Proton ENERGY SYSTEMS | The Leader in On-site Hydrogen Generation

Hydrogen By Wire – Home Fueling System

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Organization: Proton Energy Systems

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Project ID #PD067

Overview

Timeline

- Project Start: 22 Sep 2010
- Project End: 22 Sep 2012
- Percent complete: 40%

Barriers

- Barriers addressed
  - G: Capital Cost
  - H: System Efficiency

Table 3.1.4. Technical Targets: Distributed Water Electrolysis Hydrogen Production [a, b, c]					
Characteristics	Units	2003 Status	2006 Status [c]	2012 Target	2017 Target
Hydrogen Cost	$/gge	5.15	4.80	3.70	<3.00
Electrolyzer Capital Cost [d]	$/gge $/kW	N/A N/A	1.20 665	0.70 400	0.30 125
Electrolyzer Energy Efficiency [f]	% (LHV)	N/A	62	69	74

Budget

- Total project funding
  - DOE share: $1,000,000
- Funding for FY11
  - DOE share: $500,000

Partners

- Industry component suppliers

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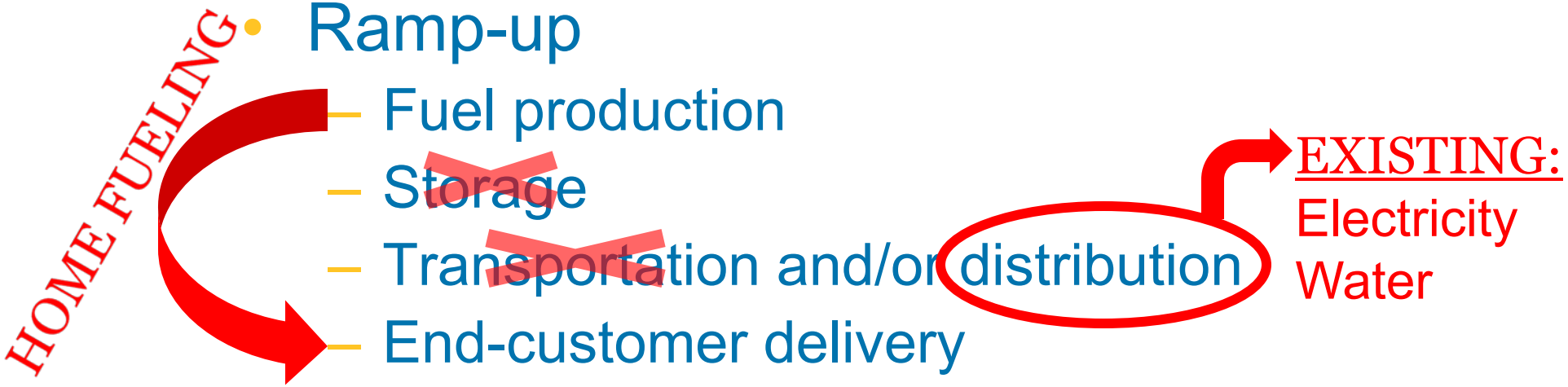
Relevance
Hydrogen Fueling Pathways

- Continuum of options
  - Large, centralized plants
    - Requires transportation or distribution of fuel
  - Neighborhood fueling stations
    - Compatible with medium-to-large scale PEM Electrolysis
    - Generates fuel closer to end-user
    - Can be renewable
  - Home-based fueling
    - Compatible with small scale PEM Electrolysis
    - Generates fuel in the end-user's garage
    - Can be renewable
- Each generation scale will have its place

Relevance
Fueling Infrastructure Challenges



- Pace with parallel ramp-up of related vehicles

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Relevance
Advantages of Hydrogen Home Fueling

Vehicle Type	Range (Miles)	Empty to Full Refueling / Charging Time (Hours)
Plug-in Hybrid Electric (PHEV)	40	4 to 6 (@110V)
Battery Electric Vehicle (BEV)	100	8 to 16 (@110V)
Compressed Natural Gas (CNG)	200-300	* 8 to 16 (potential <6h)
Fuel Cell Hybrid Electric Vehicle (FCV)	300	* 1 to 6 (Targets of study)

