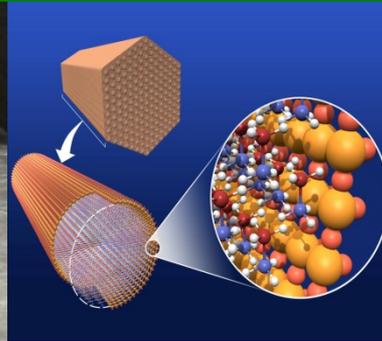




U.S. DEPARTMENT OF
ENERGY



Market Transformation

Pete Devlin

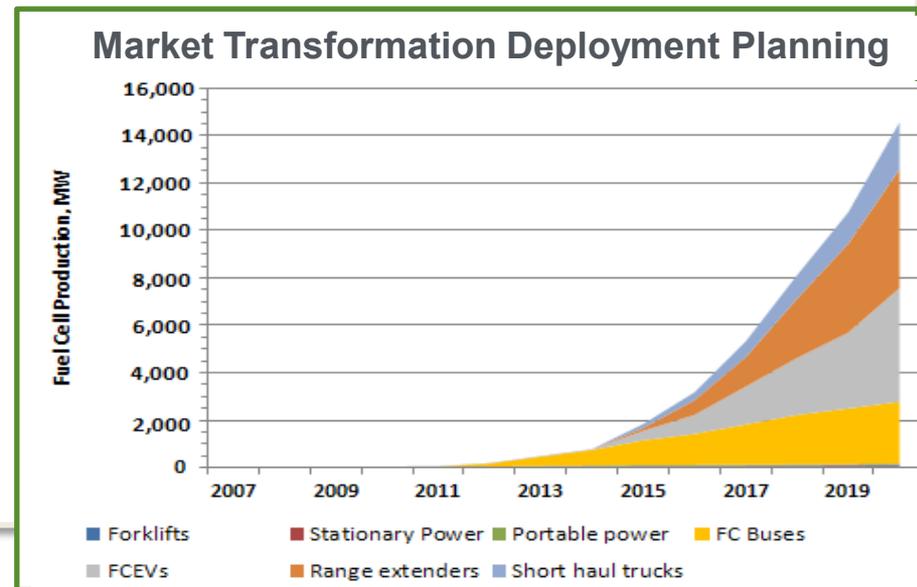
*2013 Annual Merit Review and Peer Evaluation Meeting
May 13, 2013*

GOALS

- Ensure continued technology utilization growth for domestically produced hydrogen and fuel cell systems
- Lower life cycle costs of fuel cell power by identifying and reducing deployment barriers

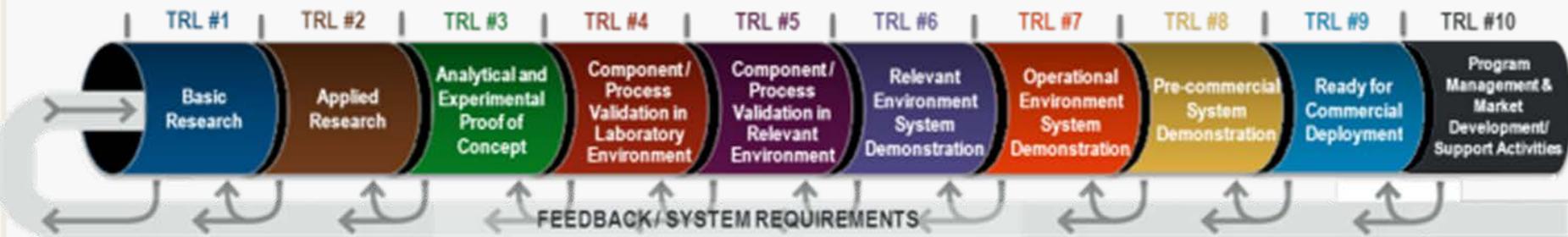
OBJECTIVES

- Catalyze key implementation projects and partnerships with state and local governments and other stakeholders
- Increase domestic market penetration by standardizing and stimulating institutional and financial market practices
- Increase data analysis associated with siting and deployment (e.g., insurance, permitting, and installation)



Data stems from research conducted by the California Fuel Cell Partnership and Pike Research

- To test emerging applications at the Technology Readiness Level (TRLs) 7-9 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

