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: 21 Sep 2009
- Project End: 21 May 2010
- Percent complete: 100%

Budget

- Total project funding
  - DOE share: $99,990
- Funding for FY10
  - DOE share: $99,990

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

Technical Sources

- Hydro-Pac
- W.E.H.
- GTI

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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

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Relevance
Fueling Infrastructure Challenges

- Ramp-up
  - Fuel production
  - Storage
  - Transportation and/or distribution
  - End-customer delivery

HOME FUELING

Existing:

Electricity

Water

- Pace with parallel ramp-up of related vehicles

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)

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Relevance
Project Objectives

- Define critical requirements for PEM Electrolysis Home Fueling System
  - Technical
    - Define hydrogen production capacity for a recharge time relevant to end-user
    - Estimate electrical service and physical size
  - Capital and operating cost
  - Codes and standards
  - Product safety
  - Operation and maintenance

Approach
Task Breakdown

- Task 1.0: Technical Requirements Analysis
  - 1.1 Capacity:
  - 1.2 Efficiency and power usage
  - 1.3 Physical size
  - 1.4 Preliminary design requirements
- Task 2.0: Cost Analysis
  - 2.1 Cost of hydrogen for different vehicle scenarios
  - 2.2 Effect of technology improvements and production volume increases
- Task 3.0: Installation Analysis
  - 3.1 Cost impact of current code compliance environment, and direction of national and international standards
  - 3.2 O&M and energy comparison to other residential appliances

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Technical Accomplishments

Task	Task Description	Progress Notes	Completion
1.0	Technical Requirements Analysis	• Estimated required capacity for a range of vehicle fuel efficiency values and vehicle usage profiles. • Estimated physical size, electricity usage. • Tabulated product requirements.	100%
2.0	Cost Analysis	• Estimated required bill-of-materials. • Estimated $/kg cost for a range of fuel efficiency and vehicle usage profiles using H2A model.	100%
3.0	Installation Analysis	• Tabulated list of relevant codes and standards. • Estimated cost impact of municipality specific codes and standards environment. • Defined maintenance strategy.	100%

Approach
Task 1.0: Technical Requirements

- Estimate high, medium, and low users based on:
  - Commute distances
  - Driving profiles
  - Day-to-day variation
- Estimate available recharge hours (assuming no storage off-board vehicle)
- Data:
  - Average One-Way Commute Miles: 14.5 [1]
  - Average Daily Driver Miles: 32.89 [2]
  - FCV MPGGE (Light Truck): 56.1 [3]

[1] US Department of Transportation, Bureau of Transportation Statistics, Omnibus Household Survey.
[2] National Highway Traffic Safety
[3] http://www.transportation.anl.gov/pdfs/TA/339.pdf

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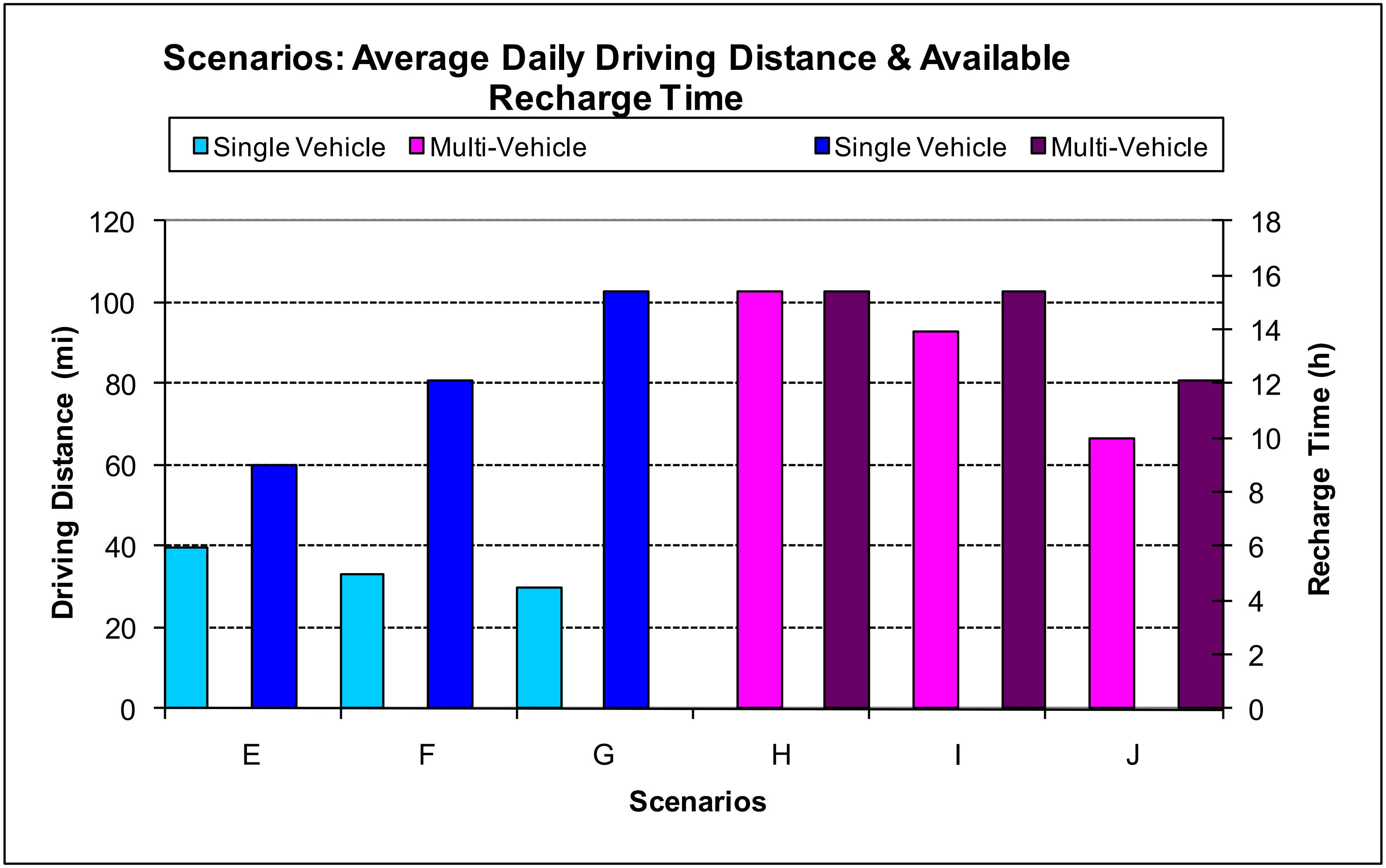
Technical Accomplishments
Task 1.0: Technical Requirements