Comparison of Residential Fueling Charge Time and Vehicle Range (J. Schneider et. al, NHA 2009)

Relevance
Project Objectives

- Develop enabling technologies
  - 350-bar differential pressure electrolysis
    - Cell stack
      - Overboard seal
      - Cross-cell seal, membrane support
    - Fueling system

- Demonstrate prototype operation
  - 350-bar hydrogen generation
  - Fueling capability

Approach
Task Breakdown

- Task 1: Prototype System Design/Fabrication
  - System and key component design
  - Safety analysis
  - Procurement, fabrication, and acceptance testing
- Task 2: Prototype Stack Design
  - Requirements definition
  - Cell hardware design
  - Stack embodiment hardware design
- Task 3: Prototype Component Verification
  - Cell and stack component verification
- Task 4: Prototype System Testing
  - Stack fabrication and assembly
  - Integrated stack/system testing

Technical Accomplishments

Task	Task Description	Progress Notes	Completion
1.0	System Design / Fabrication	• Completed concept and prototype design. • Completed system hazard analysis. • Completed hydrogen phase separator design and analysis. • Identified and tabulated key components.	40%
2.0	Stack Design	• Completed sub-scale pressure testing. • Completed concept design of cell and stack components. • Completed procurement of initial test articles.	60%
3.0	Component Verification	• Pending completion of Tasks 1-2.	0%
4.0	Integrated Testing	• Pending completion of Tasks 1-3.	0%

