National Renewable Energy Laboratory
Innovation for Our Energy Future

Presentation DEM24-2

Data Analysis of Early Fuel Cell Market Demonstrations

Fuel Cell Seminar
Palm Springs, CA

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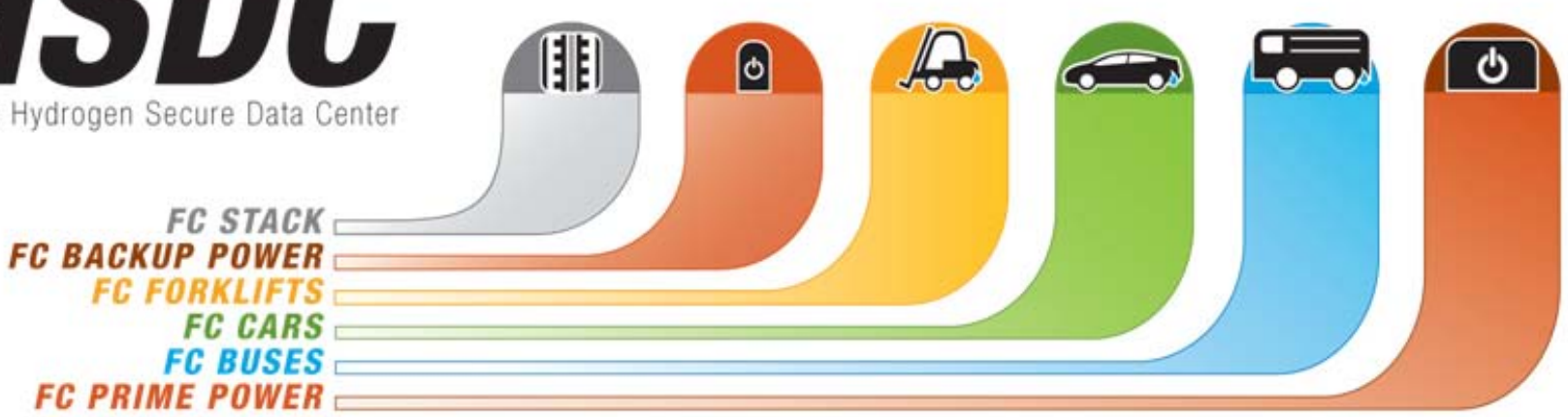
HSDC

