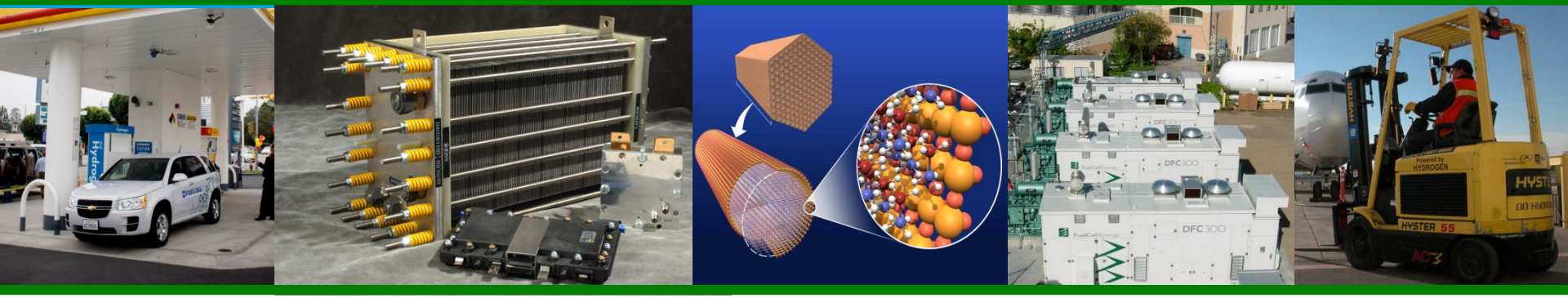
U.S. DEPARTMENT OF ENERGY



# Market Transformation
# - Plenary Presentation -

*Richard Farmer, on Behalf of Pete Devlin*

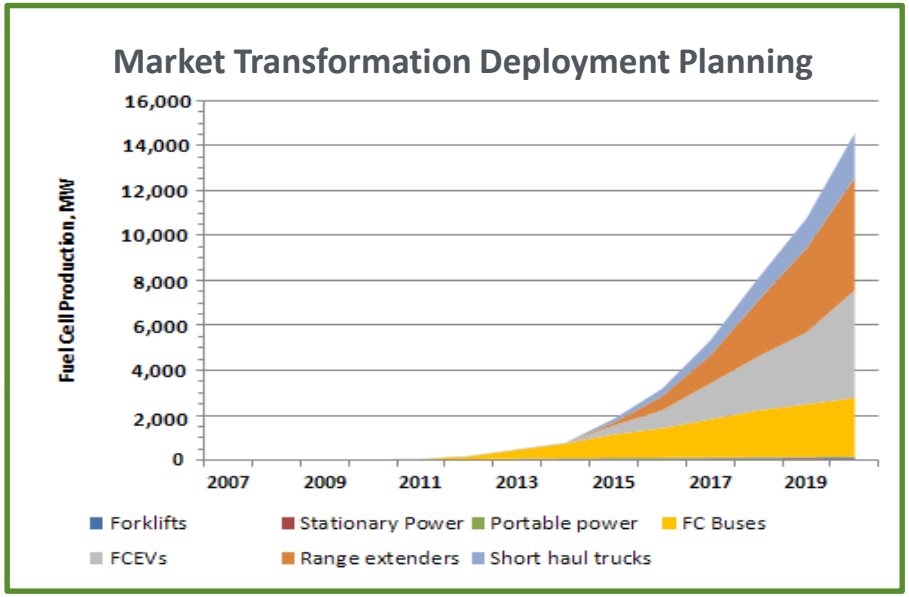
***2015 Annual Merit Review and Peer Evaluation Meeting***
***June 8 - 12, 2015***

# Goals and Objectives for Market Transformation



## Objectives

- Increase fuel cell markets by developing and deploying various applications and increase hydrogen fuel demand.
- Catalyze key implementation projects and partnerships with federal, state, and local governments and other stakeholders.
- Develop technical-economic analysis associated with early markets and infrastructure.

