NUVERA FUEL CELLS

AURORA Program Overview

Topic 4A. Transport within the PEM Stack / Transport Studies
Transport Studies Enabling Efficiency Optimization of Cost-Competitive Fuel Cell Stacks
Award#: DE-EE0000472

US DOE Fuel Cell Projects Kickoff Meeting
Washington, DC
September 30, 2009

Program Objectives

The objective of this program is to optimize the efficiency of a stack technology meeting DOE cost targets.

Table 3.4.3 Technical Targets: 80-kW$_e$ (net) Transportation Fuel Cell Stacks Operating on Direct Hydrogen [a]

Characteristic	Units	2003 Status	2005 Status	2010	2015
Stack power density [b]	W / L	1,330	1,500 [c]	2,000	2,000
Stack specific power	W / kg	1,260	1,400 [c]	2,000	2,000
Stack efficiency [d] @ 25% of rated power	%	65	65	65	65
Stack efficiency [d] @ rated power	%	55	55	55	55
Cost[e]	$ / kW$_e$	200	70 [f]	25	15
Durability with cycling	hours	N/A	2,000 [g]	5,000 [h]	5,000 [h]
Transient response (time for 10% to 90% of rated power)	seconds	<3	1	1	1
Cold start-up time to 50% of rated power					
@ –20°C ambient temperature	seconds	2	20	30	30
@ +20°C ambient temperature	seconds	<1	<10	5	5
Start up and shut down energy [i]					
from -20°C ambient temp	MJ	N/A	7.5	5	5
from +20°C ambient temp	MJ	N/A	N/A	1	1
Unassisted start from low temperature [j]	°C	N/A	-20	-40	-40

[e] Based on 2002 dollars and cost projected to high-volume production (500,000 stacks per year).

As cost reduction is of central importance in commercialization, the objective of this program addresses all fuel cell applications.

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Technical Barriers

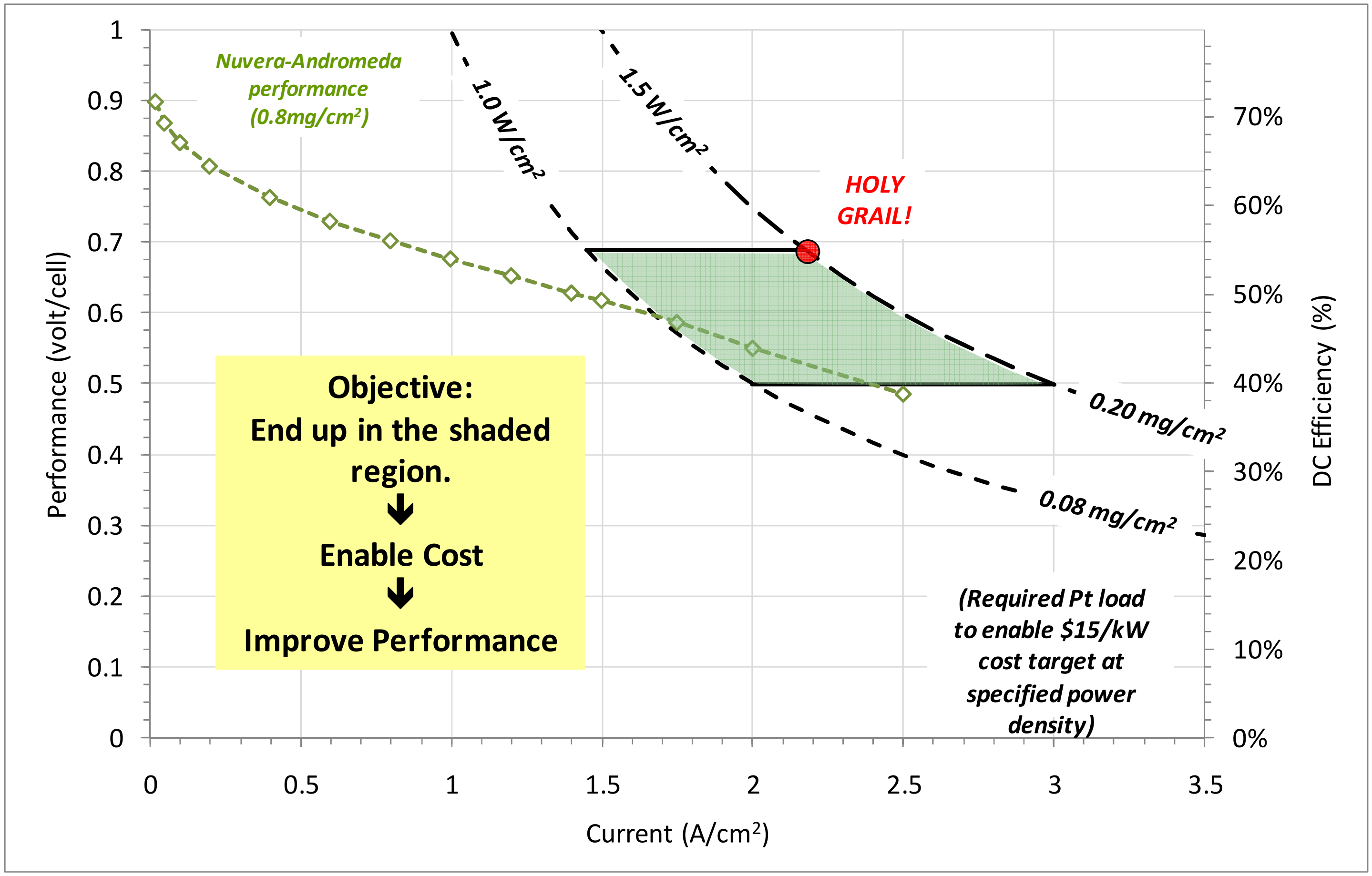
<u>Premise</u>: DOE cost targets can be met by jointly exceeding both the Pt loading (<0.2 mg/cm2) and the MEA power density (>1.0 W/cm2) targets.