NREL's Hydrogen Secure Data Center

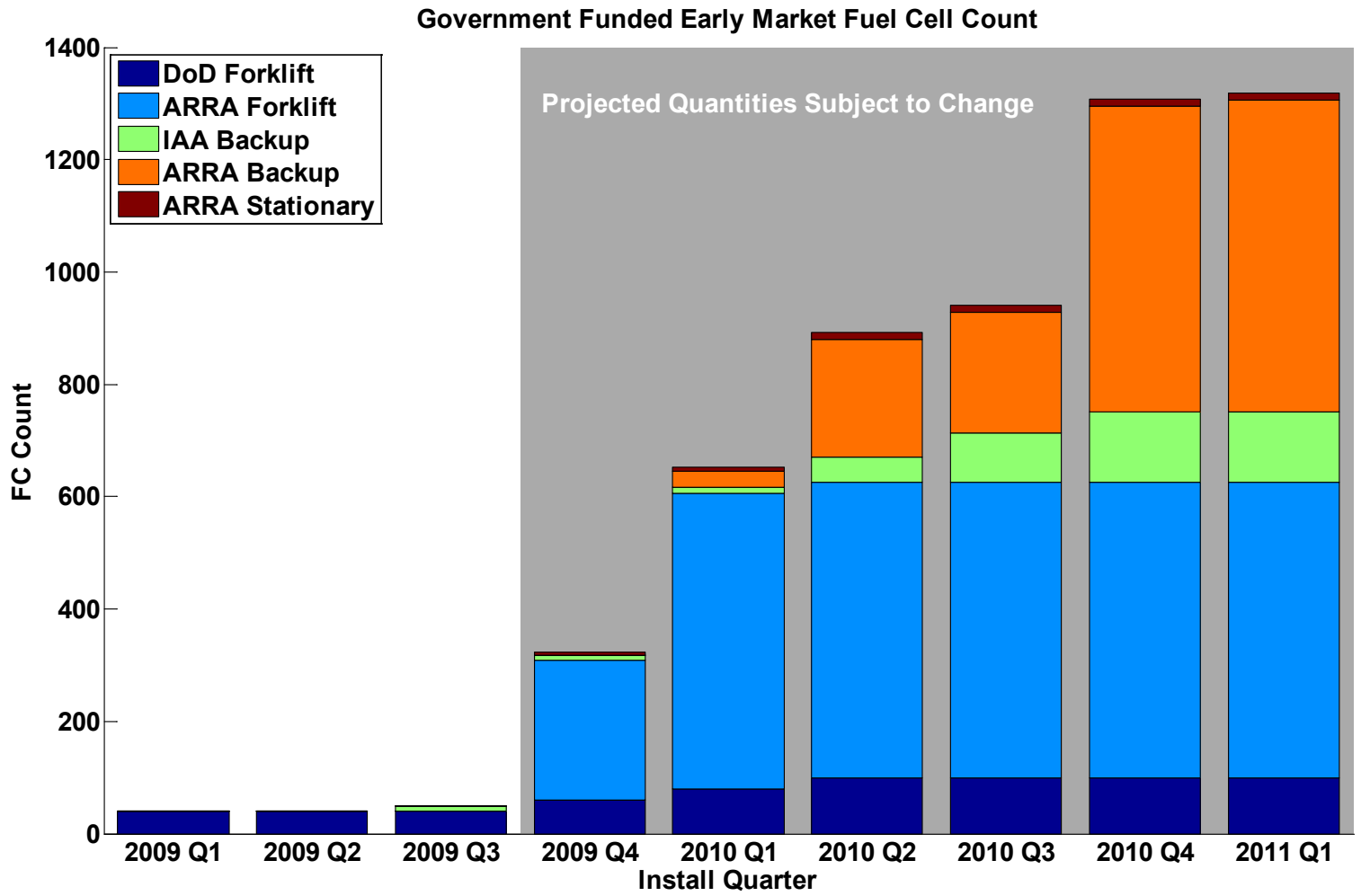


Fuel Cell & Infrastructure Data Collection, Processing, & Analysis
Demonstrations
Objectives
Methodology
Results

Government Funded Early Fuel Cell Markets

- Funding sources include DOD Defense Logistics Agency, DOE American Recovery and Reinvestment Act (ARRA), and DOE Interagency Agreement (IAA)
- Diverse collection of early market fuel cell applications, project partners, and end users
- Expected fuel cell deployment: >1,000 units
- Fuel cell applications cover fuel cell forklifts, backup power, micro-CHP, APU, and portable power

Government Funded Fuel Cell Early Market Deployments – Separated by Funding Source & Application