- Task 1.1: Capacity - Scenarios



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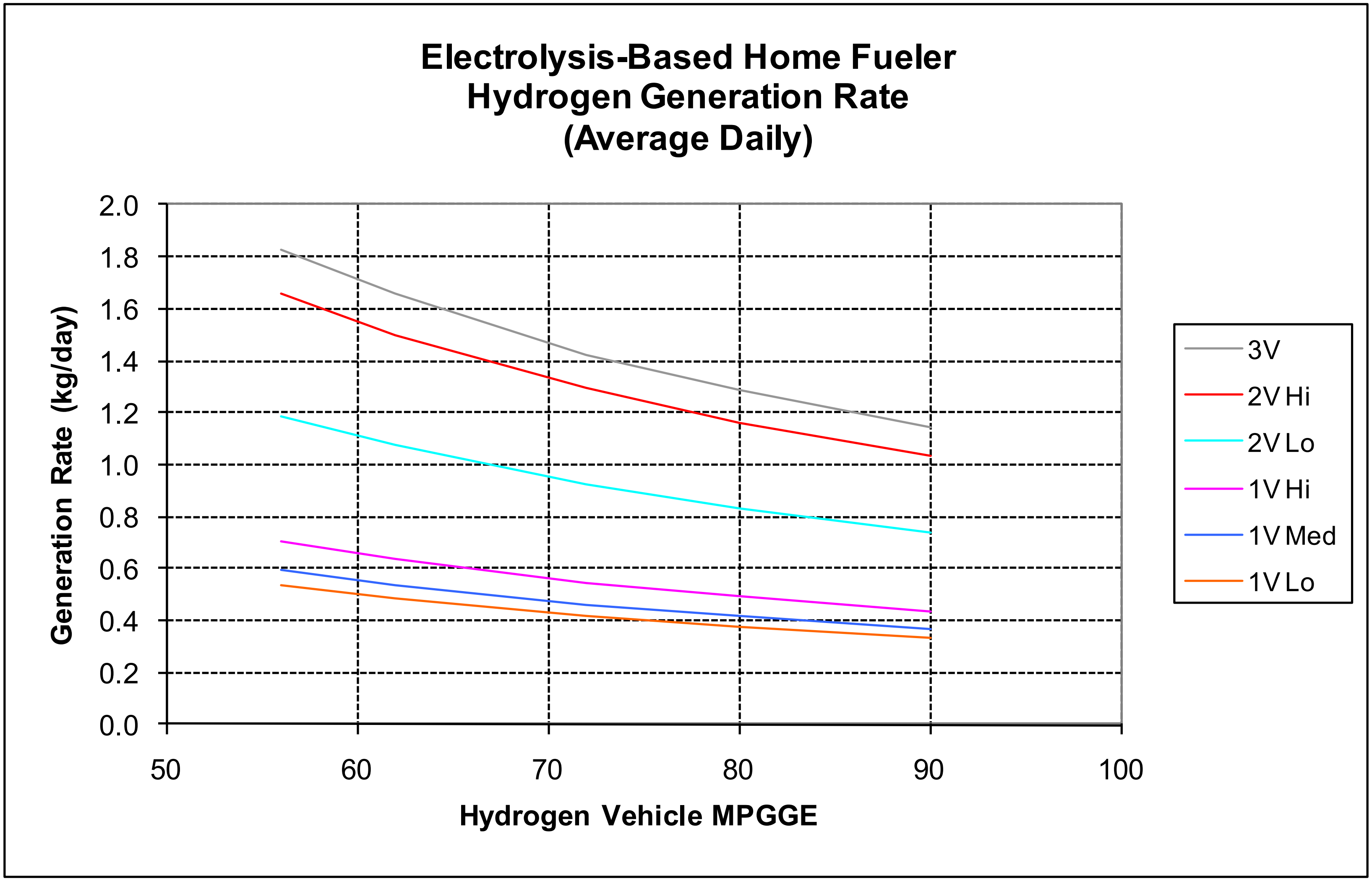
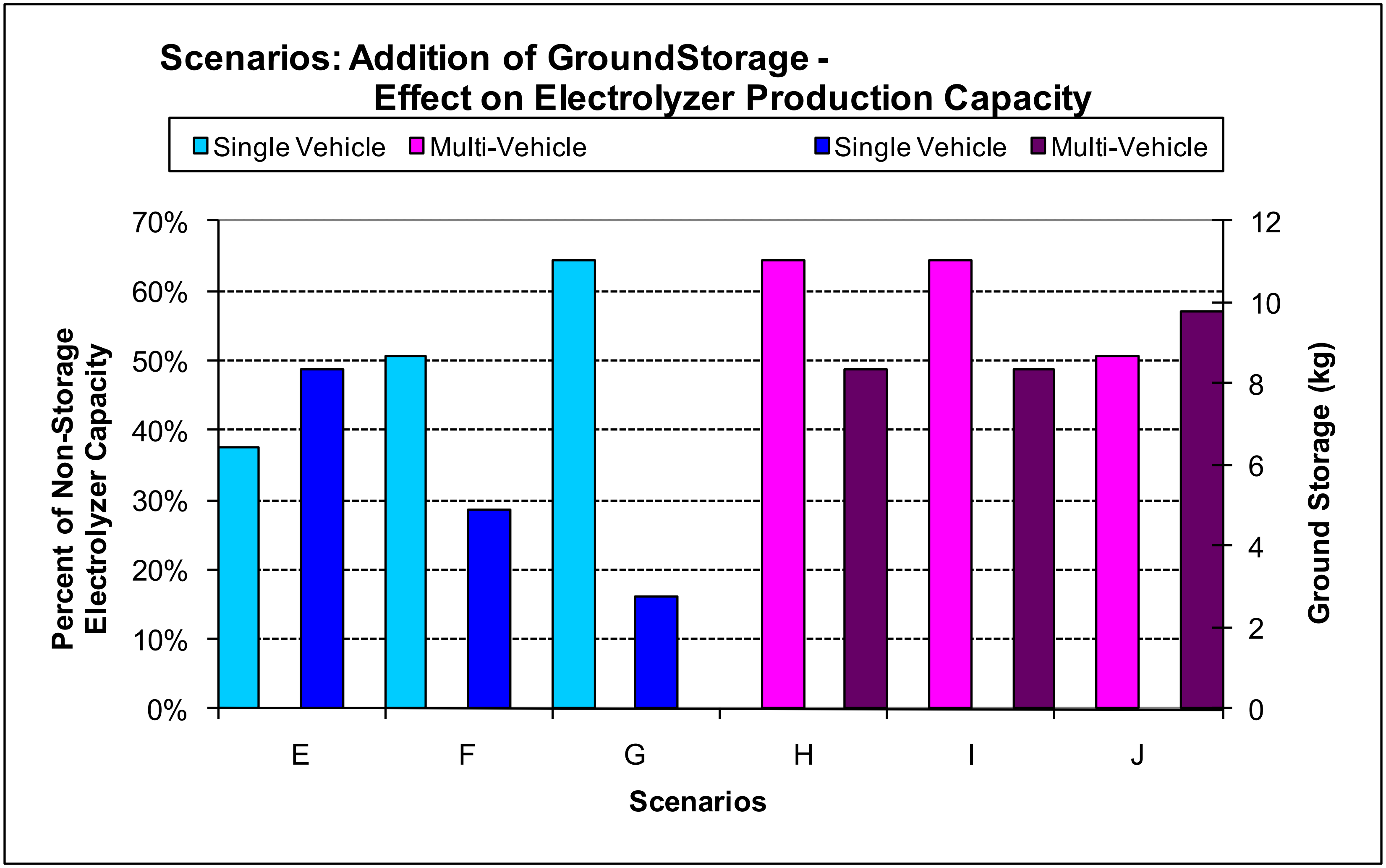
Technical Accomplishments
Task 1.0: Technical Requirements