Barrier	Approach	Strategy
B. Cost	Low Pt loadings (0.2 mg/cm2)	Electrocatalyst/MEA partner
	High power density (>1.0 W/cm2)	Open-flowfield stack
	Base metals stack architecture	Incumbent derivative
C. Performance	Bulk GDL resistance reduction	Thin GDLs (<150 um)
	Bulk membrane resistance reduction	Thin membranes (<20 um)
	Contact resistance reduction	Compression optimization
D. Water Transport	Electrode sub-model	Electrochemical expert partner
	Fuel cell transport model	Thermo-fluids expert partner
	Flow visualization	Neutron imaging
	Operating regime scoping	Model exercising
	Stack process conditions map	Parametric testing

Stack technology development to date has largely prioritized efficiency over cost -- this program will do the opposite.

Technical Target

<u>Target</u>: Demonstrate stable and repeatable high power performance on a full format fuel cell stack: 7.5 W/mg-Pt @ 500mV.



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Model Concept

The key deliverable of this program is a performance model validated over a range of stack architectures operating at high power.

Global conditions: { P_i }

Load	
Current density	---
Anode (H2)	
Inlet pressure	---
Inlet temperature	---
Stoichiometry	---
RH (%)	---
Cathode (Air)	
Inlet pressure	---
Inlet temperature	---
Stoichiometry	---
RH (%)	---
Coolant	
Inlet temperature	---
Flowrate	---
Heat Capacity	---
Other	
Parameters	---

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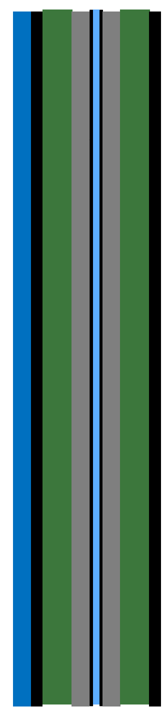
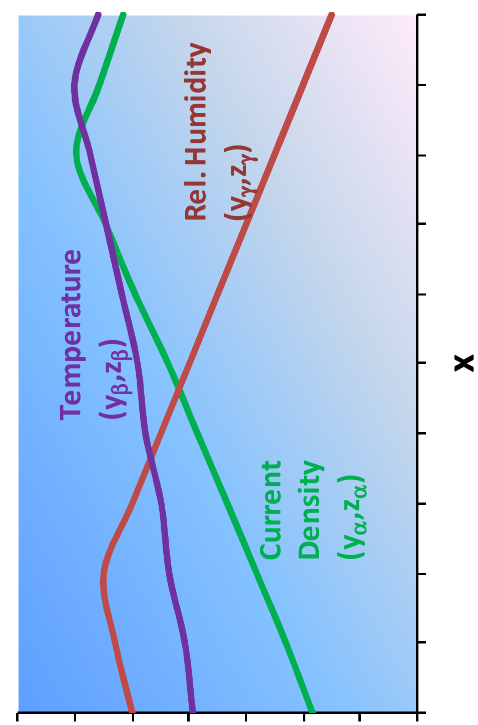
Cell architecture: { FC-V }