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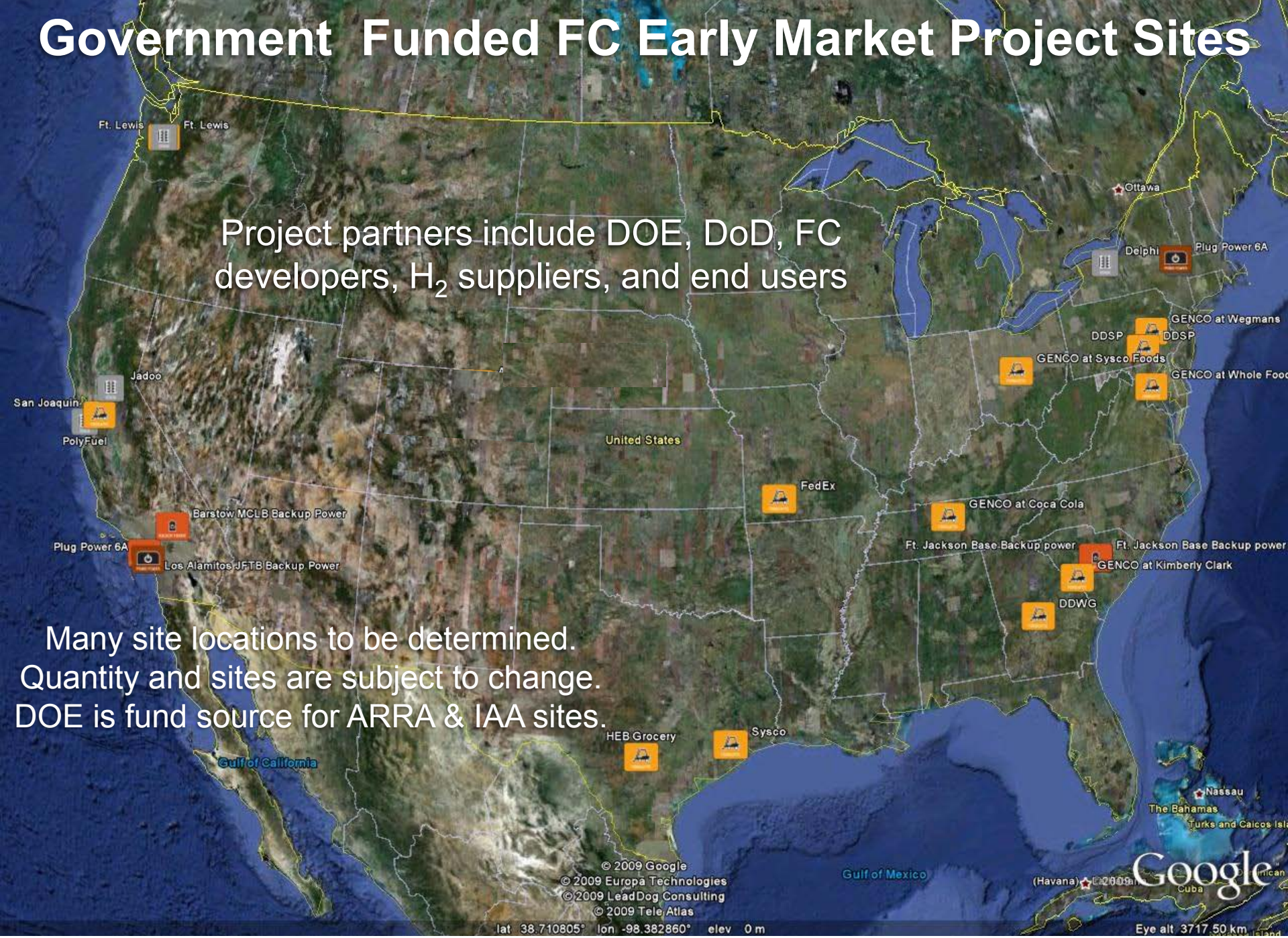
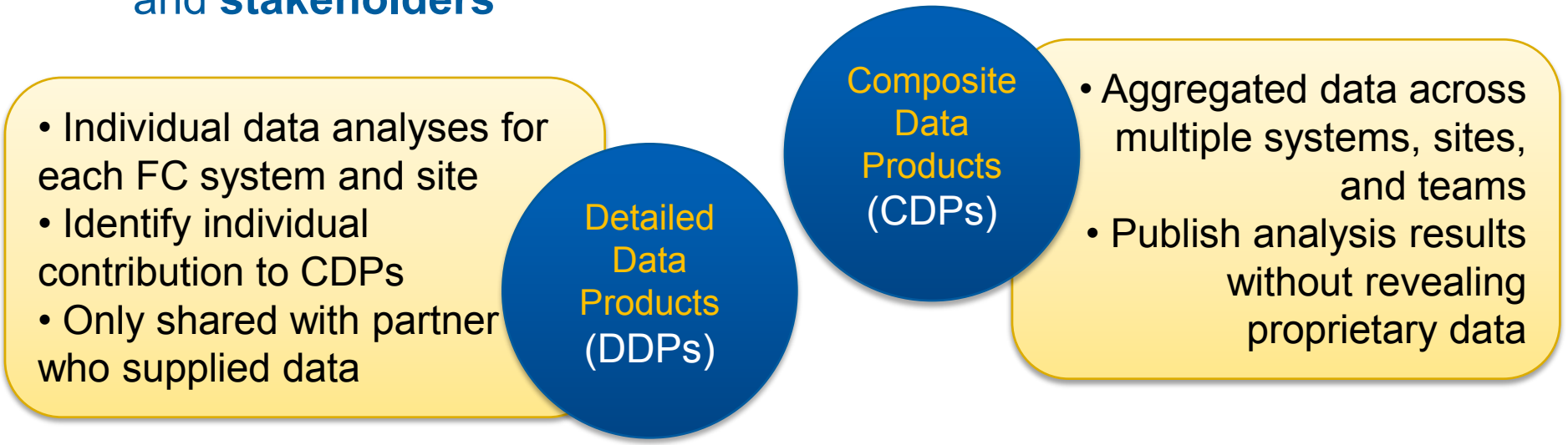
Government Funded FC Early Market Project Sites