- Task 1.1: Capacity



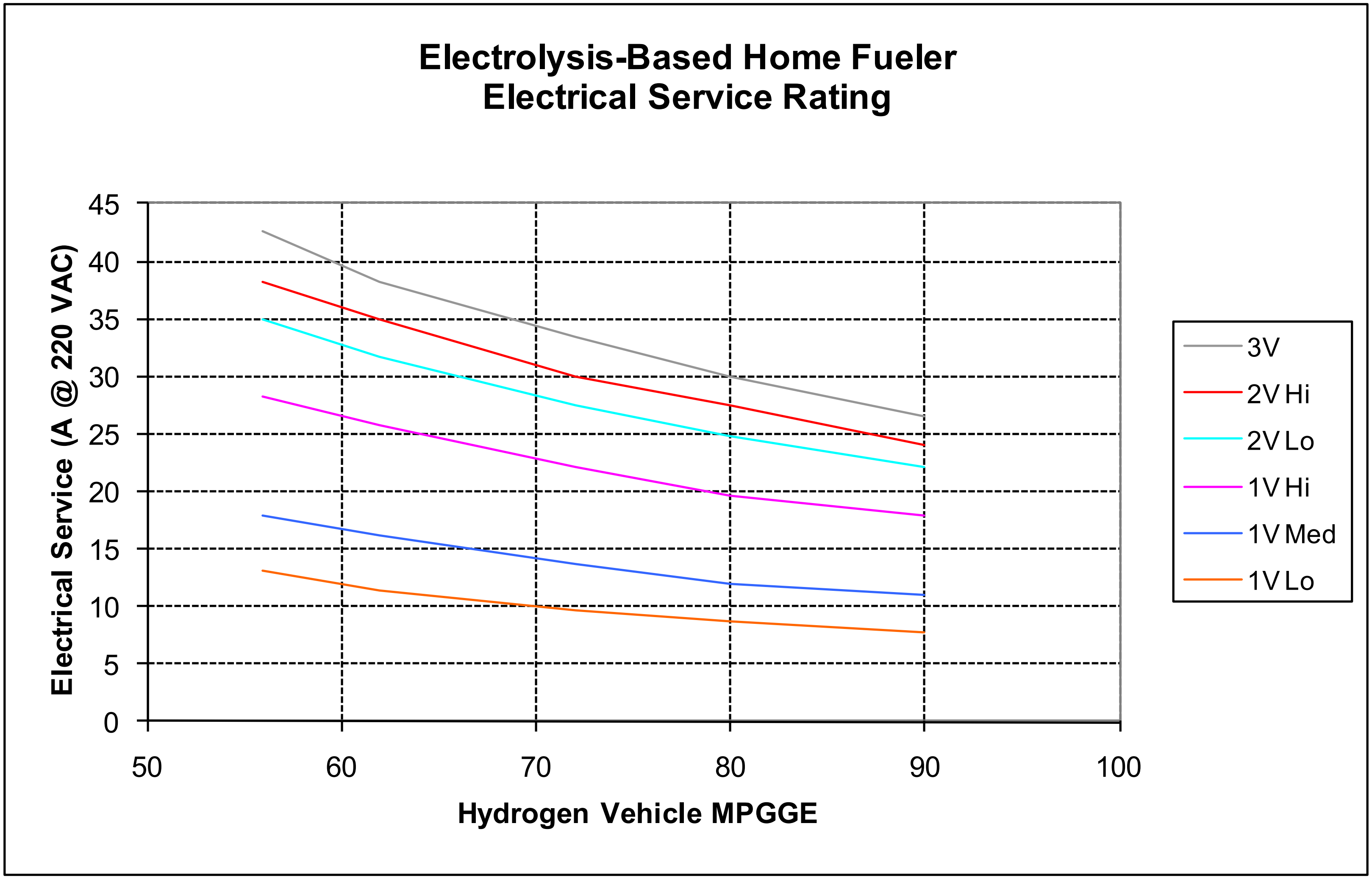
Technical Accomplishments
Task 1.0: Technical Requirements

- Task 1.1: Capacity – Effect of Ground Storage



Technical Accomplishments