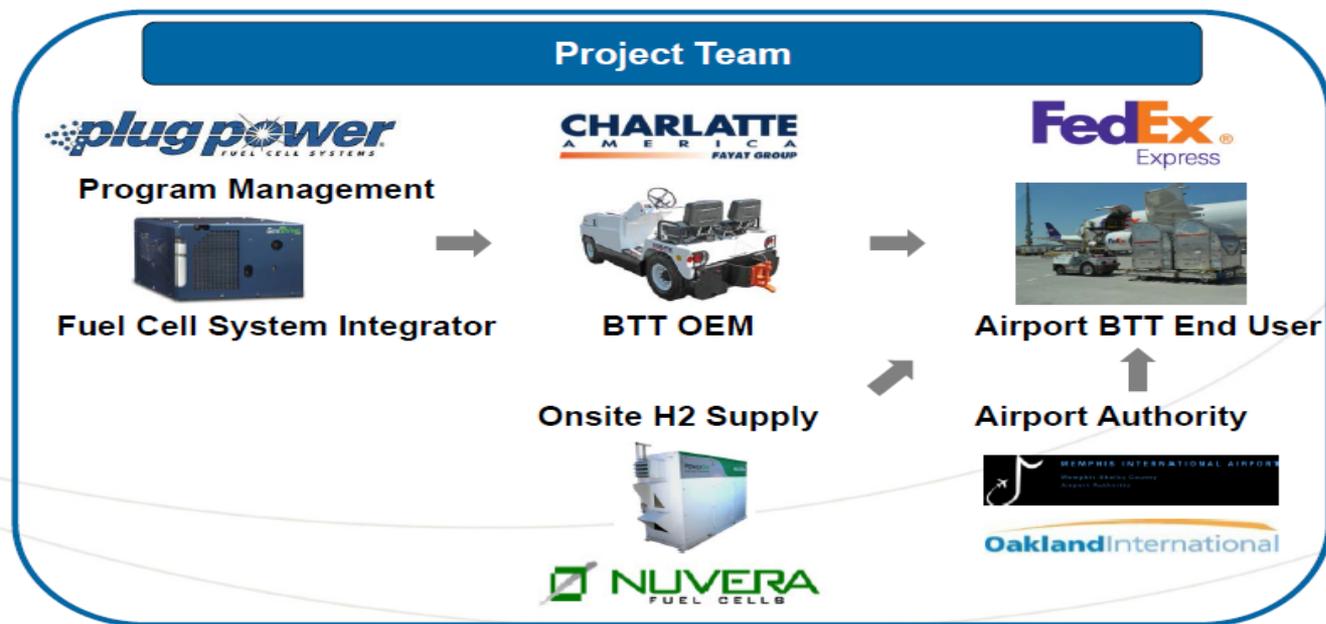
(Photo courtesy of ReliOn)



Material Handling Equipment at work in U.S. airports

(Photo courtesy of Hydrogenics)

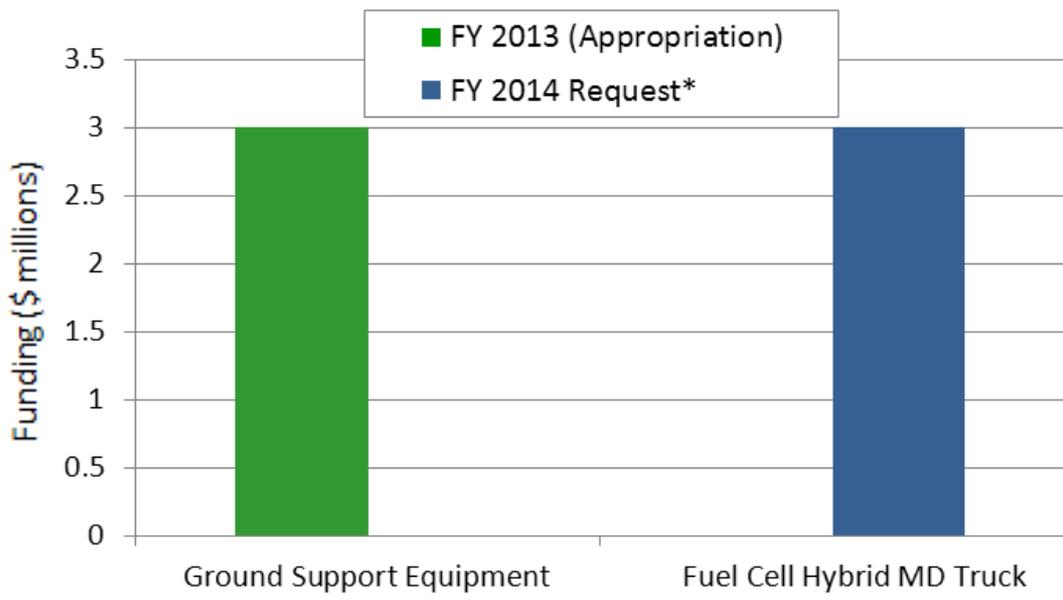
- To develop strategies to mitigate commercial risks and develop new approaches to ensure high hydrogen and system utilization and reliability under mass market penetration scenarios