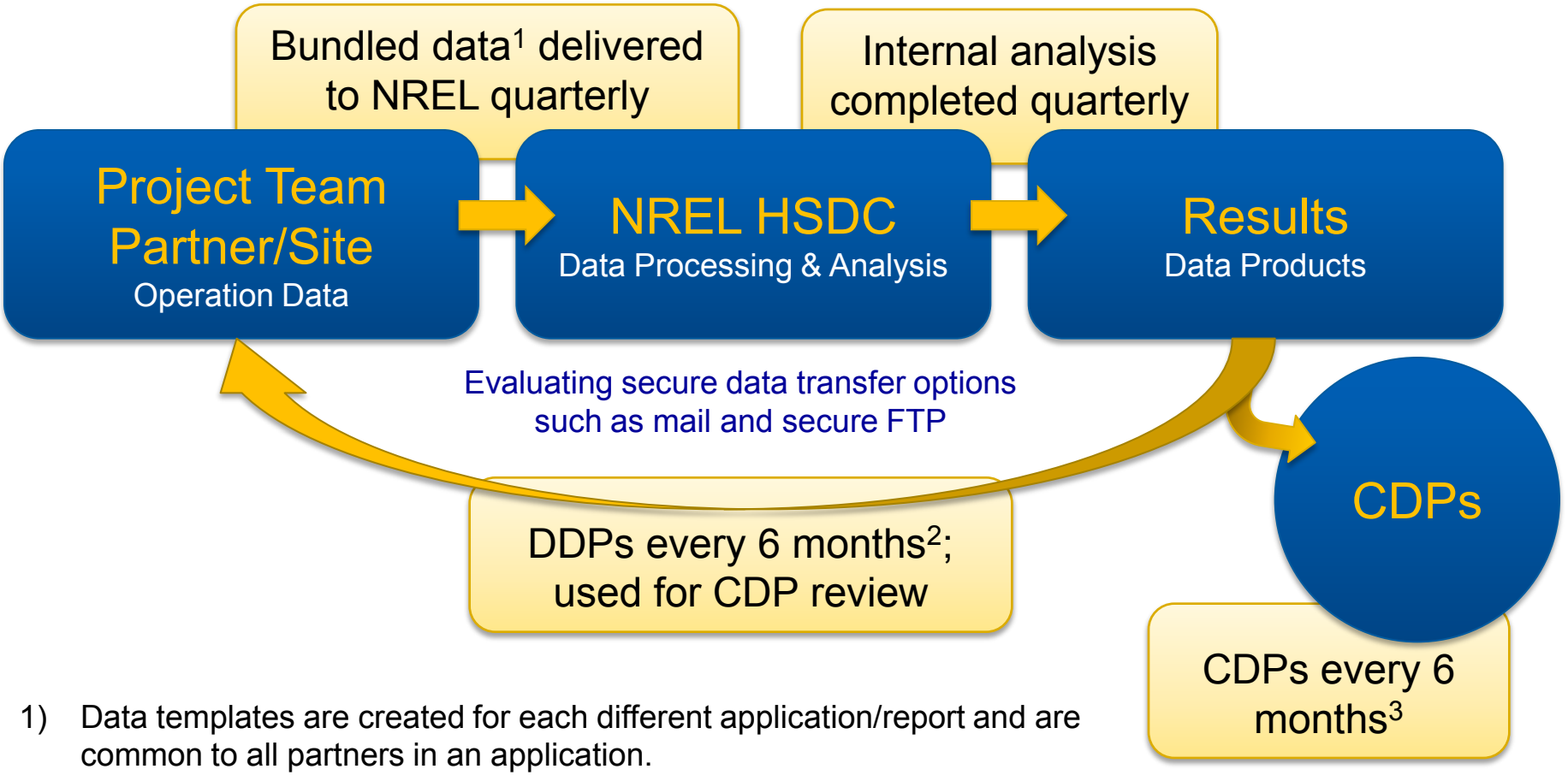


Early Fuel Cell Market Data Analysis Objectives

- Independent technology **assessment**; focused on fuel cell system and hydrogen infrastructure: performance, operation, and safety.
- **Leverage** data processing and analysis capabilities from the fuel cell vehicle Learning Demonstration project and DoD Forklift Demo.
- Establish a **baseline** of real-world fuel cell operation and maintenance data and identify technical/market barriers.
- Support market growth of fuel cell technologies by reporting on technology features relevant to the **value proposition**
- Report on technology to fuel cell and hydrogen communities, R&D, and **stakeholders**