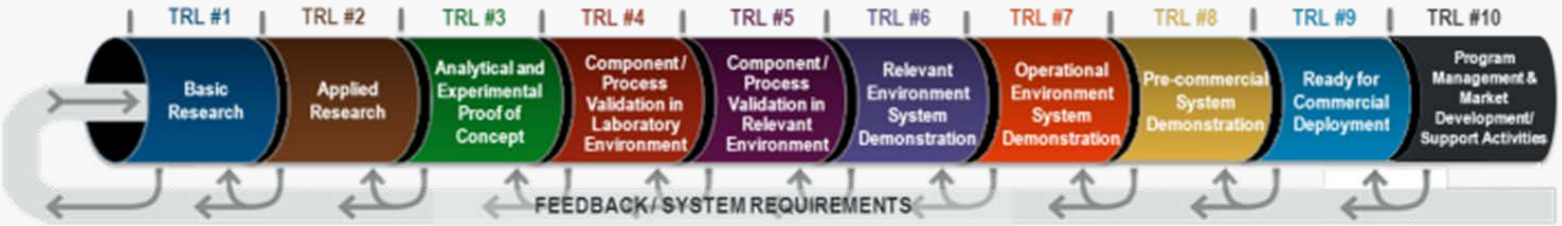




http://www.navigantresearch.com/research/

***GOALS: Accelerate technology utilization growth for domestically produced hydrogen and fuel cell systems. Lower fuel cell life cycle costs by reducing deployment barriers.***

# Challenges

- To test emerging applications at the Technology Readiness Level (TRLs) 6-9 level to expand user and servicing expertise




- To test new technology applications in user operating conditions to establish baseline energy efficiency and reliability performance and determine commercial viability

**Examples:**

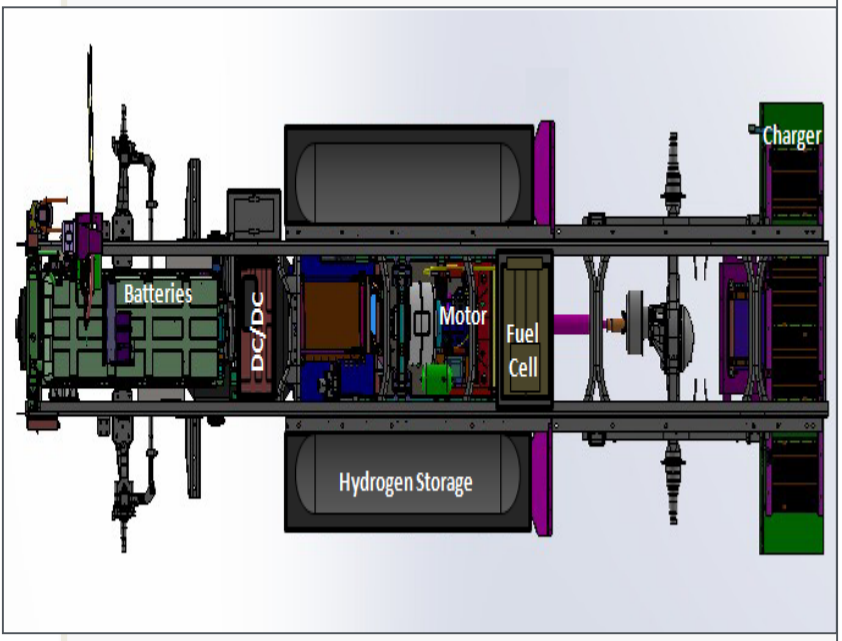
***A 1-kW fuel cell system providing power for this FAA radio tower near Chicago***

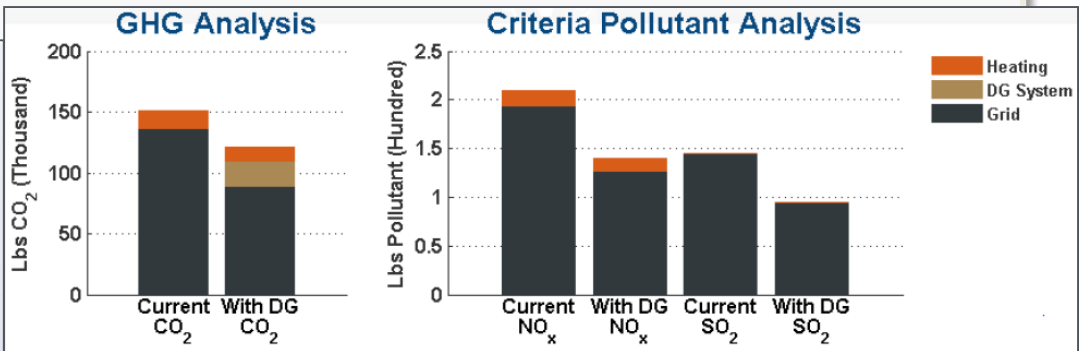
(Photo courtesy of ReliOn/Plug Power)