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

Market Transformation Budget

FY 2013 Appropriation = \$3M
FY 2014 Request = \$3M

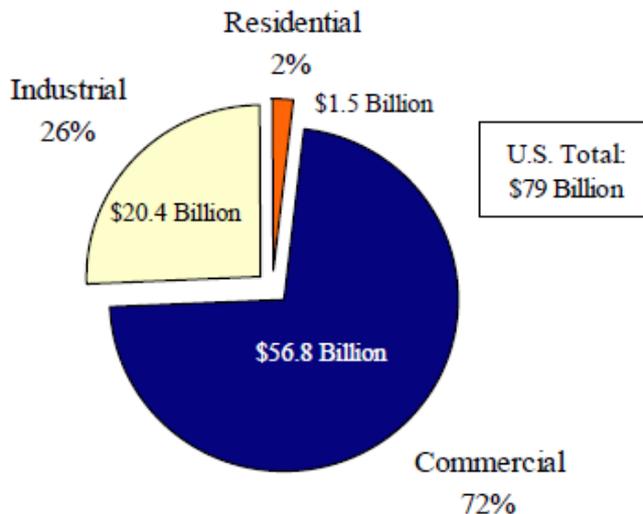


* Subject to appropriations and project go/no go decisions

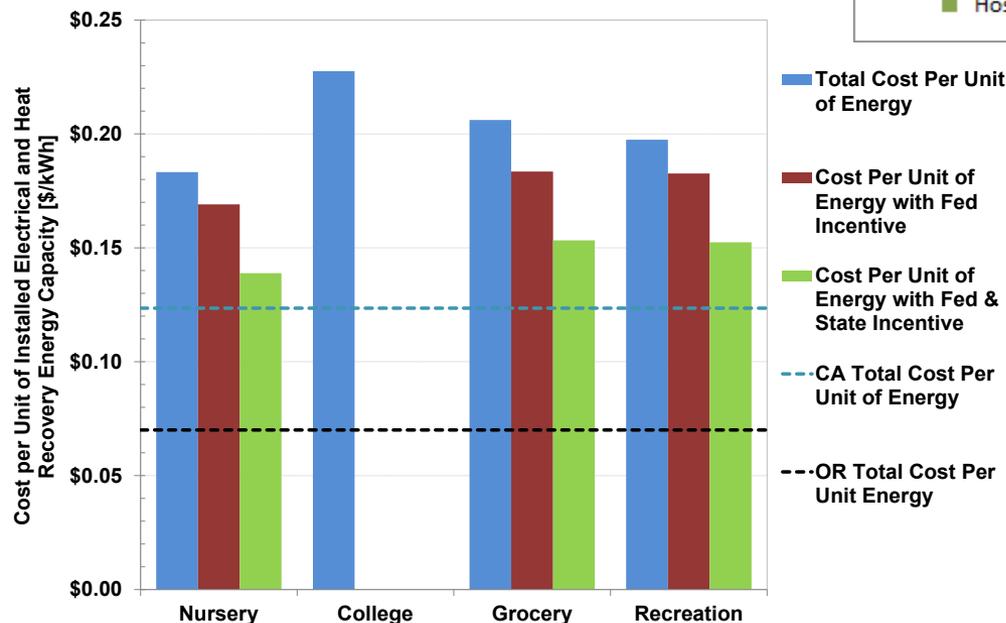
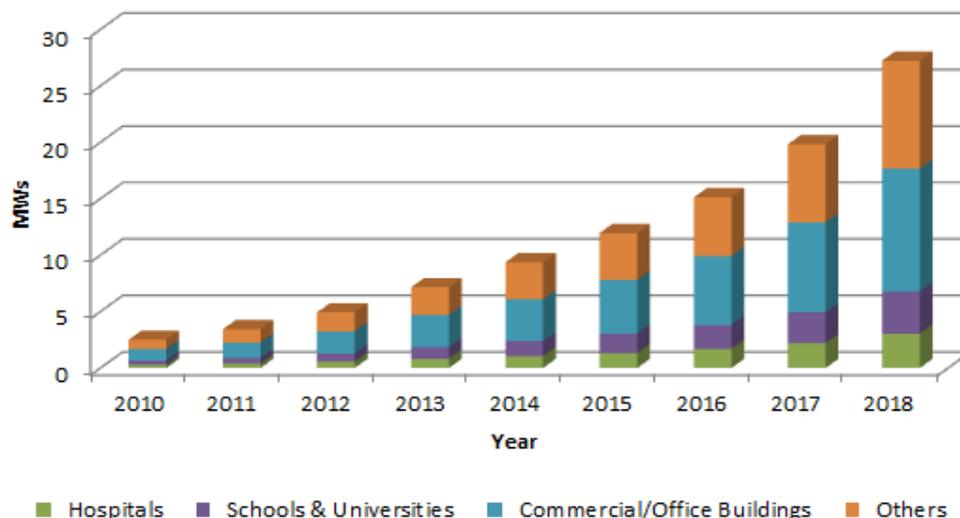
EMPHASIS

- New Ground Support Equipment Awards were made in January 2013
- Planning multiple FOAs over the next few FYs to enhance leveraging of deployments with DOE offices and other agencies
- Continue developing models, tools and templates for early markets

The Costs of Grid Outages



Stationary PEMFC CHP Commerical Market



Site	LCC Cost (\$K)	Payback* (Yrs)	Total Savings* (\$)	Payback** (Yrs)	Total Savings** (\$)
College	188	8.36	(75,731)	8.36	(75,731)
Nursery	228	6.56	(54,142)	4.97	943
Recreation	409	6.94	(122,682)	5.36	(21,061)
Grocery	427	7.02	(114,215)	5.22	(13,350)

*Without incentives
**With Incentives

- **Collected ~172,000 hour data DMFC-powered lift truck operations in 4 locations reducing unscheduled maintenance by 36% (NREL)**
- **Developed and installed electrolyzer system for geothermal renewable hydrogen (RH2) fuel demo (HNEI)**
- **Developed and installed LFG gas clean for industry RH2 fuel cell lift truck demo (SCRA/BMW)**
- **Installed and collected data on 15 Micro-CHP systems for light commercial facilities with availability of 93.4% (PNNL)**