Task 1.0: Technical Requirements

- Task 1.2: Electrical Service



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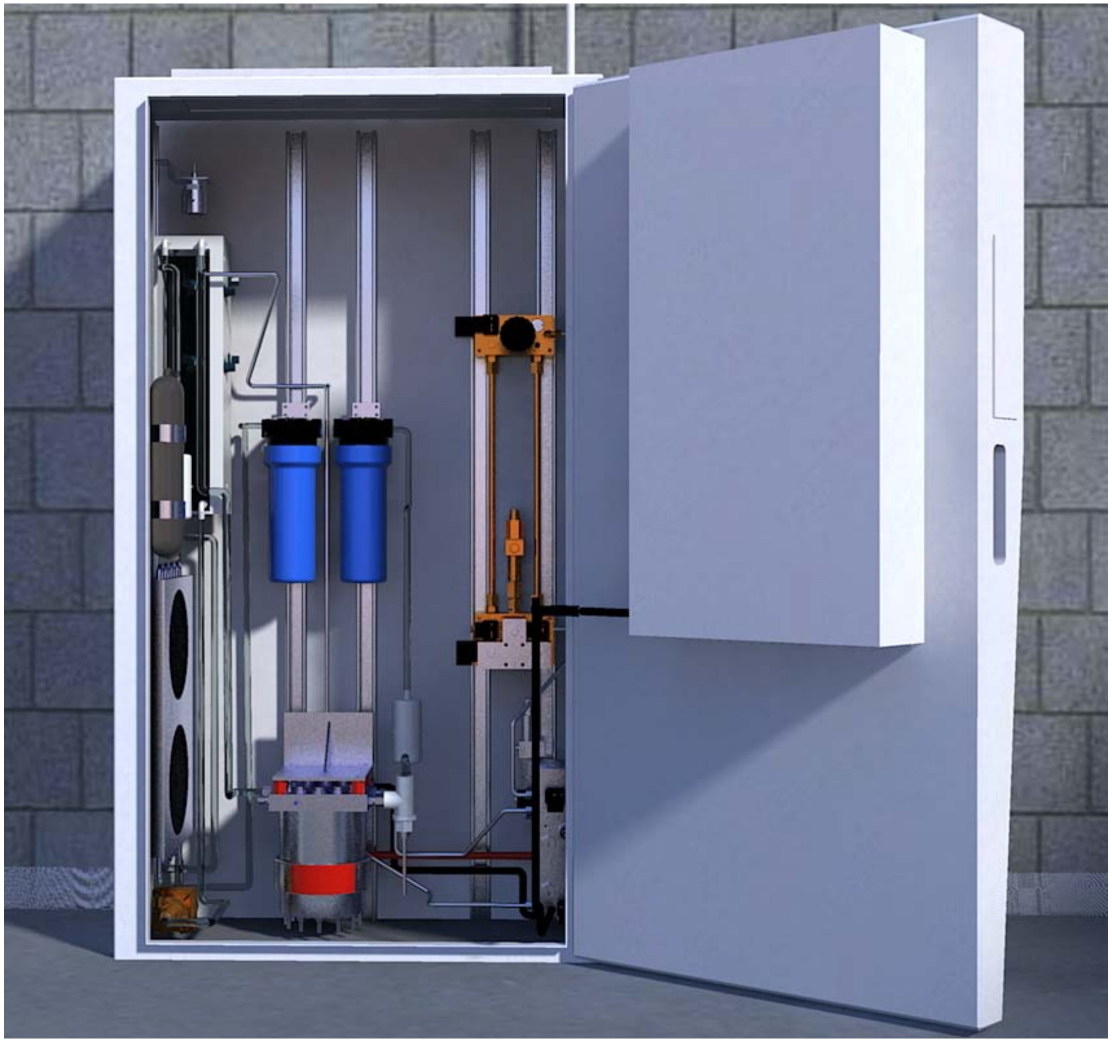
Technical Accomplishments
Task 1.0: Technical Requirements