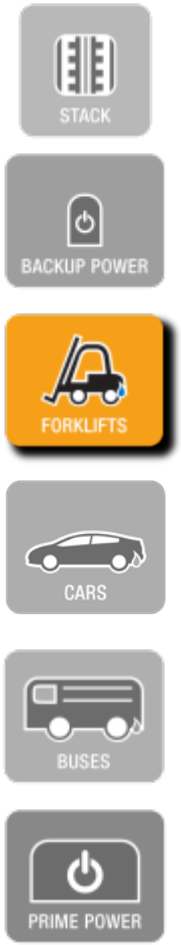


Data Flow



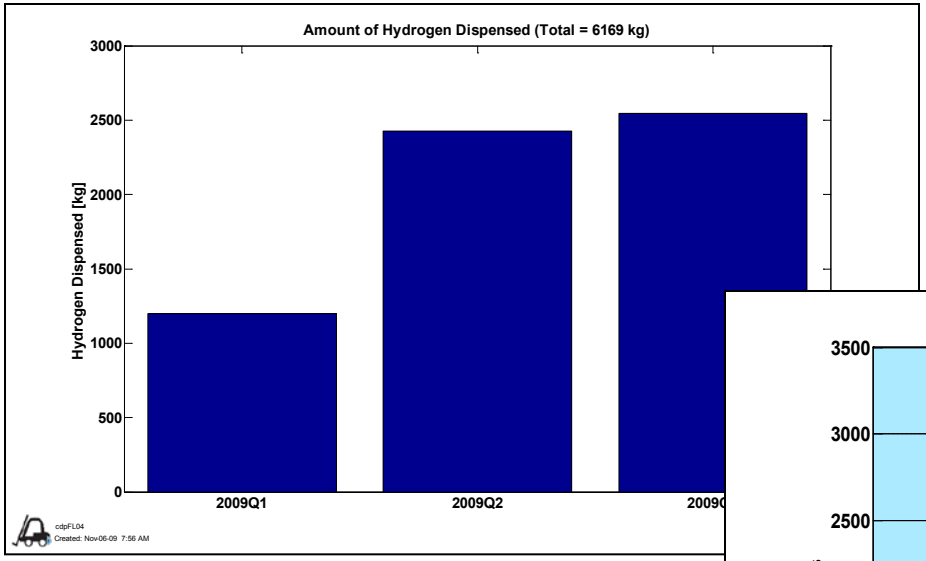
1) Data templates are created for each different application/report and are common to all partners in an application.
2) Data exchange may happen more frequently based on data, analysis, & collaboration
3) Results published via NREL Tech Val website, conferences, and reports

