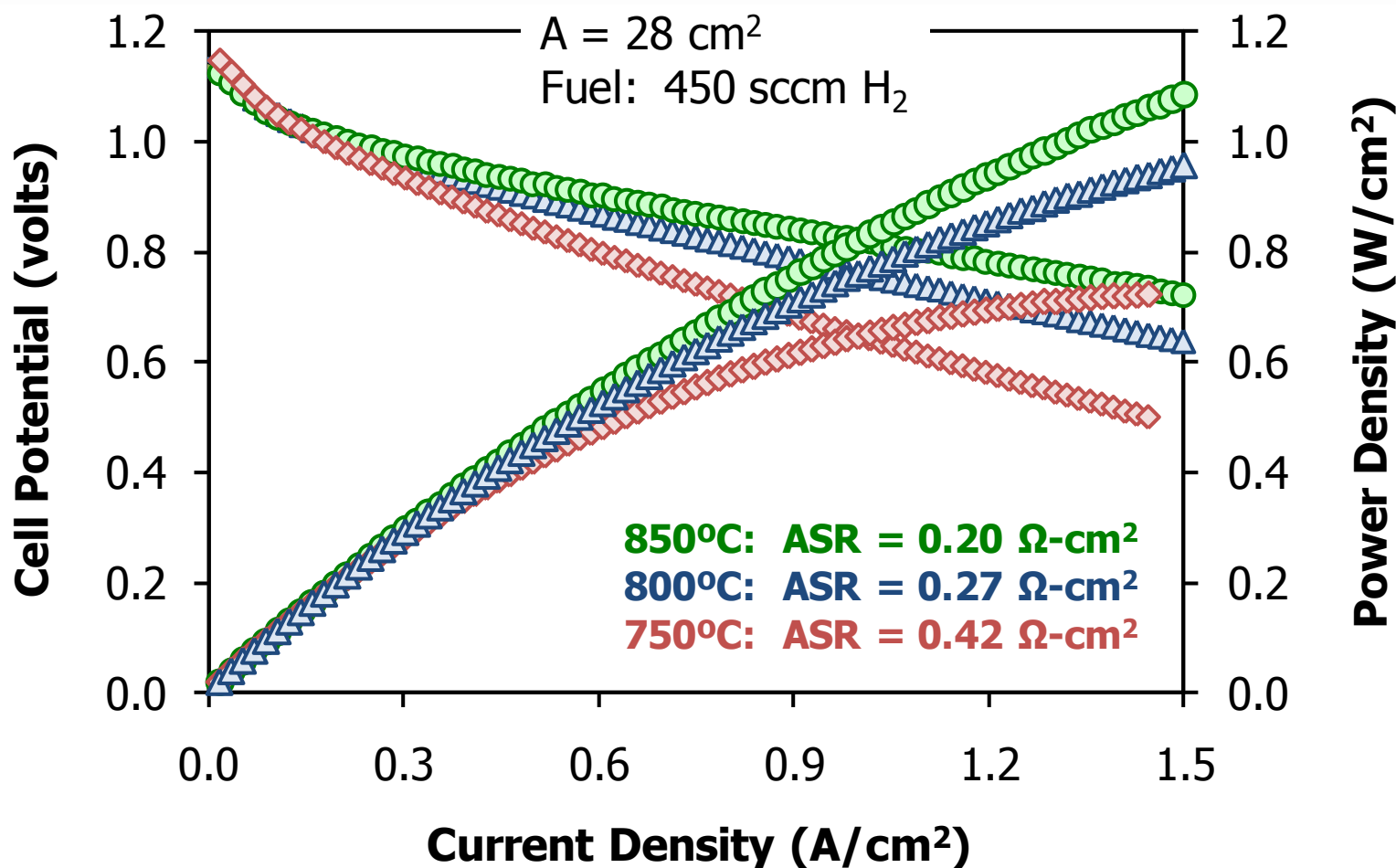
### **Architecture Variables**

- Support thickness: 80-160  $\mu\text{m}$
- Membrane thickness: 24-32  $\mu\text{m}$
- Percent thin membrane in active region: 65-75 percent
- Support mesh pattern/geometry