- Task 1.3: Physical Size – 2’ x 3’ x 5’



Technical Accomplishments
Task 1.0: Technical Requirements

- Task 1.3: Physical Size – 2’ x 3’ x 5’

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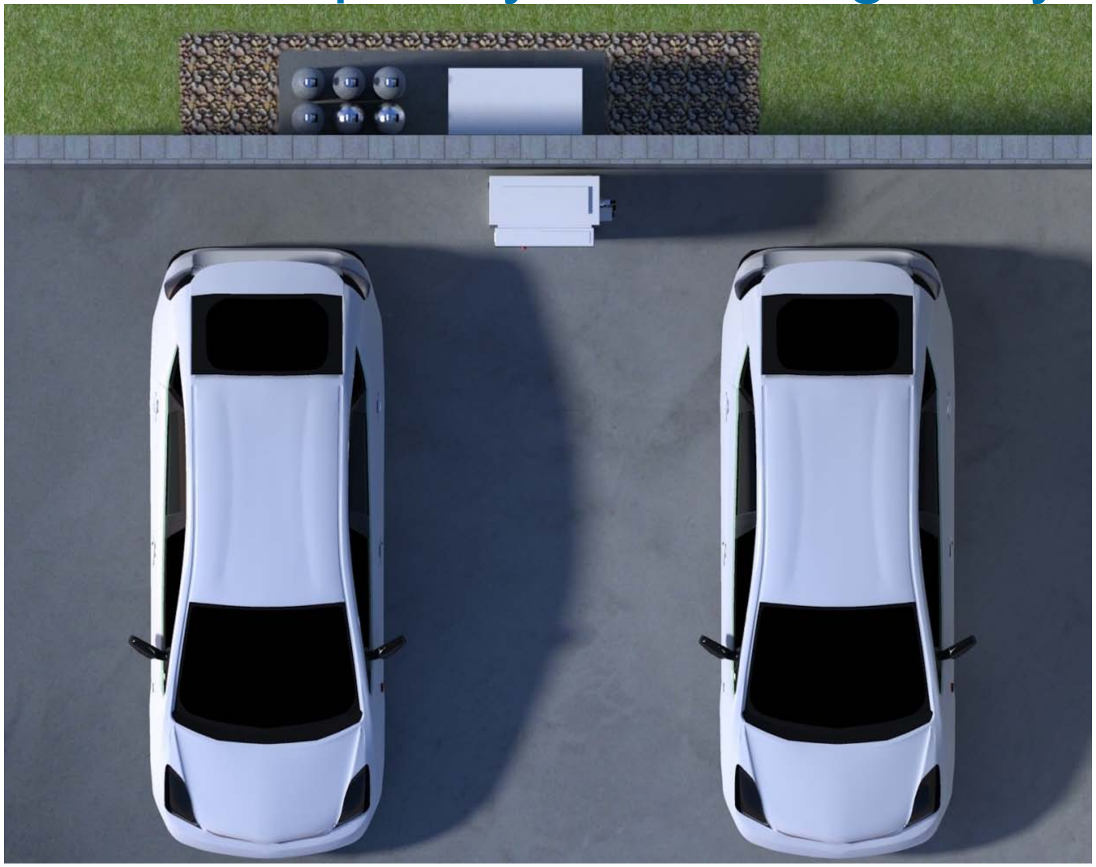
Technical Accomplishments
Task 1.0: Technical Requirements

- Task 1.3: Physical Size
  - With mechanical compression and ground storage footprint and complexity increase greatly