Technical Accomplishments
Task 1.0: System Design/Fabrication

- Requirements definition for prototype

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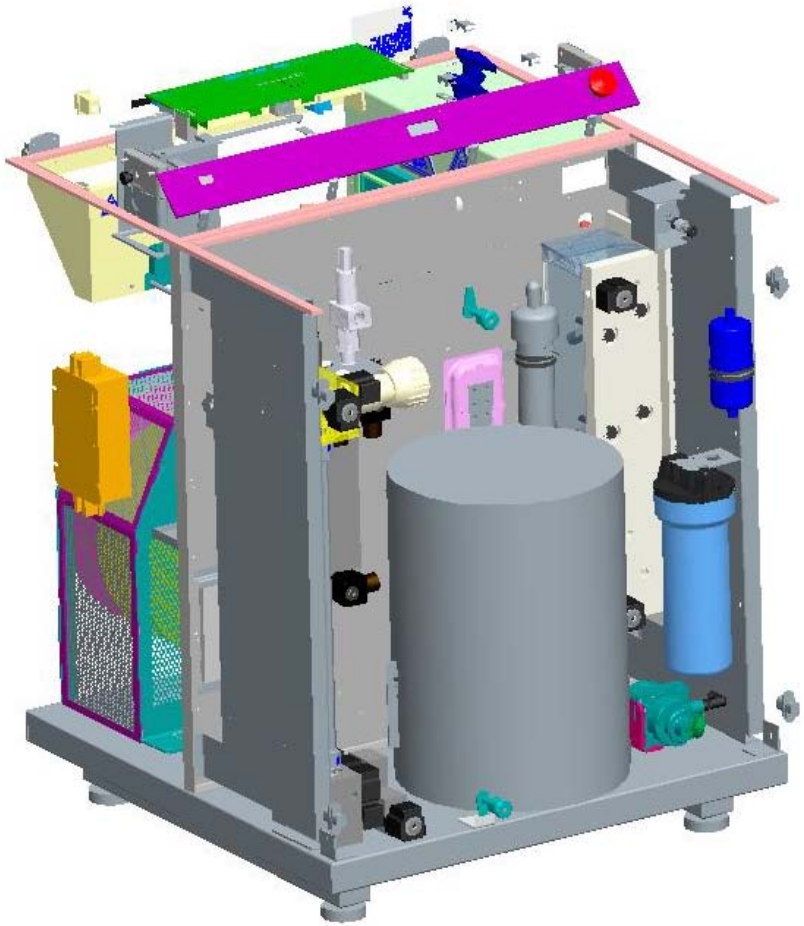
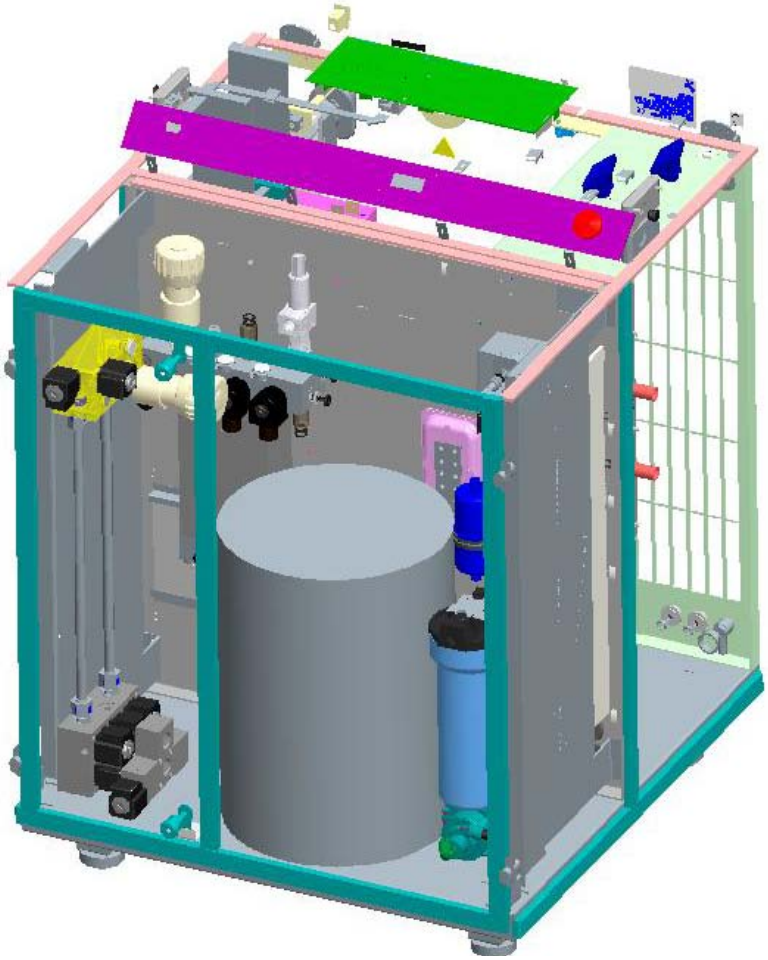
Technical Accomplishments
Task 1.0: System Design/Fabrication