***Material Handling Equipment at work in U.S. airports***
(Photo courtesy of Hydrogenics)

# Challenges

- To develop strategies to reduce commercial risks to ensure high hydrogen and system utilization and reliability under mass market penetration scenarios



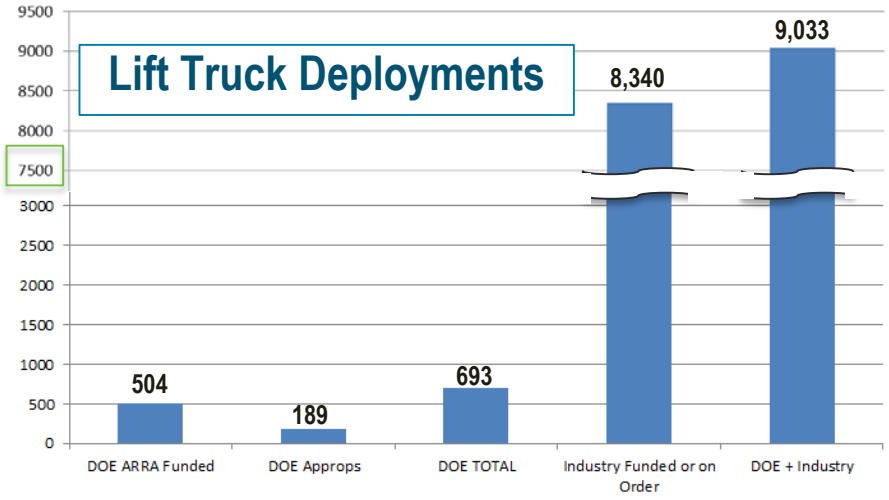

Annual GHG and Pollutant Production (lbs)

| | $CO_2$ | | $NO_x$ | | $SO_2$ | |
|---|---|---|---|---|---|---|
| | Current | With DG | Current | With DG | Current | With DG |
| Heating | 13,945 | 11,580 | 14 | 12 | 0 | 0 |
| DG System | 0 | 20,537 | 0 | 0 | 0 | 0 |
| Grid | 136,838 | 89,526 | 194 | 127 | 144 | 94 |
| Total | 150,783 | 121,644 | 209 | 139 | 144 | 94 |

- To obtain data from operating experience and develop replicable business cases

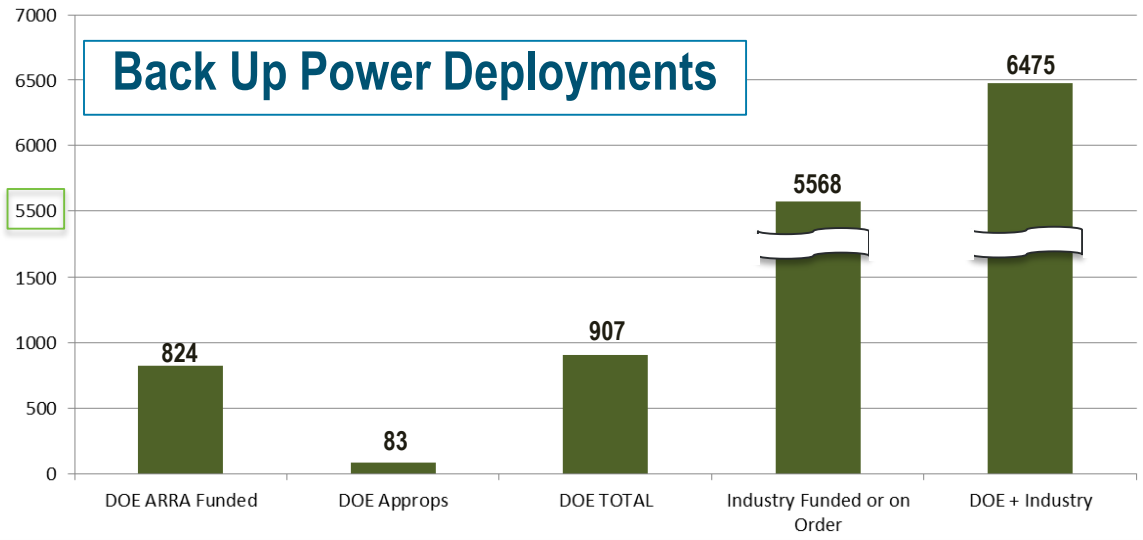
# Market Transformation Deployments






The successful deployment of nearly 700 DOE fuel cell material handling units has led to over 8,300 industry purchased and on order units with no DOE funding.