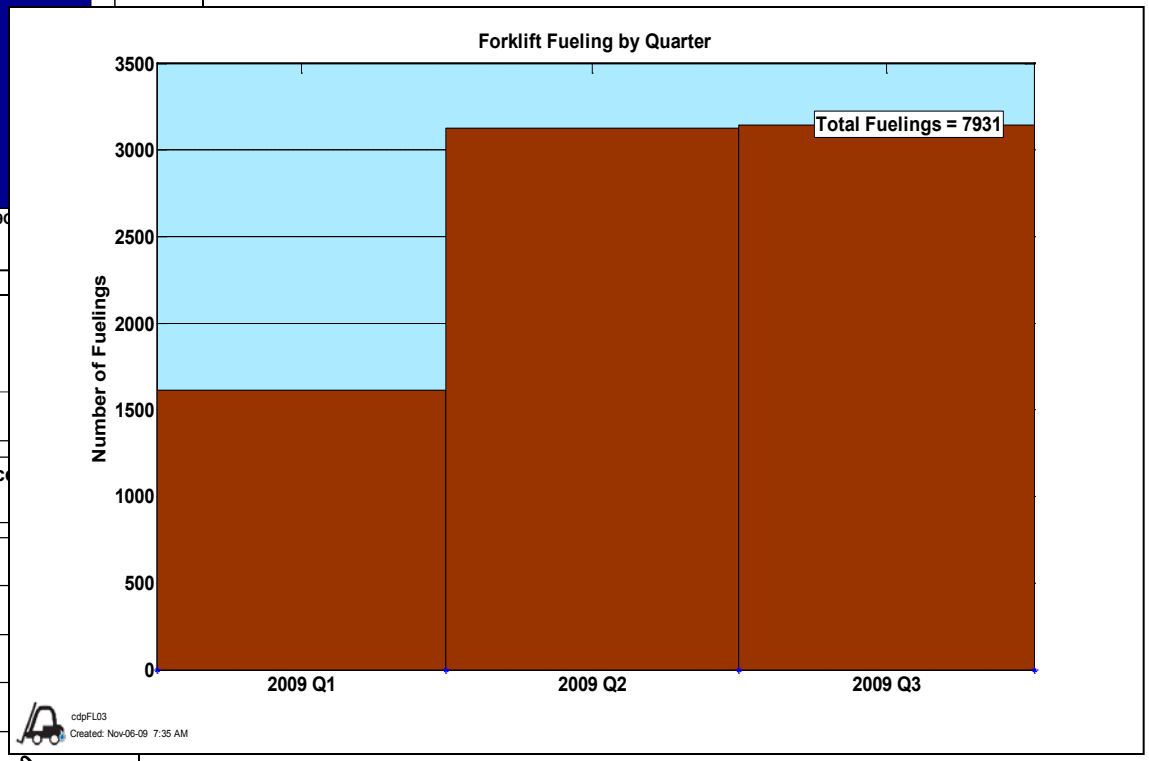
Data Reporting – Fuel Cell Forklift Example

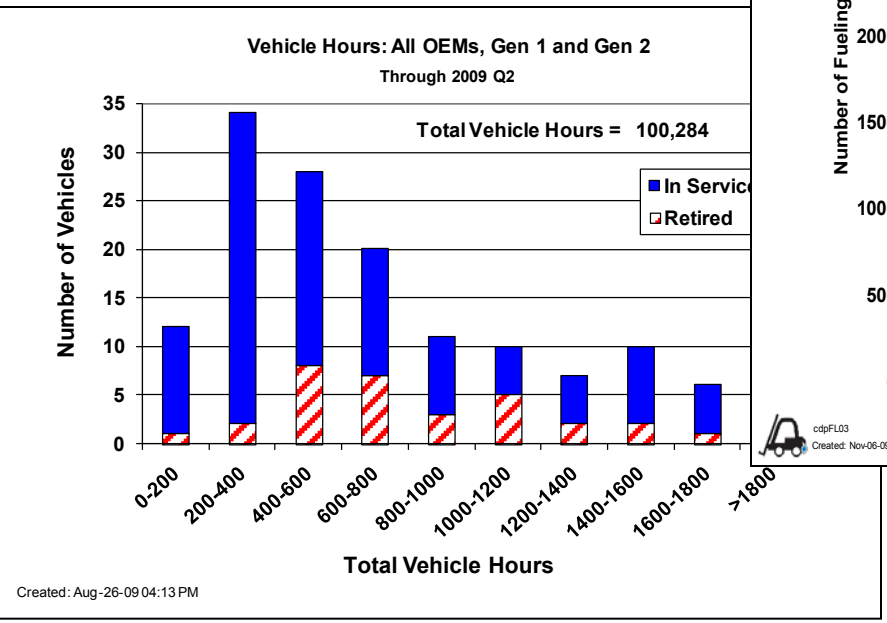


- Fuel cell forklift application represents a significant early market opportunity for fuel cells
- 40 fuel cell forklifts in operation at DLA's Defense Depot, Susquehanna Pennsylvania
- 9 months of detailed data available, including over 10,000 hydrogen fills
- Available data provides a real-world understanding of fuel cell forklift operations
- Data from this forklift installation and upcoming future installations will be used to develop Composite Data Products on early market deployments of fuel cell forklifts