- Prototype system completed internal design review





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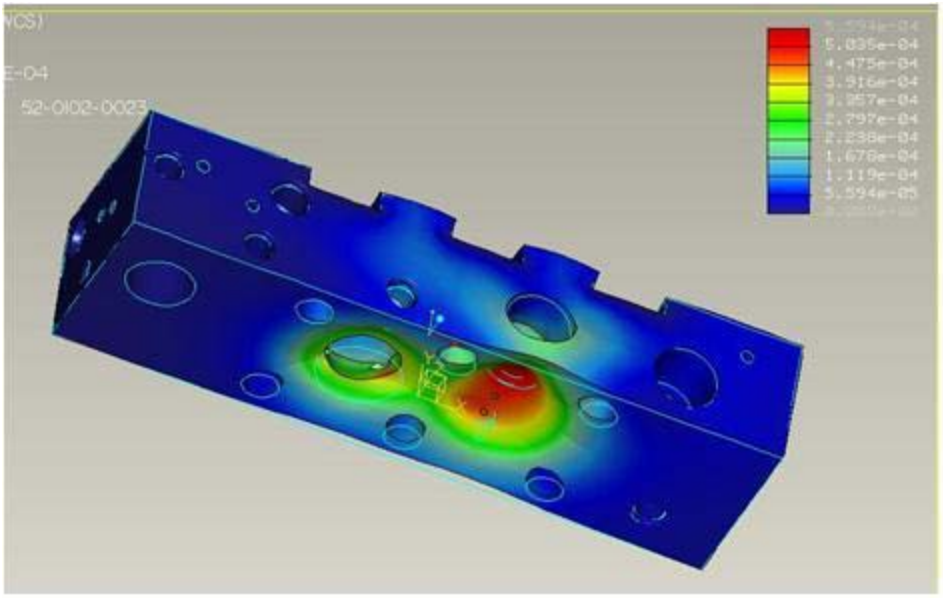
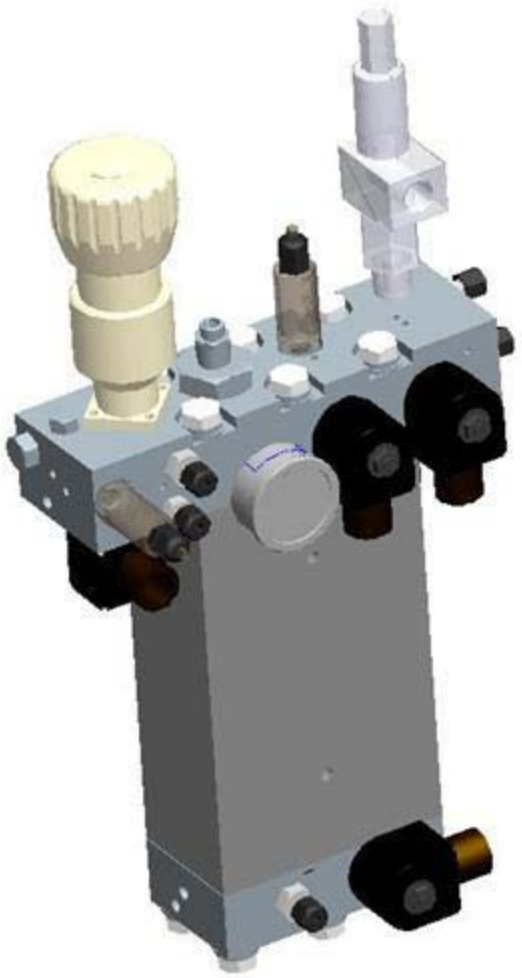
Technical Accomplishments
Task 1.0: System Design/Fabrication