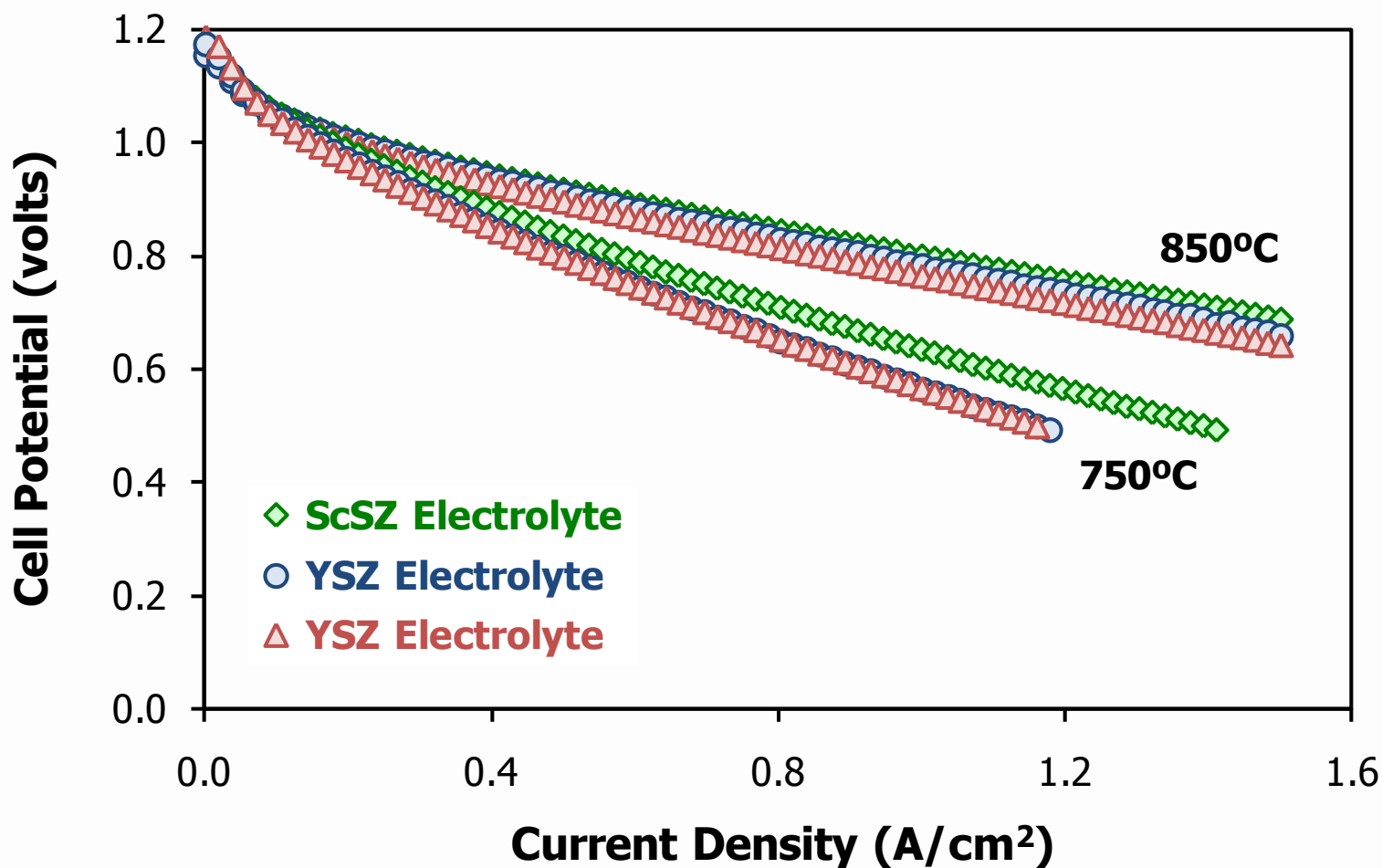




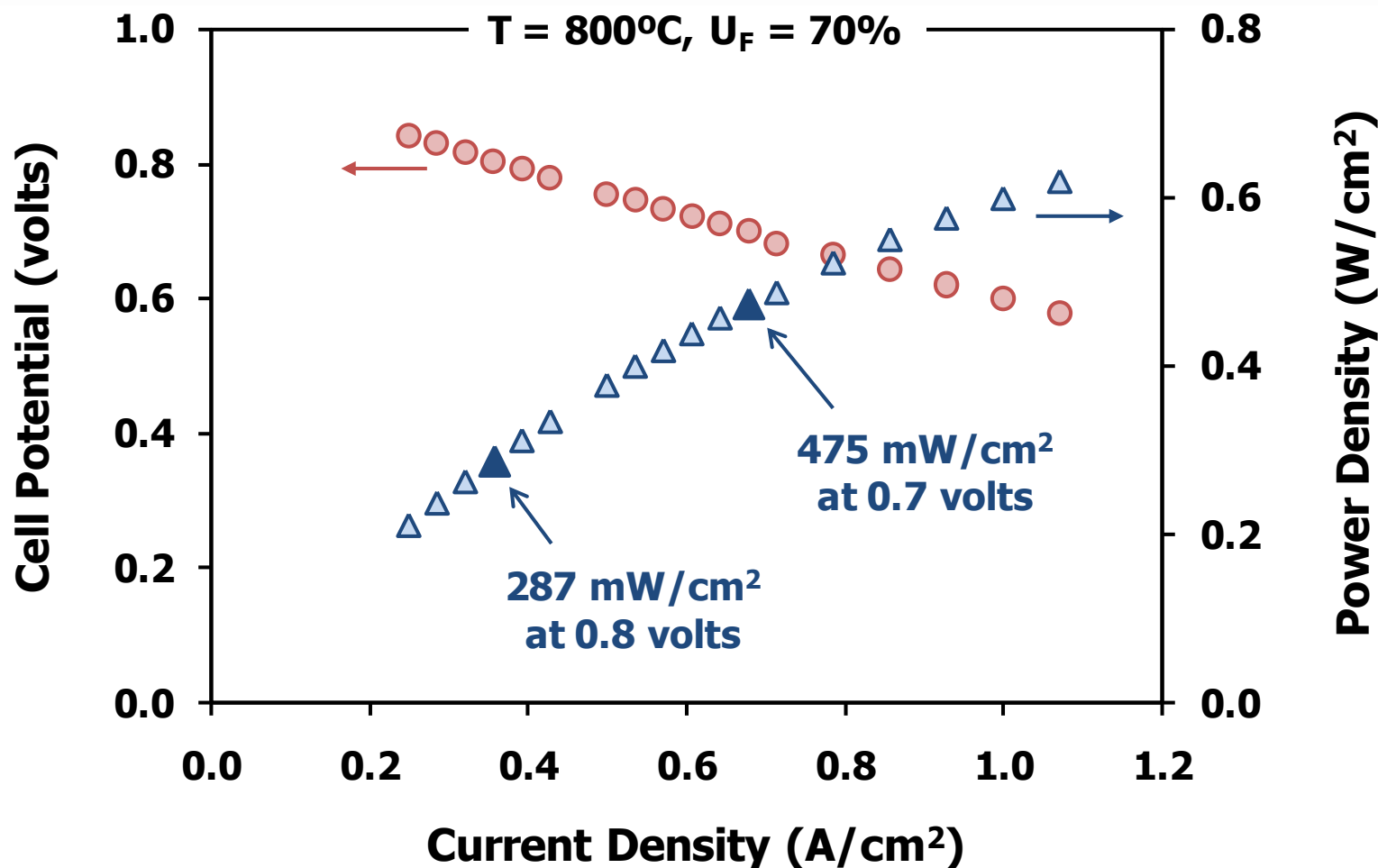