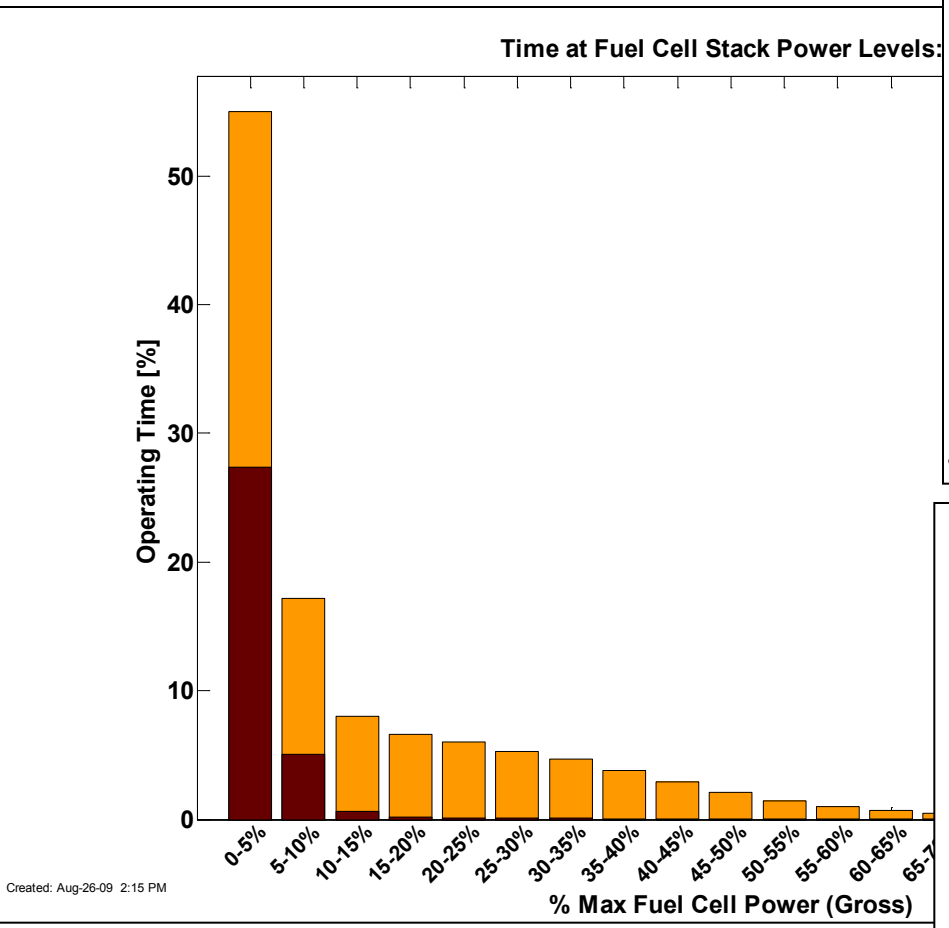
Data on Deployments and Usage

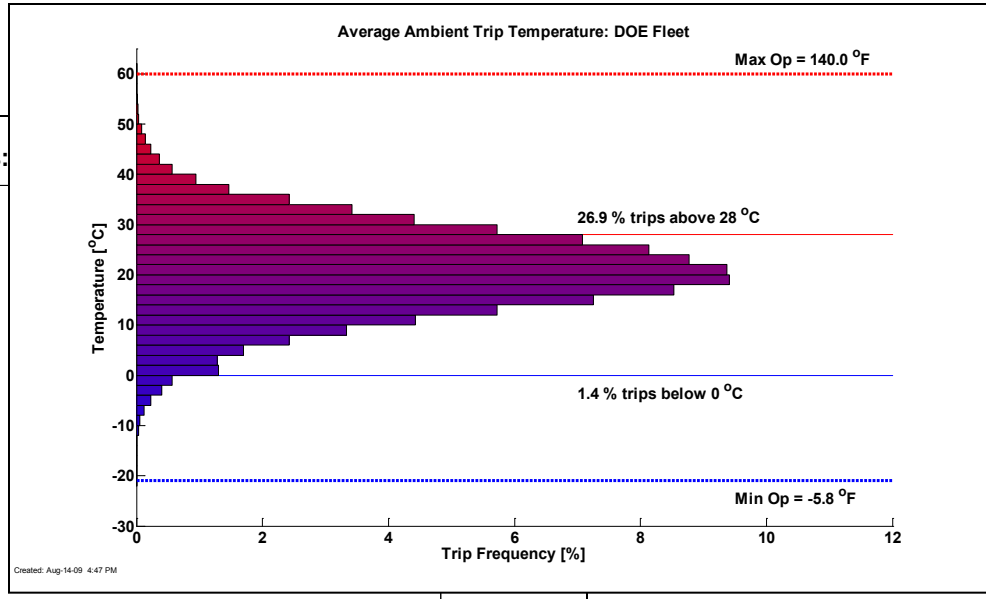