- High pressure phase separator design and finite element analysis





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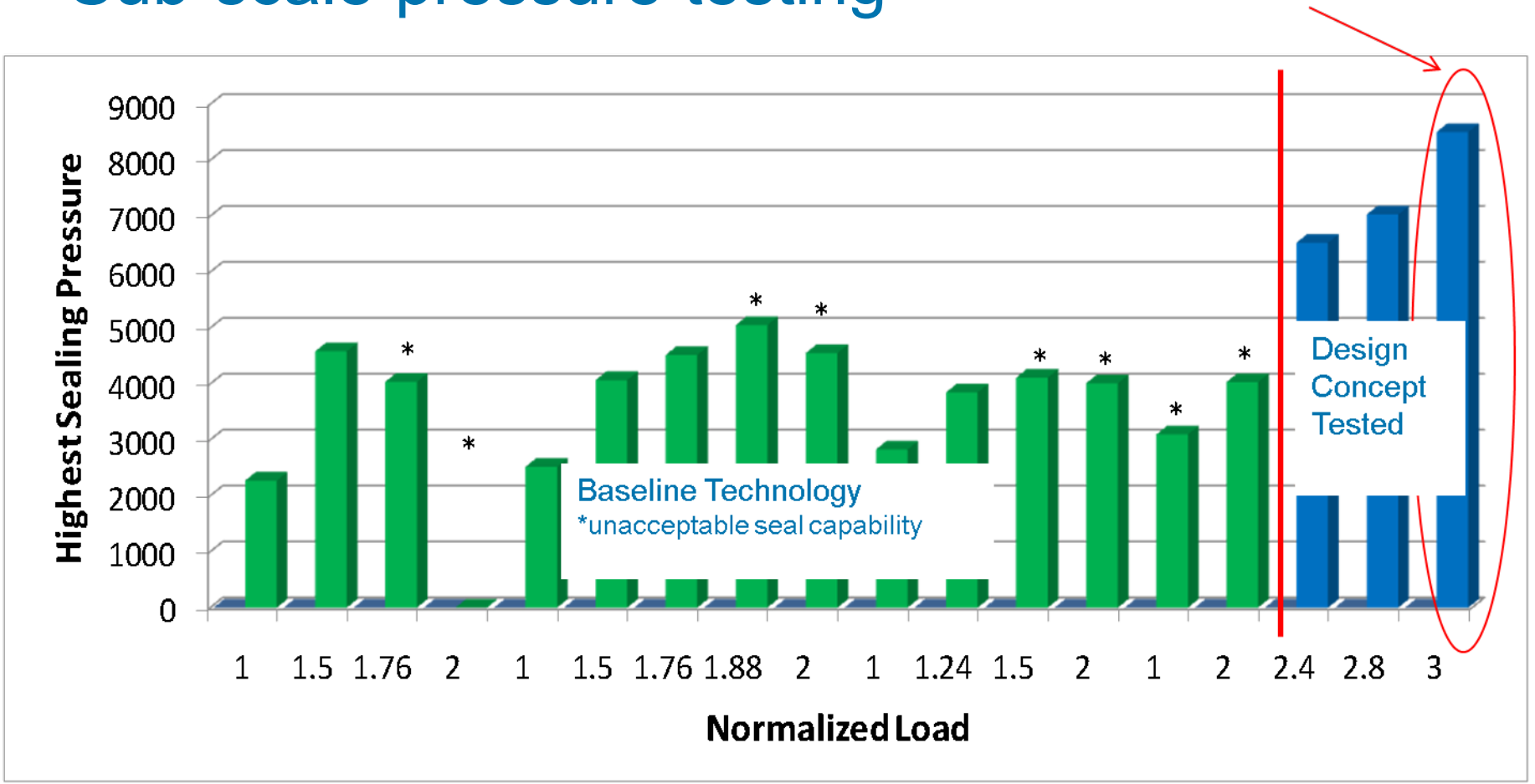
Technical Accomplishments
Task 2.0: Stack Design