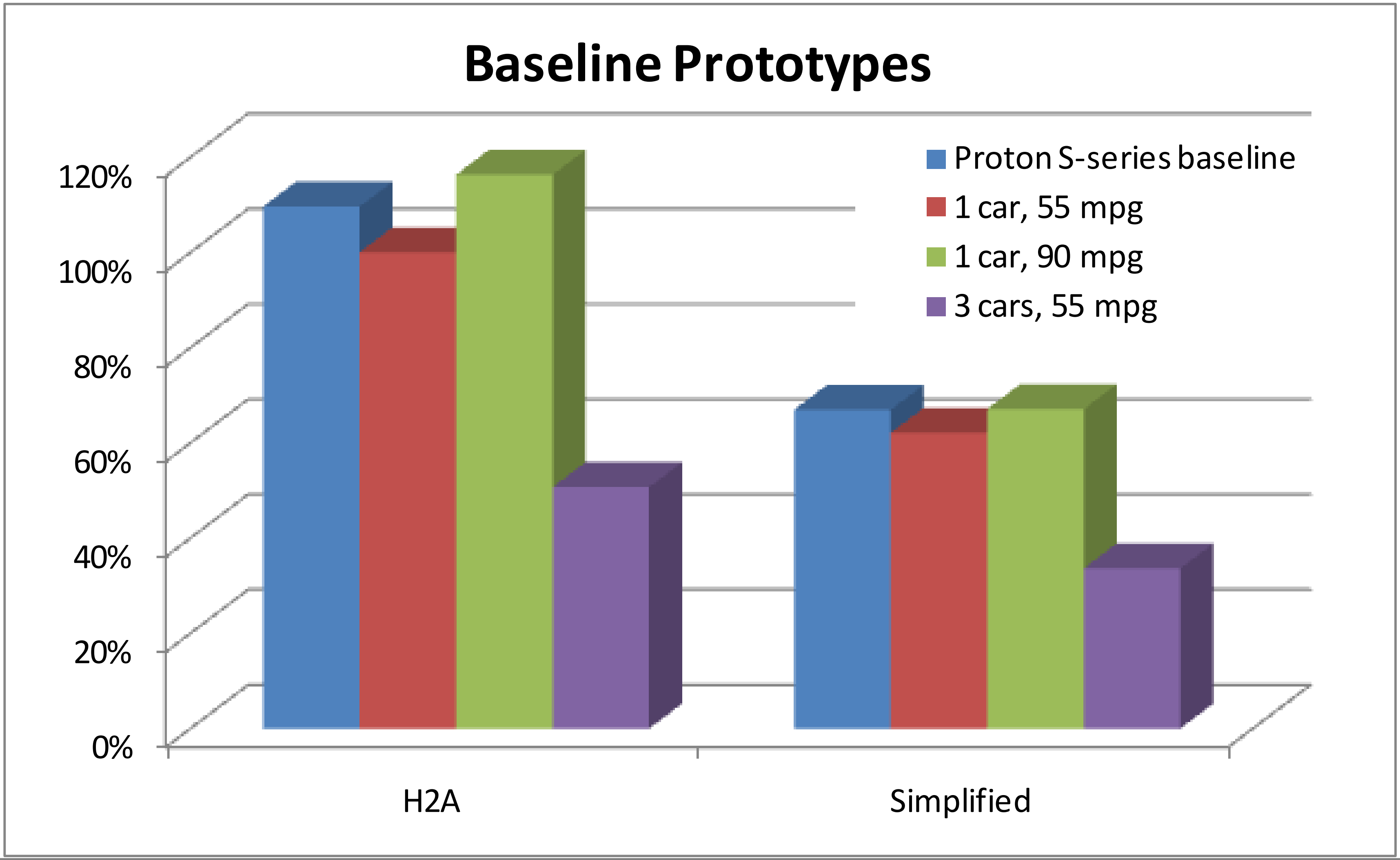


Technical Accomplishments
Task 1.0: Technical Requirements

- Task 1.4: Product Requirements Definition

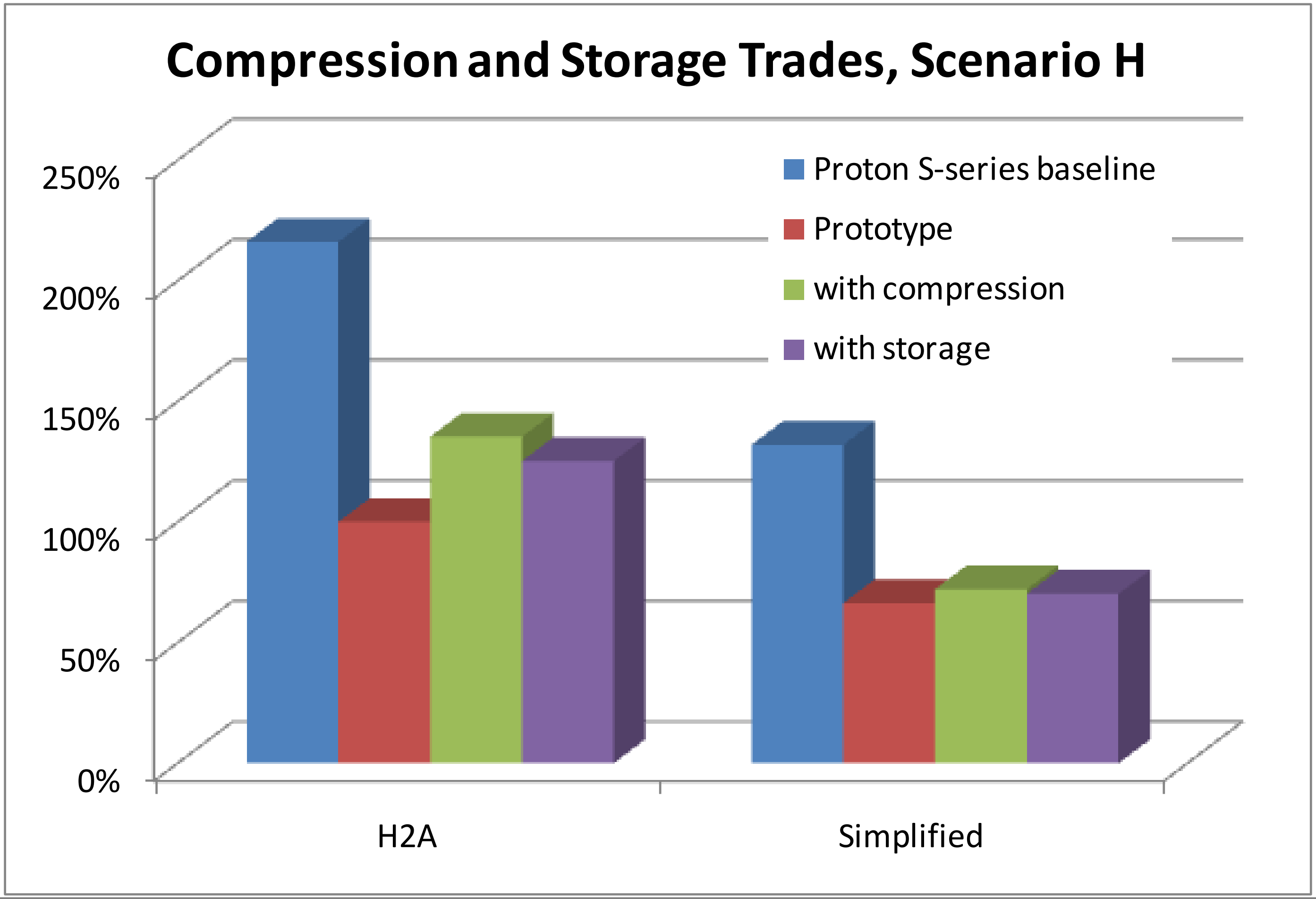
Technical Accomplishments
Task 2.0: Cost Analysis