5 kW MicroCHP



DMFC Powered Lift Truck



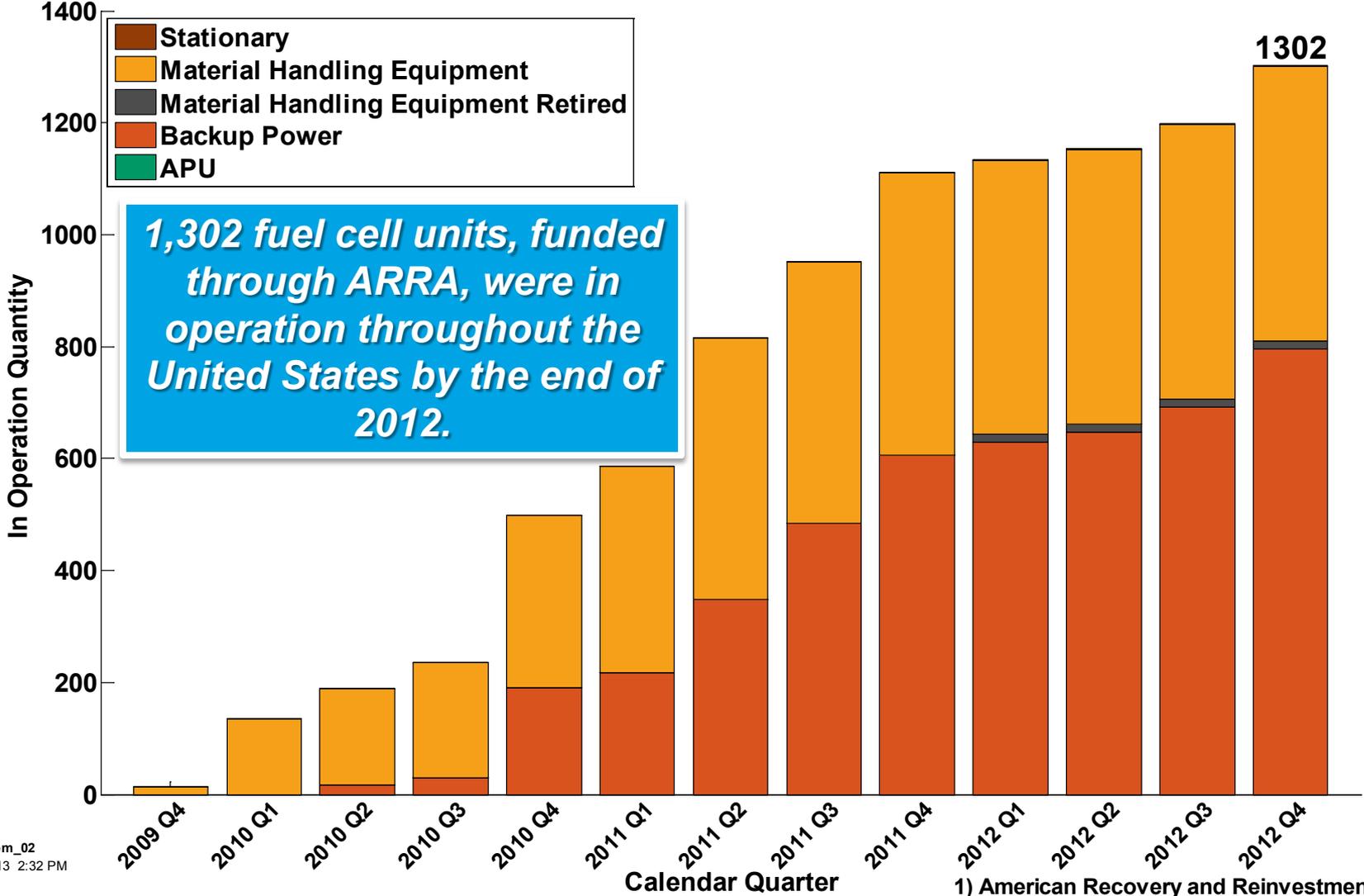
- Initiated new IWG committee (Advanced Vehicles) and identified a Fed Fleet strategy
- Awarded HDV Electric Transportation Technology Projects with VTO
- Awarded Ground Support Equipment Project (Plug Power)
- Started 2 Refrigerated APU projects (PNNL)
- Identified 4 MW of projects through a government wide procurement process
- Started Site Study with GSA and FEMP for refueling station
- Completed model and simulation analysis for on board recharging of eMDVs and eLDVs

C3-6 Delivery Truck



C8 Drayage Truck

DOE ARRA¹ Funded Early Fuel Cell Markets: Units in Operation



NREL cdparra_em_02
Created: Mar-08-13 2:32 PM

1) American Recovery and Reinvestment Act

Accomplishments: Backup Power Operation Summary 2009 Q1 – 2012 Q4



1.86

Installed capacity
in MW

Systems are operating reliably in 19 states. Reasons for unsuccessful starts include an e-stop signal, no fuel, and other system failures.