The funding of 907 DOE fuel cell backup power systems has led to over 5,500 industry installations and on-order backup power units with no DOE funding.




***DOE investment in lift trucks and back up power has led to thousands of industry installations.***

# Accomplishments: MHE Operation Summary 2009 Q4 – 2014 Q3

Validation of MHE is based on real-world operation data from high-use facilities.

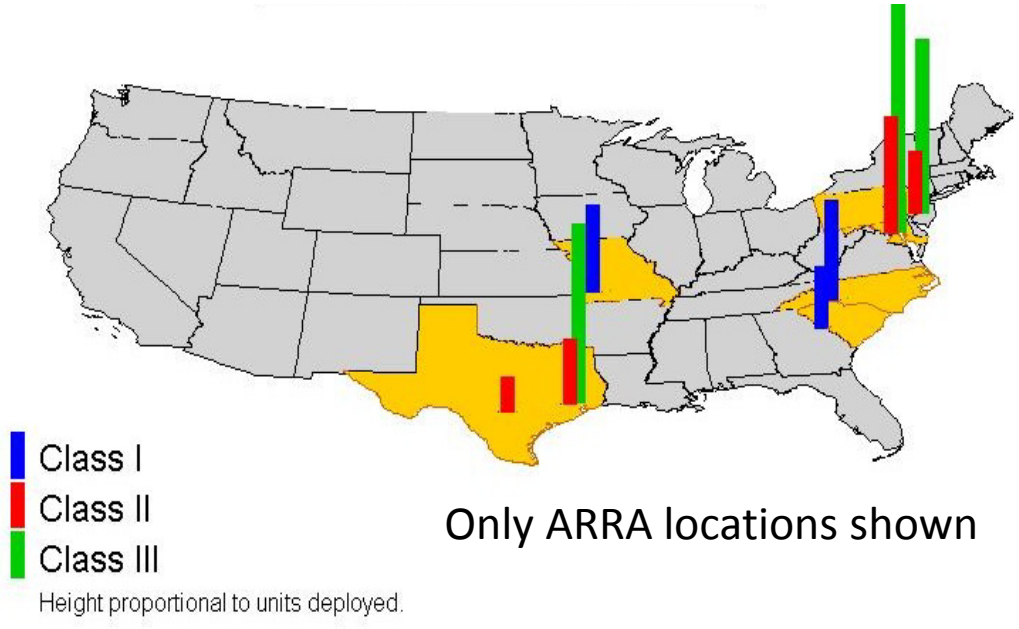
**2,683,567**
Operation hours

**352,527**
Hydrogen fills

**720**
Units in operation

**3.7**
Average operation hours between fills

**287,967**
Hydrogen dispensed in kg




Only ARRA locations shown

**0.7**
Average fill amount in kg

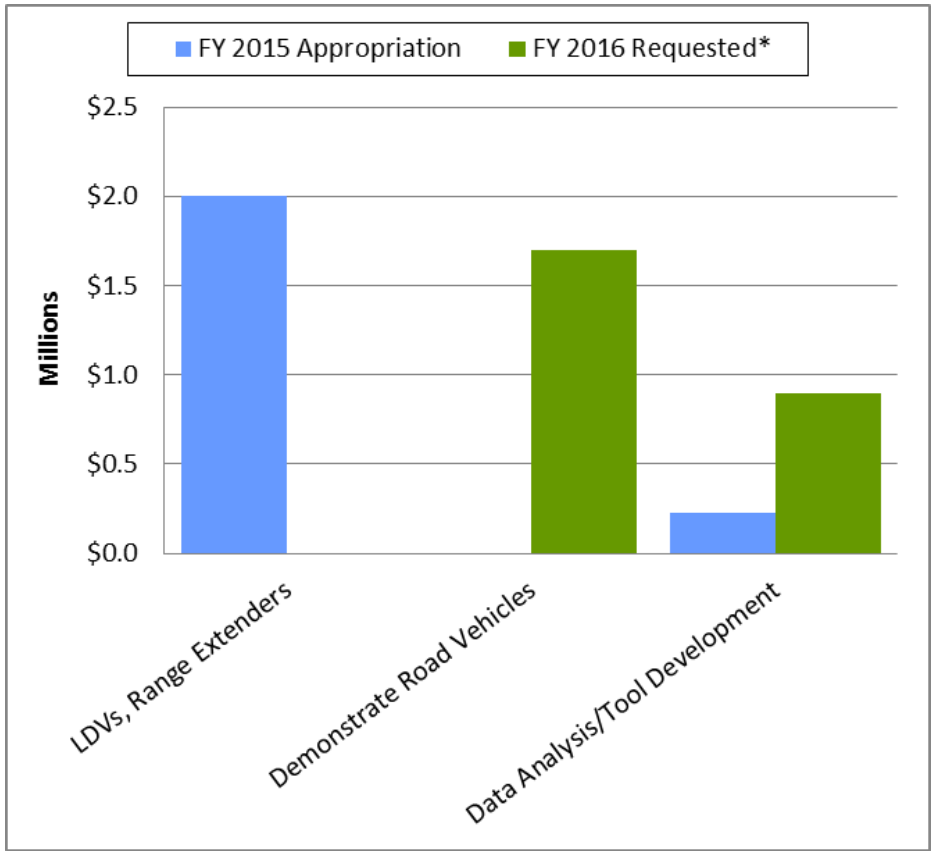
**2.5**
Average fill time in minutes

# Market Transformation Budget

U.S. DEPARTMENT OF ENERGY

**FY 2016 Request = $3.0 M**

**FY 2015 Appropriation = $3.0 M**




*Subject to appropriations

## EMPHASIS

- Conduct GSE demonstration and analyze business case
- Increase various vehicle class deployments over the next few years and create hydrogen fuel demand
- Continue developing models, tools and templates to support outreach and commercialization

# Ground Support Cargo Tow Tractors



## Timeline

- Start: January 2013
- End: December 2015
- Kickoff Meeting – 3/27/13

## Budget

- Total: $5.0M
  - DOE Share: $2.5M
  - Partners: $2.5M
  - Status: 73.6% Complete


## Barriers

- Power upsizing for this application
- Outdoor operation not proven

## Partners

- Plug Power
- FedEx Express
- Charlatte