- Sub-scale pressure testing



- Confirmed seal integrity at elevated temperature

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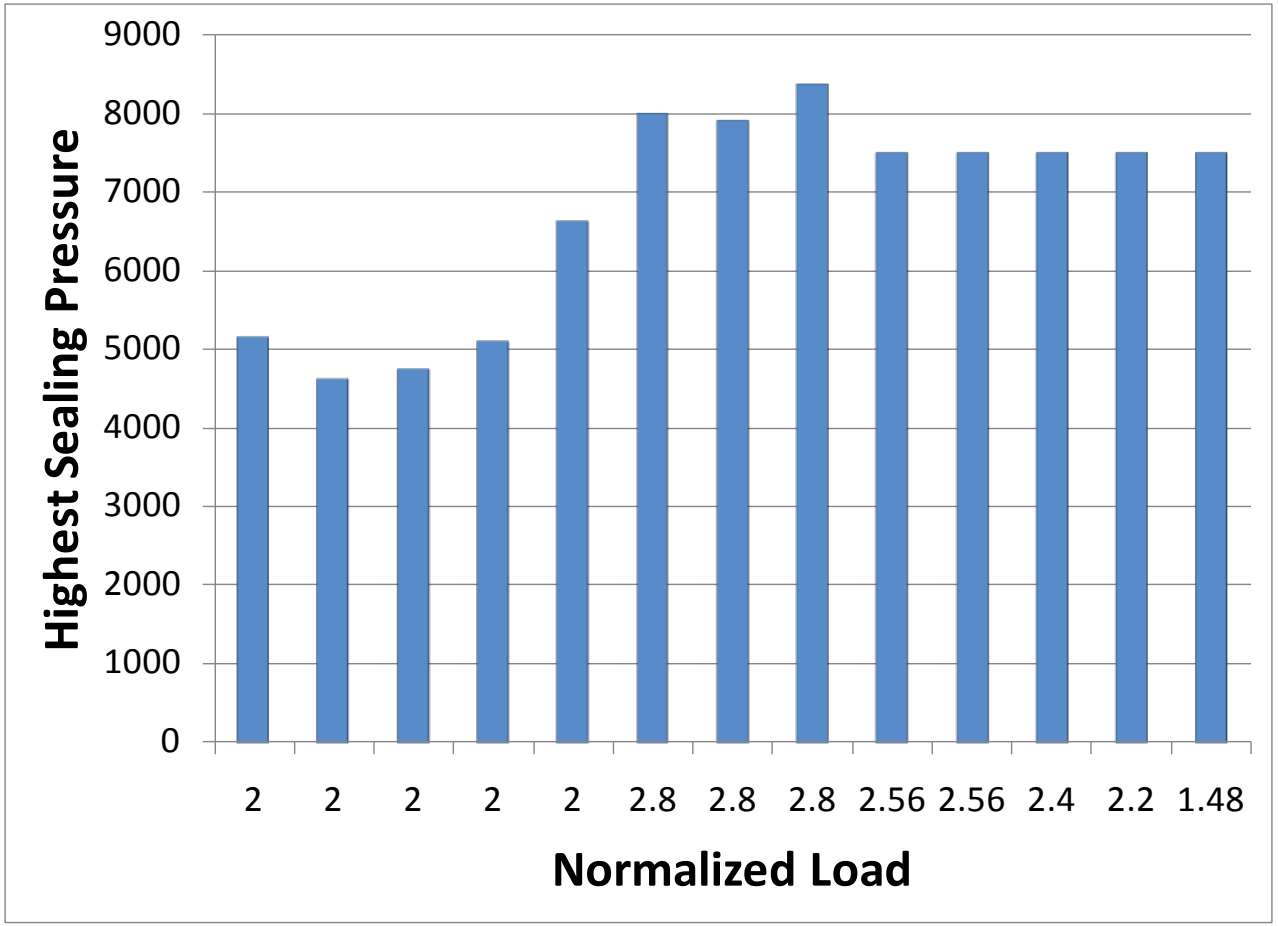
Technical Accomplishments
Task 2.0: Stack Design

- Sub-scale pressure testing - optimization



- Can decrease normalized load requirement

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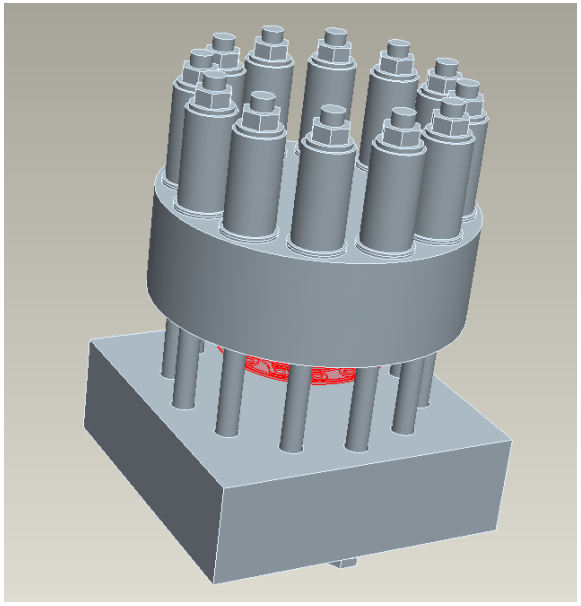
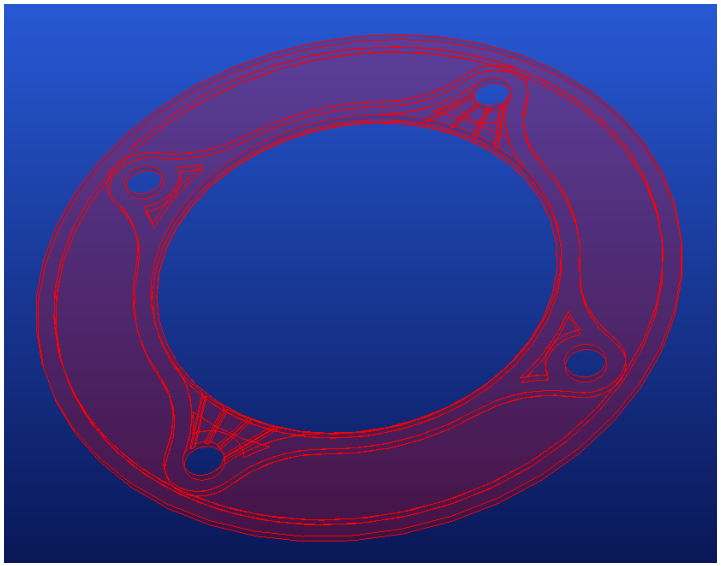
Technical Accomplishments
Task 2.0: Stack Design