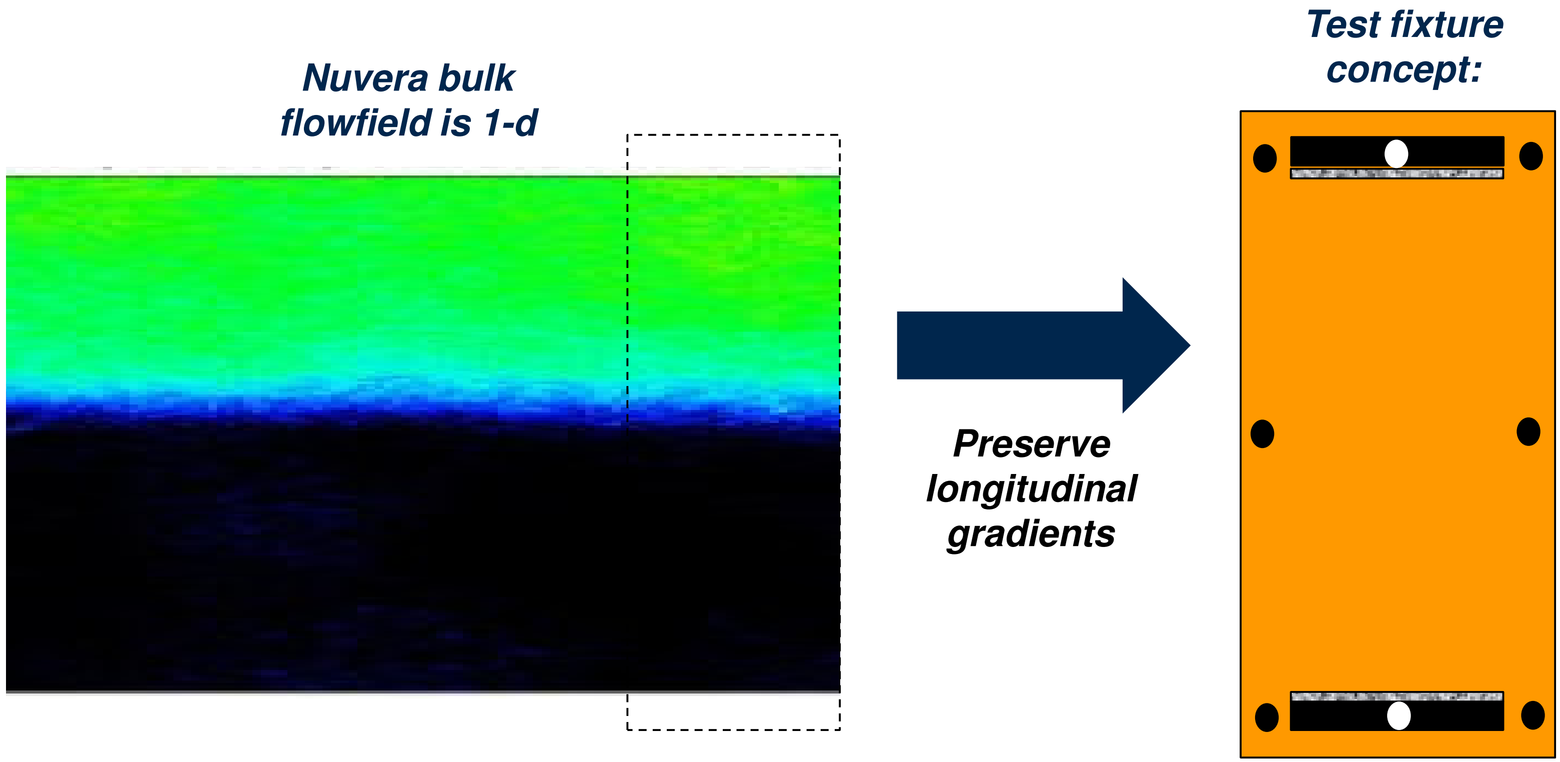
→ *Model*

Local conditions: { $P_o(P_i, V; x_j)$ }



New Test Fixture

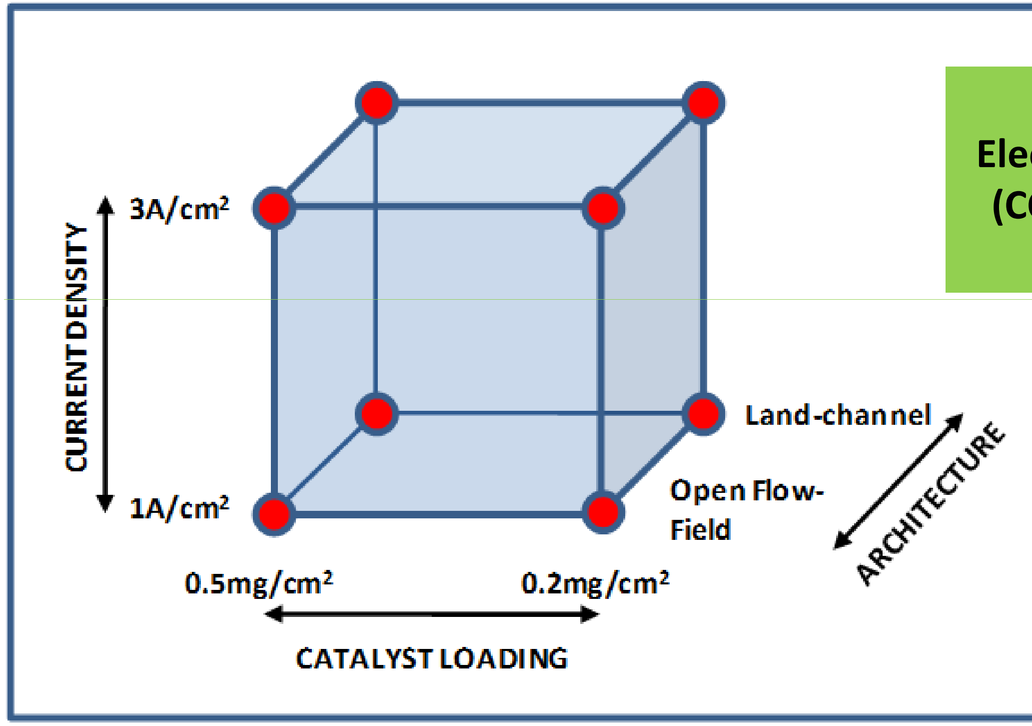
Conventional single cell test fixtures have two shortcomings for the program: mass transfer limitations and gradient distortion.



In this program, a new, gradient-preserving fixture will be developed to enable testing in the high power operating regime (>1.0 W/cm2).

Parameter Space

A focused experimental campaign will be pursued to characterize cell physics at high power and with reduced Pt loadings.