- Memphis-Shelby County International Airport

## Accomplishment

- Designed and built 15 units for fleet demo

*Designed and built 20 kW fuel cell system for airport ground support vehicle*

# Marine Generator for Pier Side and Auxiliary Sea Vessel Power



**Timeline**

- Start: Sept. 2013
- End: Dec. 2015
- 60% complete

**Budget**

- Total: $2.4M
  - DOE Share: $885k
  - DOT/MARAD Share: $825k
  - Contractor Share (est.): $700k


**Barriers**

- Inadequate standards
- Financing mechanisms (Lack of cost and performance data)
- Inadequate user experience

**Partners**

- Sandia *(project lead)*
- Young Brothers, Ltd.
- Foss Maritime
- Hydrogenics
- Hawaii Natural Energy Institute (HNEI)
- American Bureau of Shipping (ABS)
- US Coast Guard (USCG)

***Developed a prototype design for a marine generator for pier side and auxiliary sea vessel power.***

# APUs for Refrigerated Trucks



## Timeline

- Project Start: April 2013
- Project End: Dec. 2016
- Percent complete: 37%

## Budget

- FY13 DOE Funding: $800k
- Planned FY14 DOE Funding: $0k
- Total DOE Project Value: $1.6M Total (PNNL) Program
  - Includes $1.3M for subcontracts
  - Contractor cost share $1.6M


## Barriers

- Inadequate private funds available for new applications
- Lack of value proposition awareness of applications

## Partners

- Project Lead – Pacific Northwest National Lab
- System Integrators – Nuvera, Hydrogenics
- Transport Refrigeration Unit Developers
  - ThermoKing
  - Carrier Transicold
- System Demonstrators
  - HEB and Sysco
- $H_2$ Provider: Air Products