- Conceptual designs
  - Preliminary calculations of clamping force and endplate thickness are complete

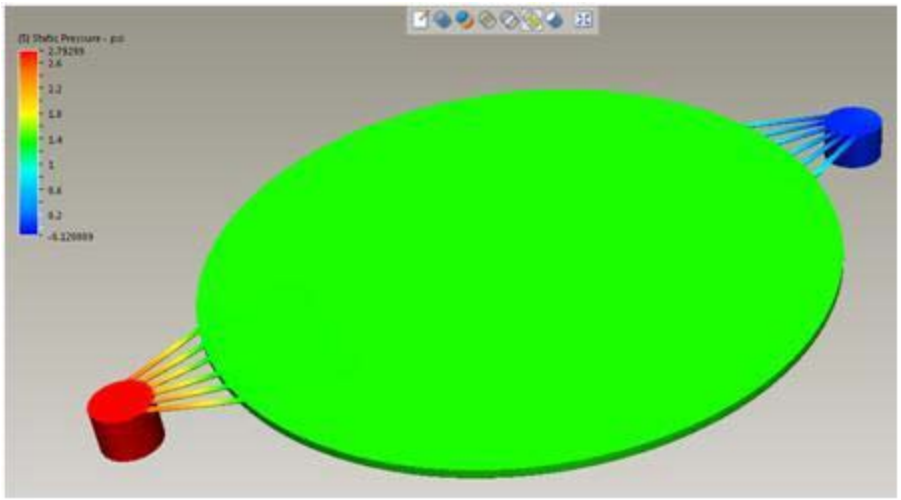




  - Concepts for cell seals and porting have been modeled

Technical Accomplishments
Task 2.0: Stack Design

- Conceptual designs
  - Preliminary finite element analysis (FEA) on key components is complete