99.6%

Successful starts

806

Systems in operation*

4-6

Average site
capacity in kW

1,796

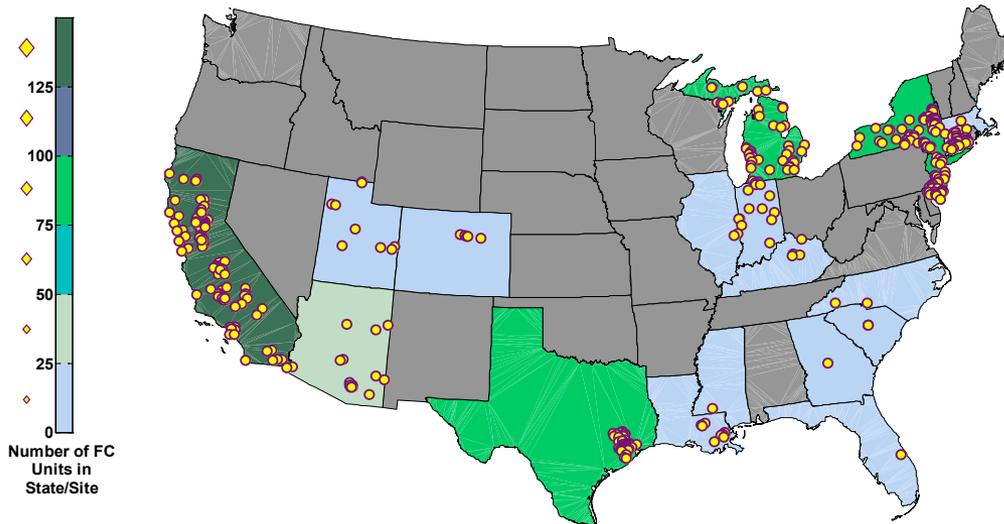
Start attempts

65

Continuous run
hours demonstrated

1,153

Operation hours



*Not all systems have detailed data reporting to NREL

Accomplishments: MHE Operation Summary

2009 Q4 – 2012 Q4



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

1,445,558
Operation hours

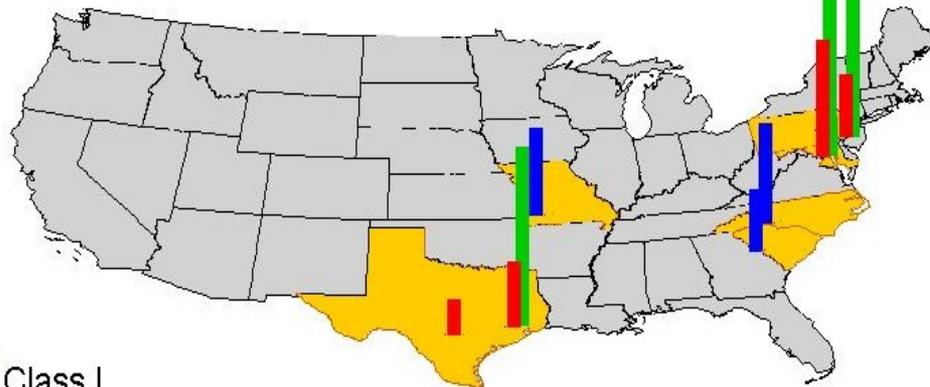
246,997
Hydrogen fills

490
Units in operation*

4.6
Average operation hours
between fills

187,426
Hydrogen dispensed
in kg

504 Units 8 Sites



- Class I
- Class II
- Class III

Height proportional to units deployed.

0.6
Average fill amount
in kg

2.3
Average fill time
in minutes

*One project has completed

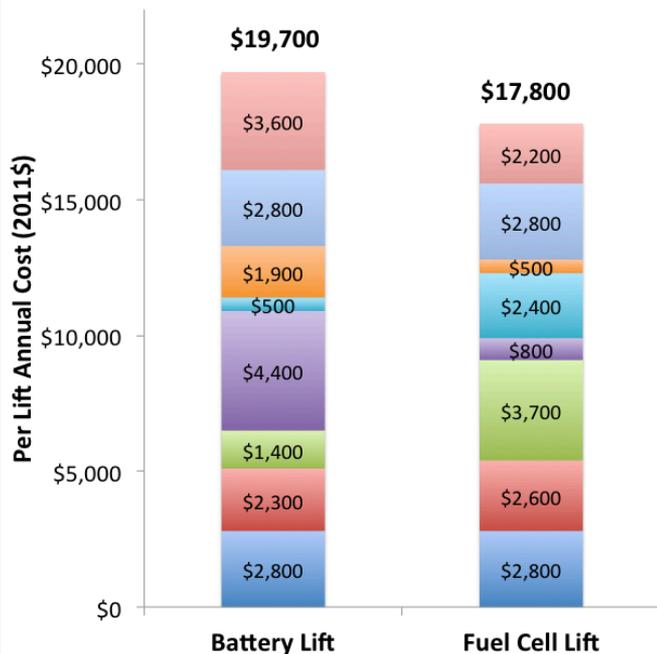
Accomplishments: Completed MHE Cost of Ownership Report*



Cost advantage per unit is ~\$2,000/year for the average high-use facility with Class I and II fuel cell lift trucks analyzed by NREL.

Class I & II MHE -- Annualized Costs

- Battery / Fuel Cell Maintenance
- Lift Truck Maintenance
- Cost of Infrastructure Warehouse Space
- Cost of Electricity / Hydrogen
- Labor Cost for Battery Charging & H2 Fueling
- Per Lift Cost of Charge/Fuel Infrastructure
- Amortized Cost of Battery / Fuel Cell Packs
- Amortized Cost of Lift



Key Findings

- Cost advantages dependent on deployment size and use (i.e., multi-shift operation per day)
- H₂ fuel cell cost advantages in maintenance, warehouse infrastructure space, and refueling labor cost
- H₂ fuel cell cost disadvantages in infrastructure and fuel cell cost and hydrogen cost