- Task 2.1: Effect of driving scenarios



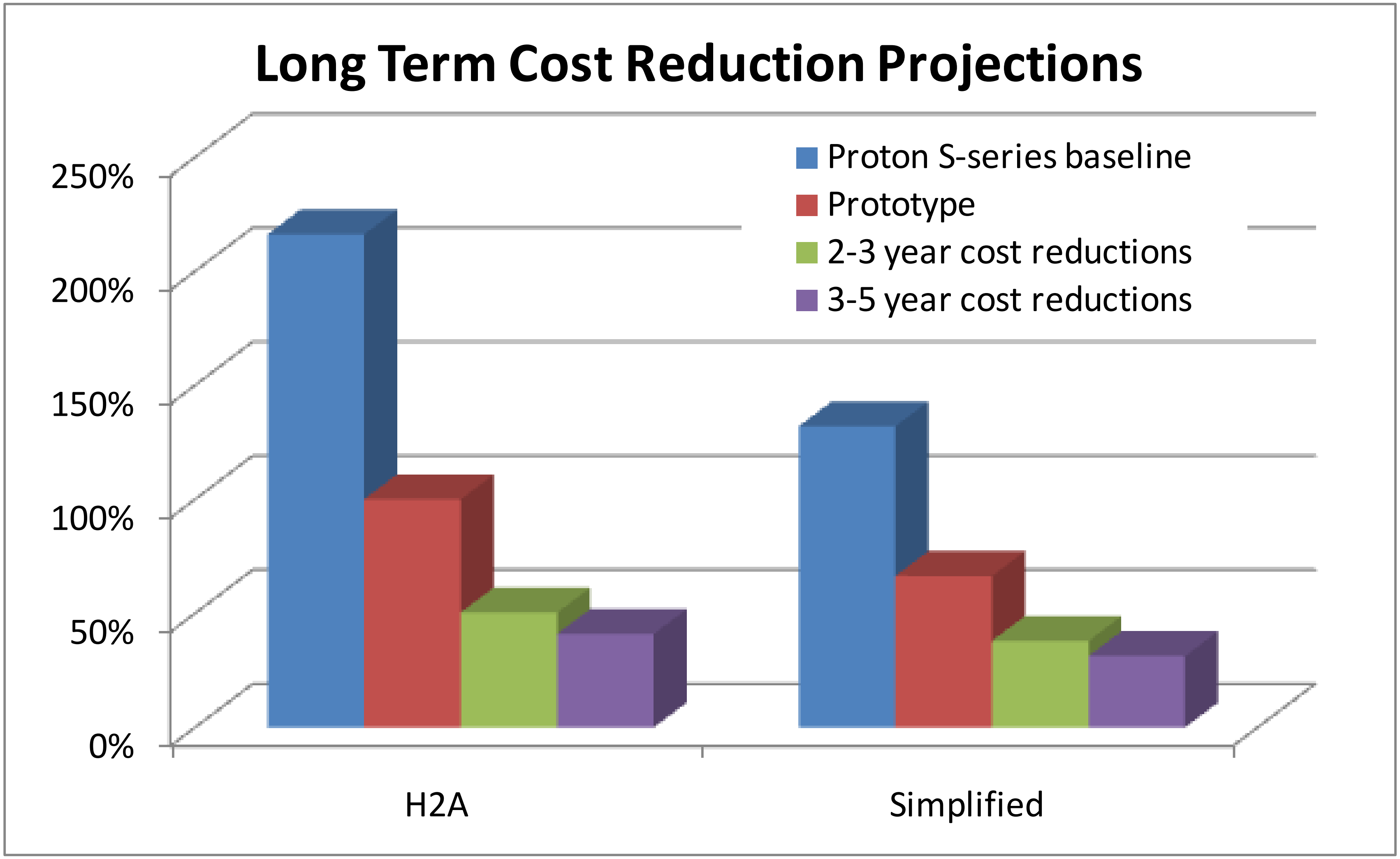
Technical Accomplishments
Task 2.0: Cost Analysis

- Task 2.1: Effect of ground storage and mechanical compression



Technical Accomplishments
Task 2.0: Cost Analysis

- Task 2.2: Effect of Cost Reductions



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Technical Accomplishments
Task 3.0: Installation Analysis

- Task 3.1: Current Codes and Standards Environment
  - NFPA 70 National Electric Code
  - NFPA 79 Electrical Standard for Industrial Machinery
  - NFPA 69 Standard on Explosion Prevention Systems
  - IEC/UL 61010-1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use
  - Municipality specific codes vary by location