***Designed and developed 2 auxiliary power systems for refrigerated trucks***

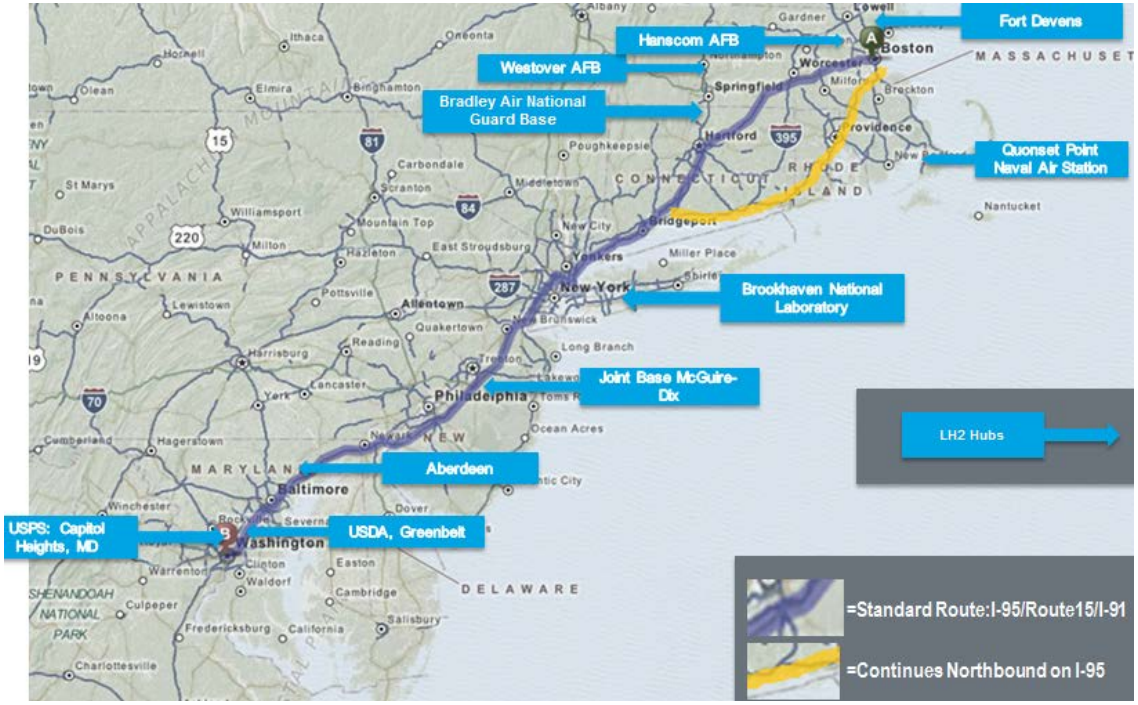
# Accomplishments

- Completed fuel cell electric waste hauling refuse truck develop and deploy SBIR projects (US Hybrid) Phase I
- Issued FOA for demonstration and deploy of battery-fuel cell hybrid electric vehicle
- Completed design, build, and factory testing of 15 cargo tow tractors
- Completed maritime power design and build
- Completed TRU APU design and testing of prototype
- Developed hydrogen refueling infrastructure plans and fleet deployments, working with states
  - Example – Hawaii Transportation Plan
  - Completed Phase 1 SBIR for refuse truck
- Launched SBIR program to develop and deploy fuel cell bucket truck

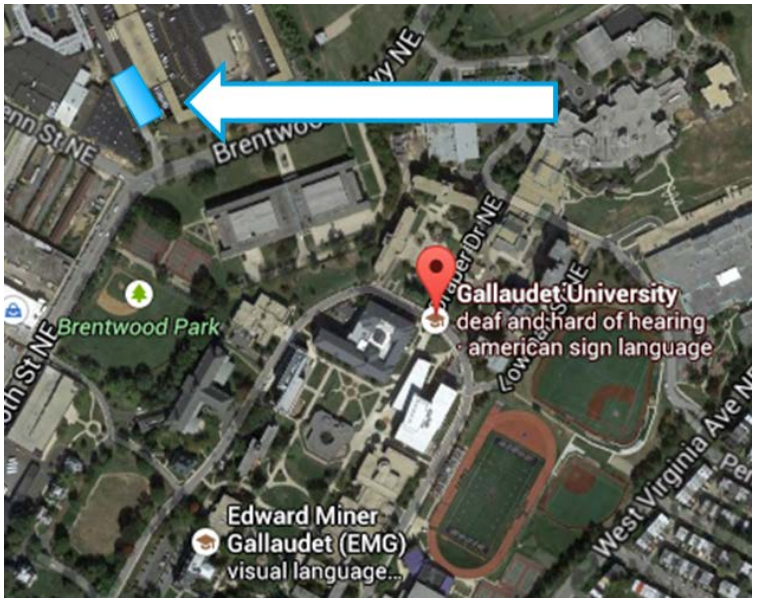
# Accomplishment: Infrastructure

- ✓ Developed Federal fleet analysis and strategy
- ✓ Developed plan for public station at Camp Pendleton
- ✓ Planned and implementing temporary refueling station at NPS Brentwood facility
- ✓ Developed "Infrastructure Briefing" for novice state/local station refueling planners