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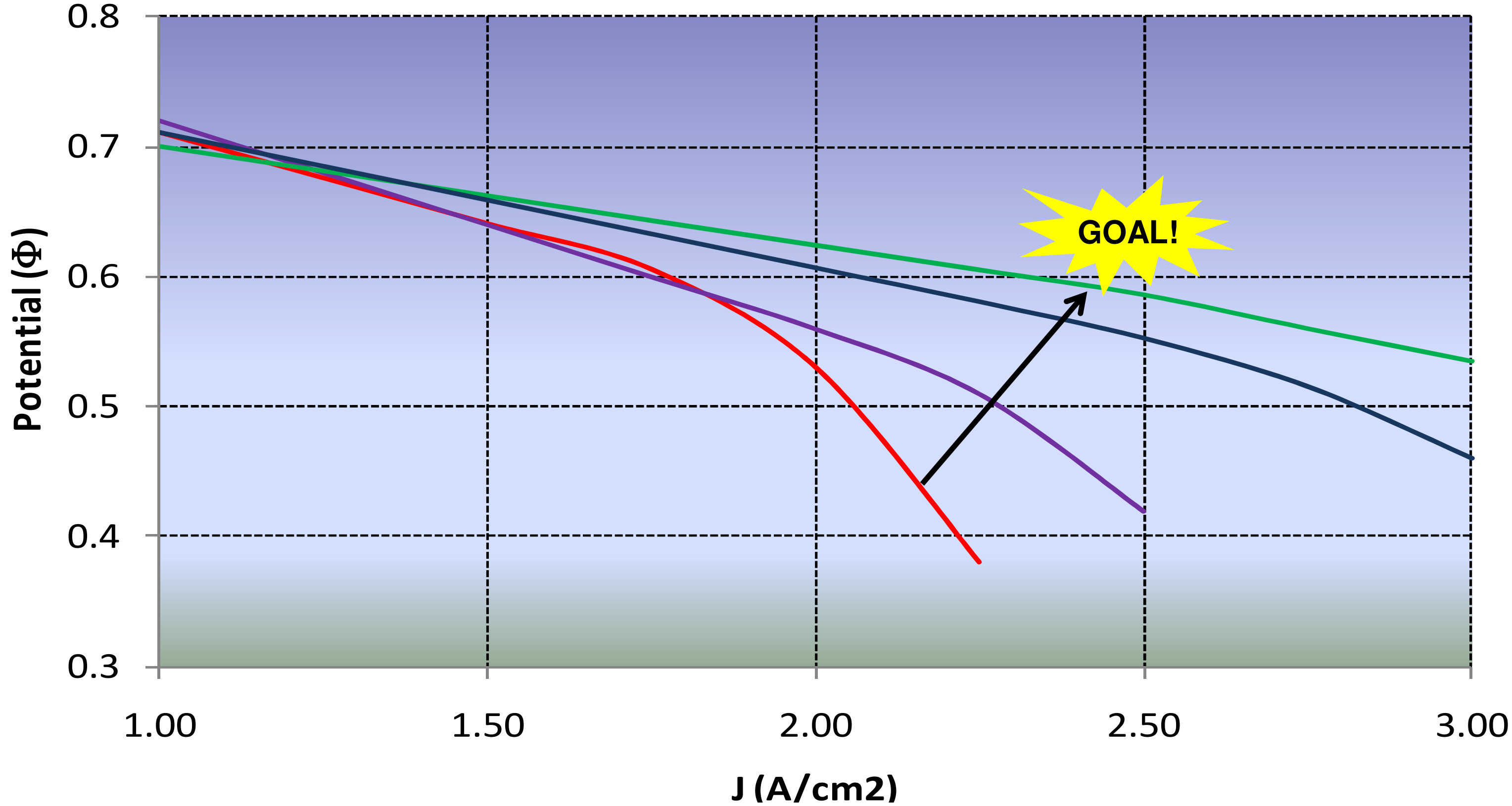
Electrode Structure (CCM, GDE, novel structures)

Results from these parametric studies will be used to inform and calibrate an electrode sub-model and an overall integrated transport model.