## YSZ Based FlexCell



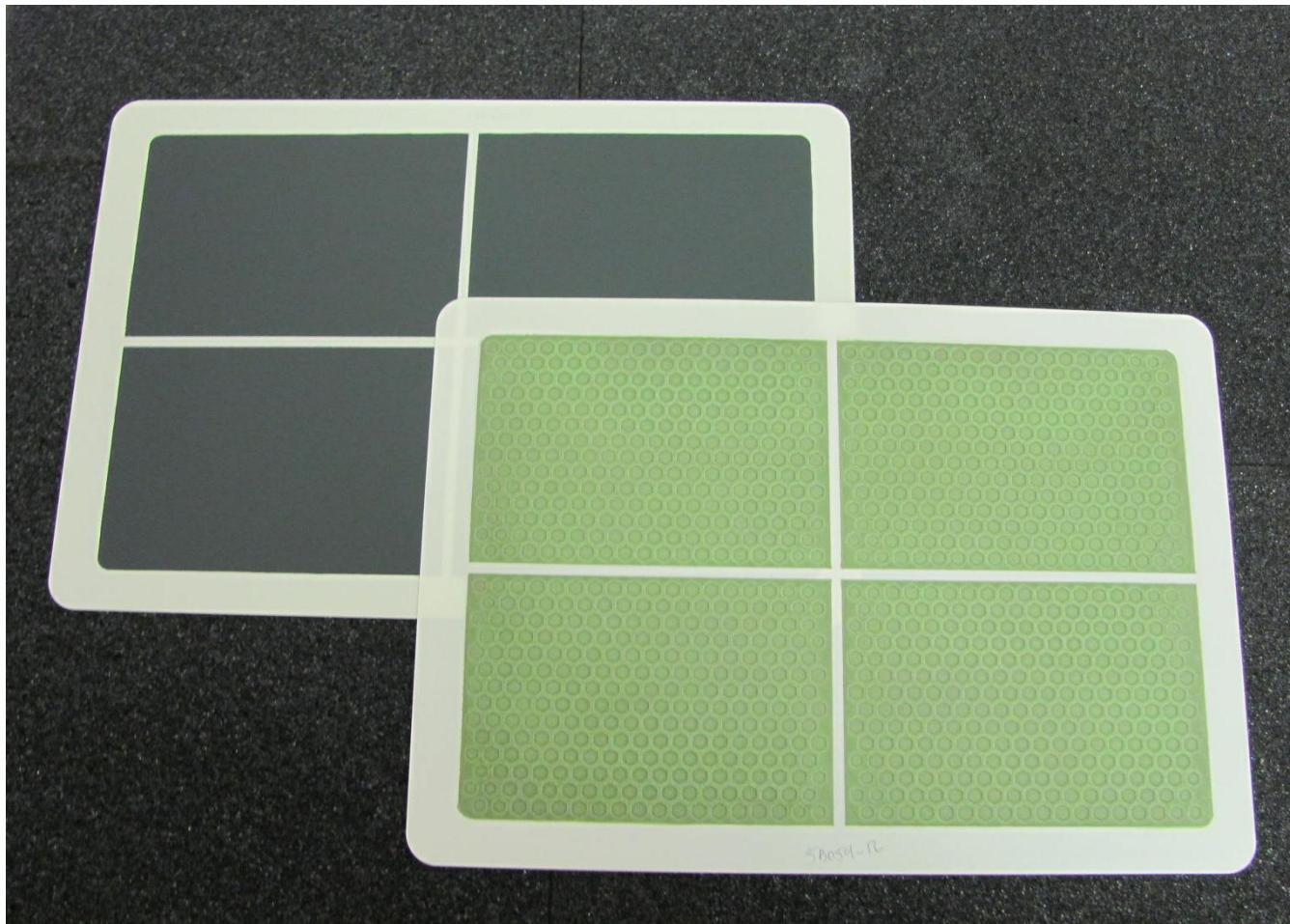
## ***YSZ versus ScSZ (Identical Geometry)***