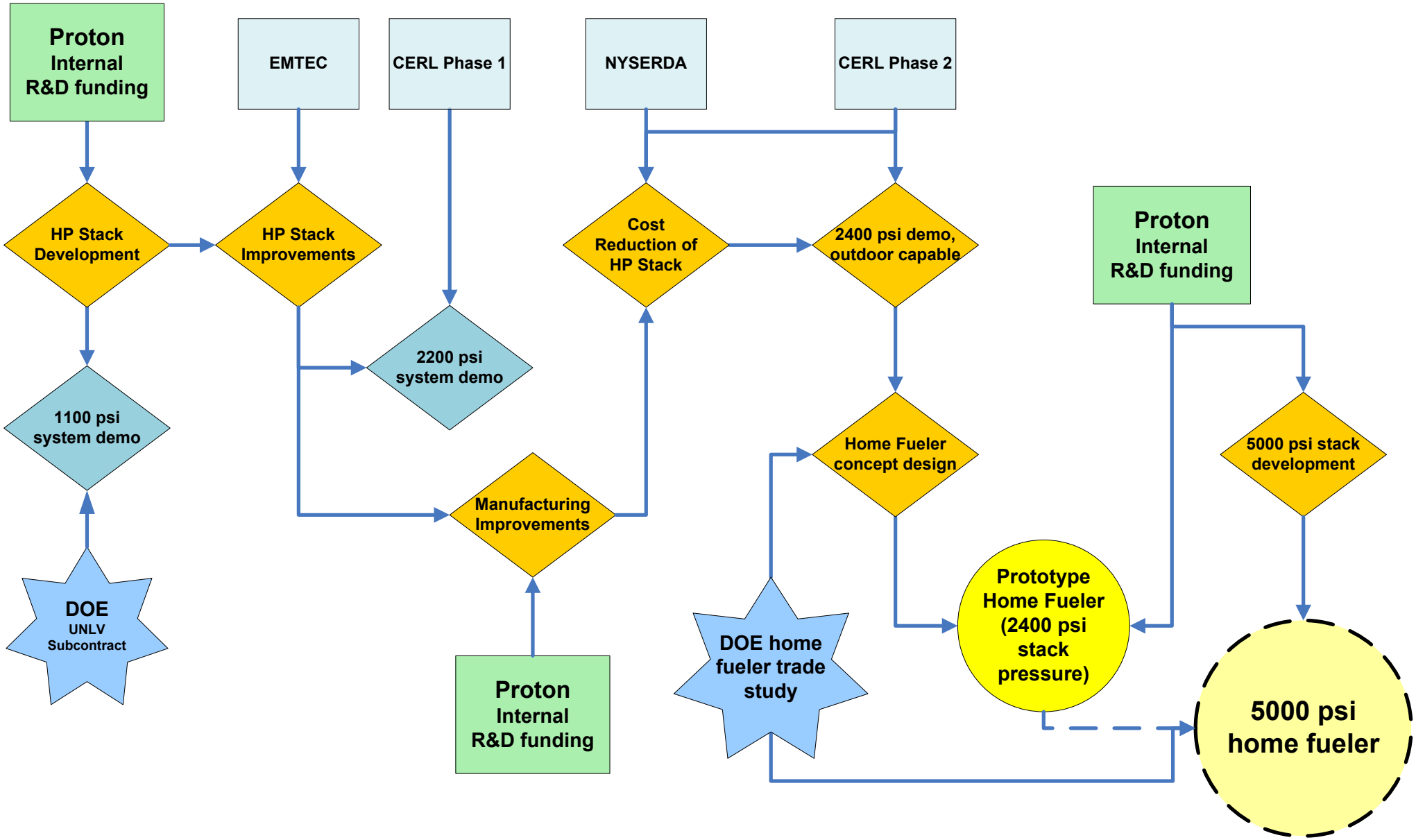


  - Initial computational fluid dynamics (CFD) analysis for flow passages is complete

Future Work

- Complete cell stack design phase
- Initiate cell component verification phase
- Initiate prototype system procurement, fabrication and assembly
- Integrated operational testing

Future Work: Home Fueler Roadmap



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Future Work
Product Package Development

- Physical Size – 2’ x 3’ x 5’

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Summary

- **Relevance:**
  - Home fueling is a viable pathway on the continuum of options. Home fueling grows organically with vehicle introduction. PEM electrolysis is ideal technology for small footprint, easy maintenance.
- **Approach:**
  - Execute development of key enabling technologies including PEM electrolysis cell stack and balance-of-plant components for 5,000 psi operation. Draw upon *Proton's experience with commercial products* to inform the design and safety analysis.
- **Technical Accomplishments:**
  - Completed prototype system design, including key balance-of-plant components. Completed sub-scale cell stack pressure testing. Initiated product scale cell stack design.
- **Collaborations:**
  - Drew upon relevant data from prior work and key component suppliers.
- **Proposed Future Work:**
  - Cell stack design and verification. System procurement, fabrication, and assembly. Integrated testing.