Stack Verification

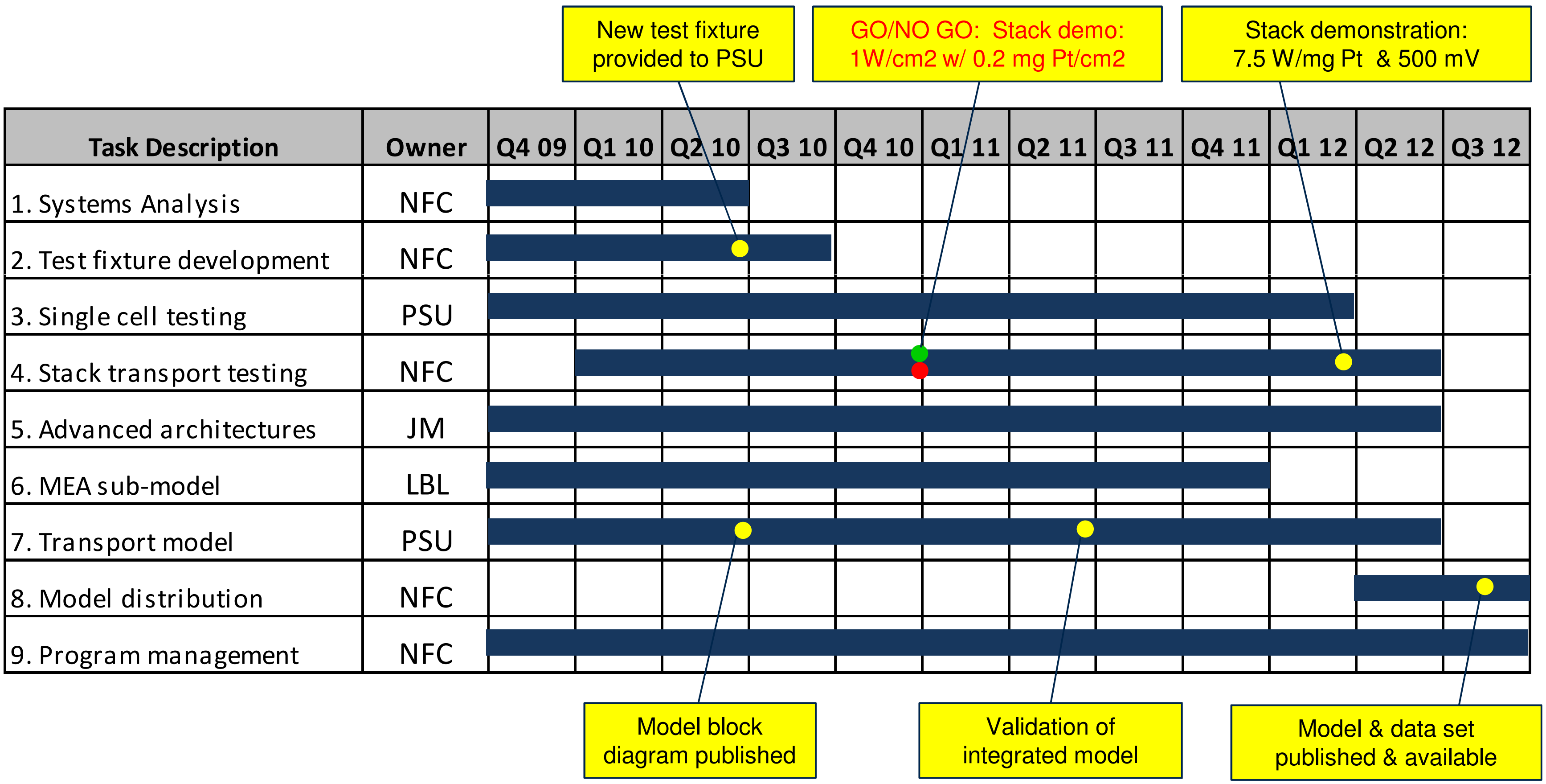
The model will be used to refine cell design elements, and identify operating conditions supporting maximum efficiency.



The operating map of the most promising architecture will be optimized in full format stack testing, in pursuit of the program technical target.

Program Timeline

The program has a planned duration of three years, with several important milestones and a go/no-go decision along the way.



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Program Budget

The total program value is $6.03 Million with Nuvera and partners providing a cost-share contribution of 26%.

AURORA Program Budget ($/000)							
Fiscal Year	**Federal Funding**		**Cost Share**		**Total Value**	**FY/Total %**	**FY/Total Cumul. %**
FY09	$ 169		$ 59		$ 228	4%	4%
FY10	$ 1,553		$ 539		$ 2,092	35%	38%
FY11	$ 1,529		$ 535		$ 2,064	34%	73%
FY12	$ 1,209		$ 437		$ 1,646	27%	100%
Total	$ 4,460	74%	$ 1,570	26%	$ 6,030	100%	100%

Summary

The AURORA program prioritizes fuel cell stack cost, and accordingly has direct import for all PEM fuel cell applications.