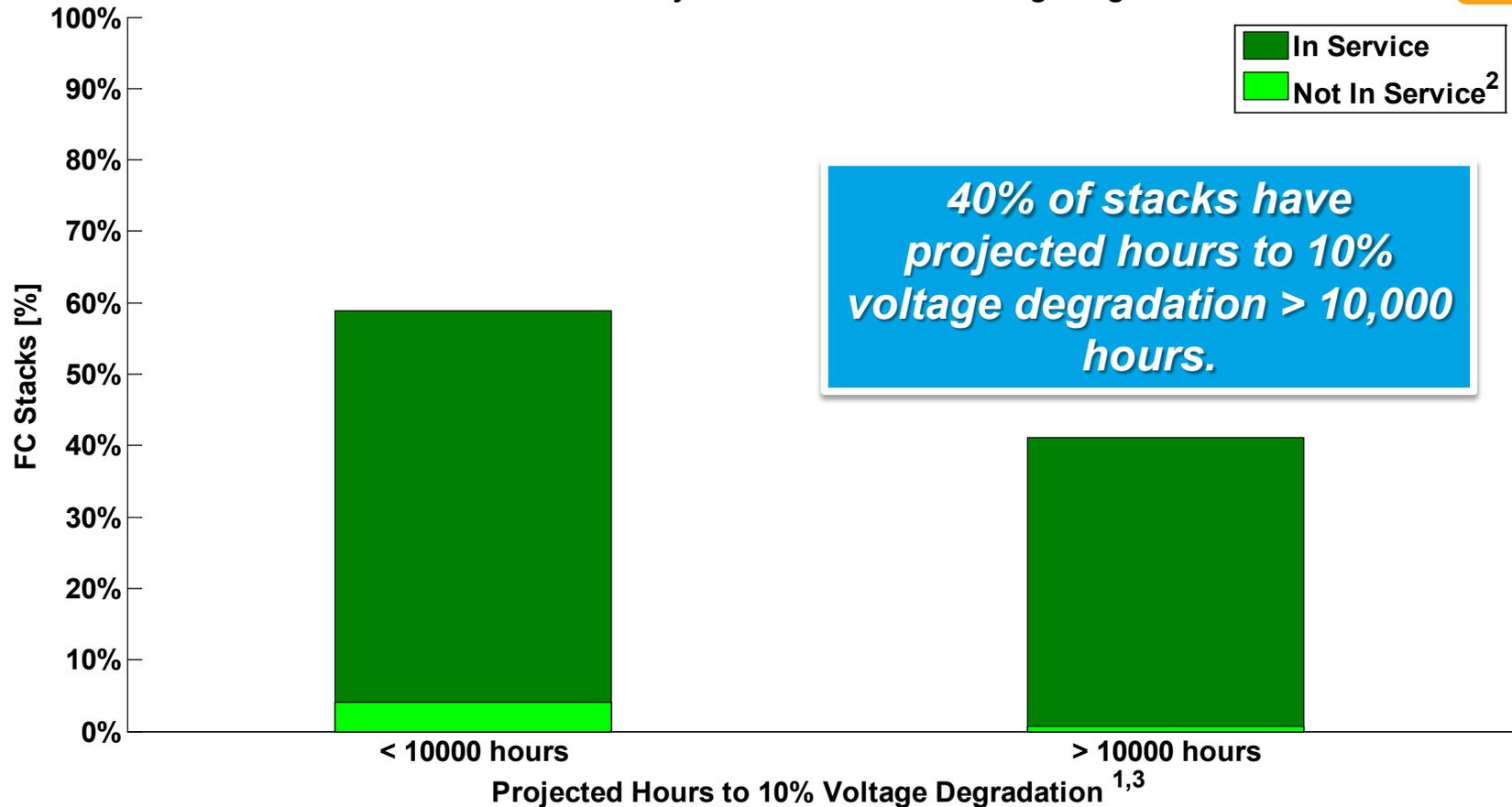
Report Sections

- Inputs, assumptions, and results for Class I/II and Class III
- Sensitivity study
- Intensive deployment scenario

*Publication expected 04/2013



Fuel Cell Stacks Projected Hours to 10% Voltage Degradation



1) Projection using field data, calculated at high stack current, from operation hour 0.

Projected hours may differ from an OEM's end-of-life criterion and does not address "catastrophic" failure modes.

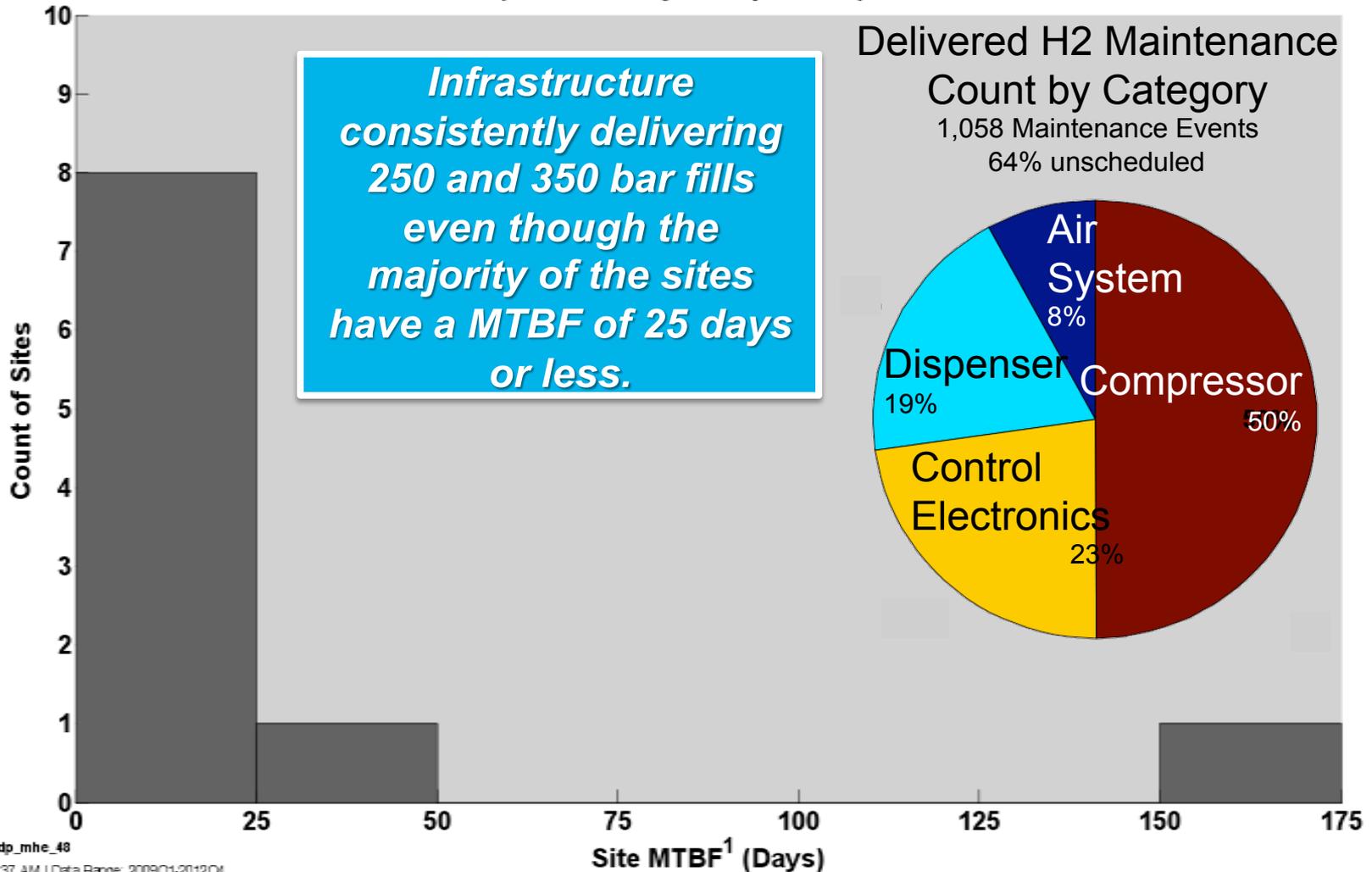
2) Indicates stacks that are no longer accumulating hours either a) temporarily or b) have been retired for non-stack performance related issues or c) removed from DOE program.