Technical Accomplishments
Task 3.0: Installation Analysis

- Task 3.1: Desirable Codes and Standards Environment
  - ISO/IS 22734-1 (Commercial/Industrial)
  - ISO/DIS 22734-2 (Residential)

  - Education campaign to make local AHJ's familiar with the ISO standards and hydrogen equipment

Technical Accomplishments
Task 3.0: Installation Analysis

- Task 3.2: Operation and Maintenance
  - Service plan:
    - Home-owner access to:
      - Air Inlet Filter
      - Water De-Ionizing Cartridges
    - Annual maintenance required for additional items
      - Locked cabinet accessible only to qualified service technicians
      - Service centers to stock replacement parts and dispatch technicians

Collaboration

- Technical sources
  - Hydro-Pac
  - W.E.H.
  - GTI

Future Work

- Fabricate prototype based on existing commercial components
- Develop key electrolysis system components to achieve cost, manufacturability, and serviceability requirements
- Extend electrolysis pressure range
- Transition full pressure, cost-reduced, residential fueling product to commercial readiness

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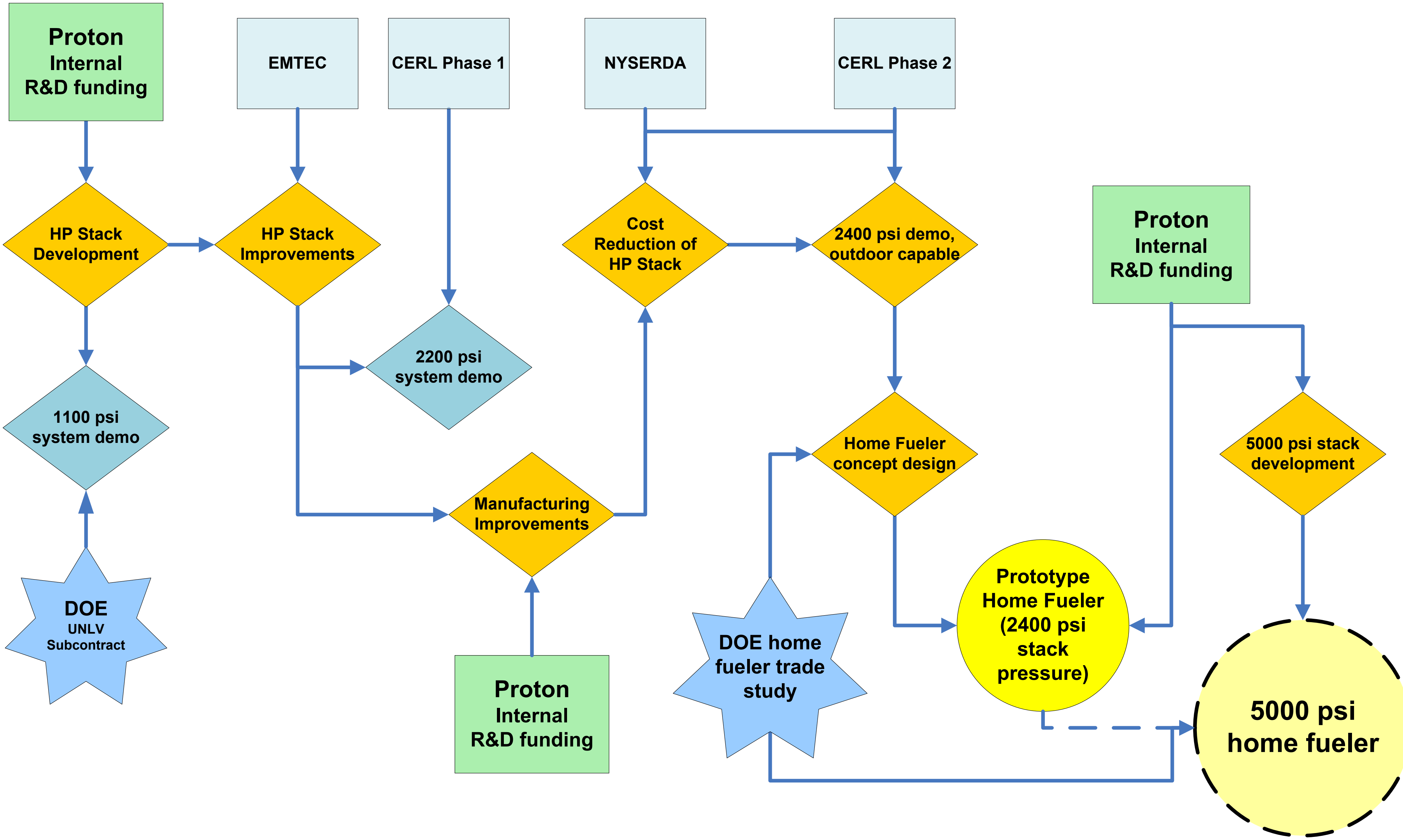
Future Work: Home Fueler Roadmap



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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:**
  - Examine key technical, cost, and installation requirements through sound analytical approach. Draw upon *Proton's experience with commercial products* to inform the design, cost estimates, and technical service plans.
- **Technical Accomplishments:**
  - Developed model for electrolysis capacity based on real-world driving data. Examined effects of different driving scenarios on capacity, size, service rating and cost. Described the codes and standards environment
- **Collaborations:**
  - Drew upon relevant data from prior work and key component suppliers.
- **Proposed Future Work:**
  - Prototyping, component development, product development