U.S. DEPARTMENT OF ENERGY

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BERKELEY LAB

JM

PENNSTATE 1855

Current state of the art:

- RCD = 0.8 - 1.1 A/cm2 (688 mV)
- Power = 1.6 - 2.9 W/mg-Pt

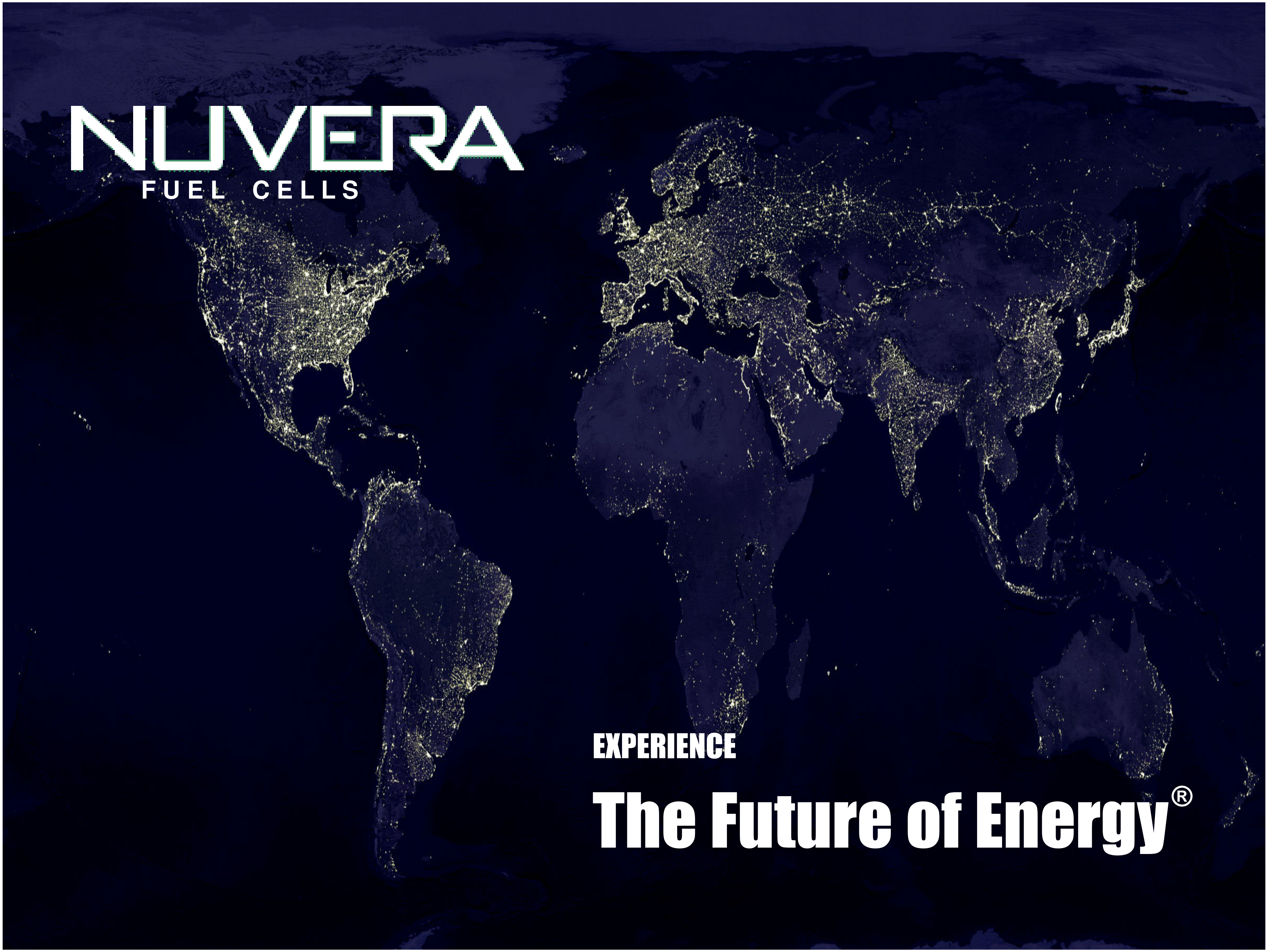
Program trajectory:

- Low Pt electrodes (0.2 mg/cm2)
- High power density (>1 W/cm2)
- Target: 7.5 W/mg-Pt (500 mV)

Key deliverable:

- Integrated transport model

Thank you for your attention!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