3) Projected hours limited based on NREL demonstrated hours.



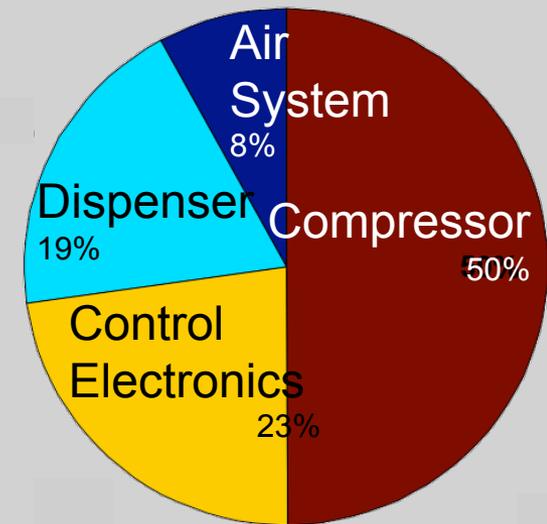


Site MTBF (Calendar Days In Operation): Infrastructure

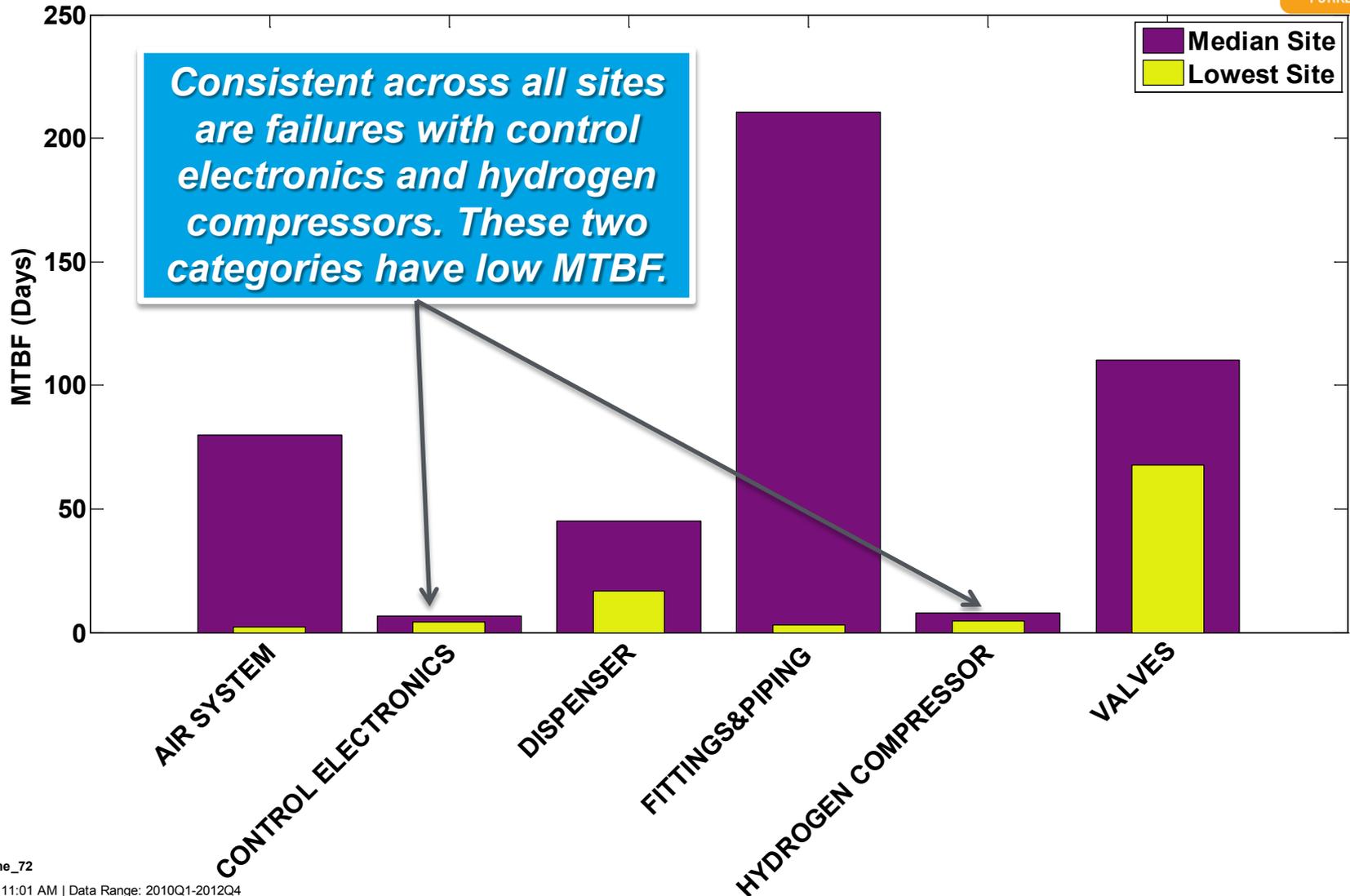


Infrastructure consistently delivering 250 and 350 bar fills even though the majority of the sites have a MTBF of 25 days or less.