**East Coast Installation Possibilities Map**




**NPS Brentwood Facility**

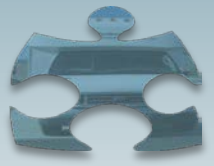


# Infrastructure Briefing

## The Key Pieces of the FCEV-$H_2$ Puzzle

Creating ZEV and $H_2$ station **incentives and cost share** opportunities

**Establishing Initial Infrastructure**: Coordinating with the right stakeholders



**FCEV fleet planning**

Harmonizing **codes and regulations**

Creating an **affordable hydrogen** system

Exercising the **Financing Options**

**Form broad communities of interest** to promote FCEVs and $H_2$ stations

Timely **Education & Outreach**

# Battery-Fuel Cell Hybrid Vehicle



U.S. commercial fleets are a large automotive market segment, with vehicle inventories totaling:

- ~11.7 million vehicles
- New car and light truck sales of about 2.6 million vehicles annually.

Commercial fleets include:

- Government owned vehicles (e.g. police cars)
- Company-owned vehicles
- Rental fleets
- Taxis
- Delivery vehicles


Mercedes-Benz Sprinter

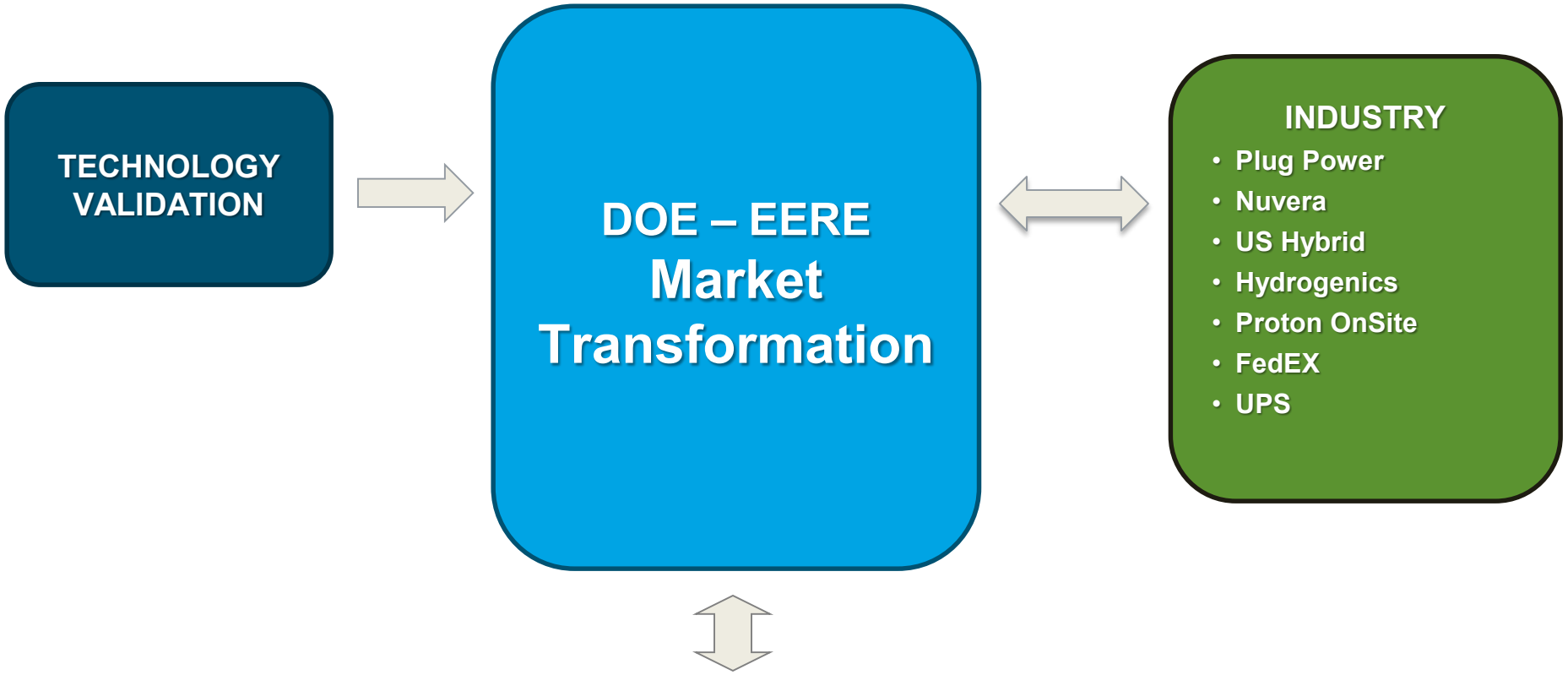
**Expected FOA Outcomes**:

- Design, demo, and deploy 20 to 60 fuel cell power systems installed in commercially available Class 1/2/3 vehicles
- Collect, analyze, and report performance data
- Conduct economic assessment including payback analysis

***New FOA to develop and deploy for commercialization fuel cell range extenders for available BEVs in the United States market***

# Collaborations






*Applied R&D is coordinated among national and international organizations*

# Recent and Upcoming Activities



**Early Markets**

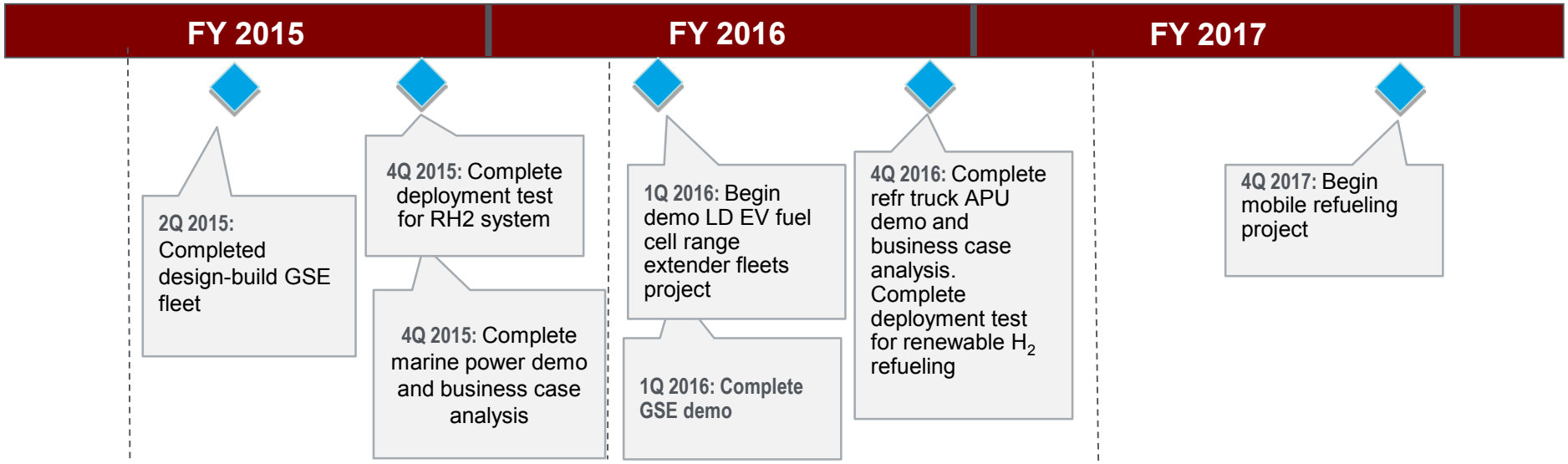
- Fuel cell-based forklifts and back-up power systems continue to demonstrate successful and reliable operations under real-world conditions.
- Stationary fuel cells demonstrate high availability; deployments increasing steadily, with most running on natural gas. However, prices for these systems remain high.
- Back up power business case completed showing economic viability of fuel cell power for this application.

**Vehicles**

- FOA for Light duty all electric fuel cell range extenders issued.

**Stations**

- Working with H2USA partners to plan and deploy infrastructure in Hawaii and North East/Mid-Atlantic states e.g. Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Maryland.




***New investments in critical areas of early markets and infrastructure to support FCEV commercialization.***

# Contacts

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