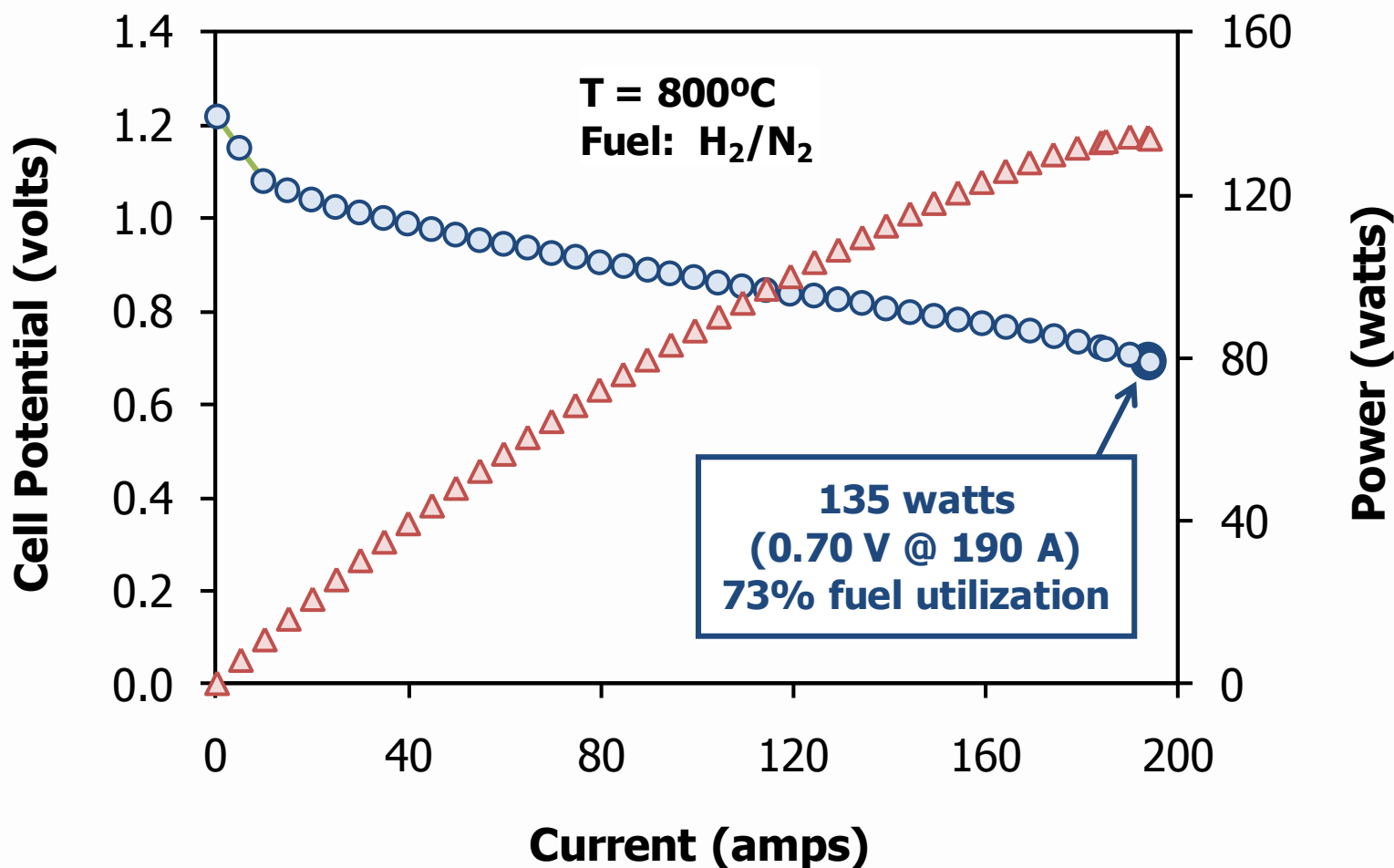
## *Constant Utilization Pole Curve Data*



## ***Large-Area YSZ-Based FlexCells***



## *Large-Area YSZ-Based FlexCell*



## ***Future Work***

- Fabrication of YSZ-based *FlexCells* for stack testing at NexTech
- Long-term testing of three-cell stacks with simulated coal gas
- Testing of full-scale SOFC stacks made with YSZ-Based *FlexCells*
- Preparation of the Final Report