Delivered H2 Maintenance Count by Category
1,058 Maintenance Events
64% unscheduled

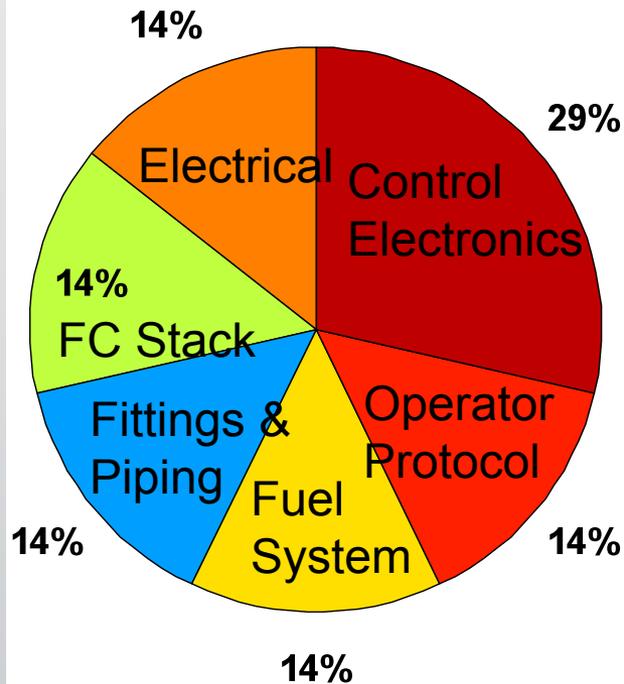


Accomplishments: Breakdown of MTBF by Key Delivered Hydrogen Infrastructure Categories



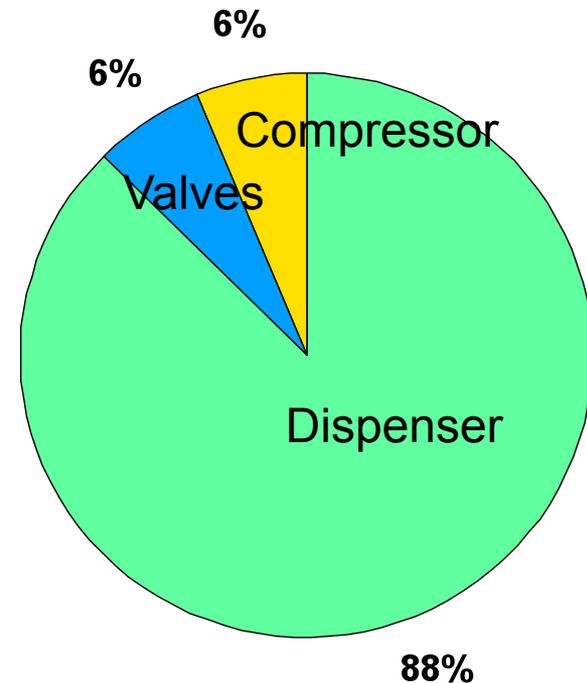
Majority of MHE safety reports (217) are minor hydrogen leaks
(4,480 stack hours per report)

By Number of Incidents
Total Incidents = 7



Majority of infrastructure safety reports (82) are hydrogen leaks primarily from the hydrogen compressor and plumbing
(3,587 kg dispensed per report)

By Number of Incidents
Total Incidents = 16



Key milestones and future plans

FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016 - 2020
<p>Complete multi-site backup power award with DOD, NASA, and NPS</p>	<p>Complete Government Facilities Procurement Guide</p> <p>Complete 3 DOD-DOE Workshops</p> <p>Complete MYRD&D Plan</p>	<p>Installed and tested Renewable H₂ Plant (Hawaii)</p> <p>Awarded with VTO¹ ETT Projects</p> <p>Awarded GSE Project</p> <p>Started eHDVx Demos with VTO</p>	<p>Complete MicroCHP Business Case Analysis</p> <p>Data Collection & Assessment of DMFC Powered Lift Trucks</p> <p>Publish MHE and Backup Power Business Cases</p> <p>Award eMDVx demo project (s)</p>	<p>GSE Deployment and Business Case Analysis</p> <p>eHDVx – Business Case Analysis</p> <p>MHE Refueling Case Study</p>	<p>Deploy Test and Business Case for BEVx</p> <p>Financing Methods Test for Mobile Power / Lighting</p>	<p>Deployment and Finance Test for 1st Gen FCEVs</p> <p>Deployment Test for LDVs in Fed fleets</p> <p>Deployment Test for Renewable H₂ Refueling</p>

¹Vehicle Tech Office

Market Transformation Team

DOE

Pete Devlin
*Market Transformation and
Intergovernmental Coordination Manager*
202-586-4905
peter.devlin@ee.doe.gov

Nancy Garland
202-586-5673
nancy.garland@ee.doe.gov

Jim Alkire
720-356-1426
James.alkire@go.doe.gov

National Renewable Energy Laboratory Support:

John Christensen
703-391-2075
jchrste1@comcast.net

Technical Support:

Greg Moreland
240-499-4434
greg_moreland@sra.com

Kristen Nawoj
202-287-6319
kristen.nawoj@ee.doe.gov