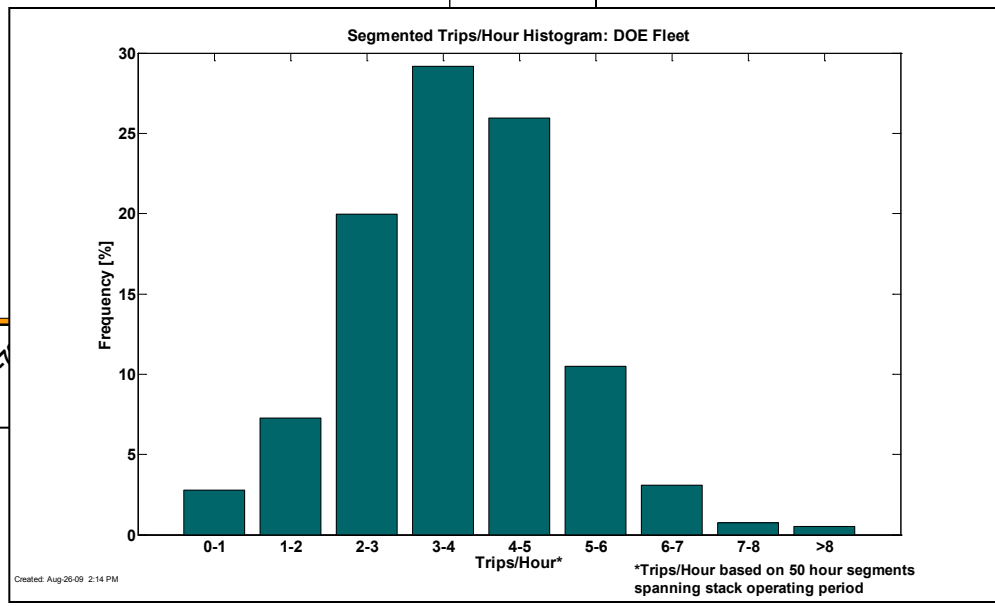




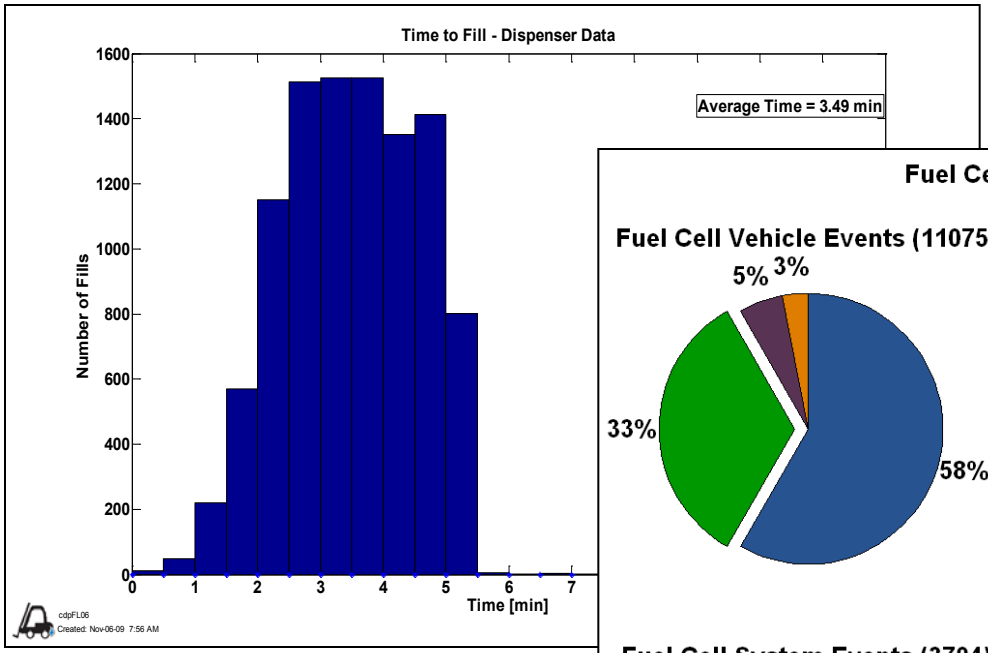
Data on Deployments and Usage *(cont.)*

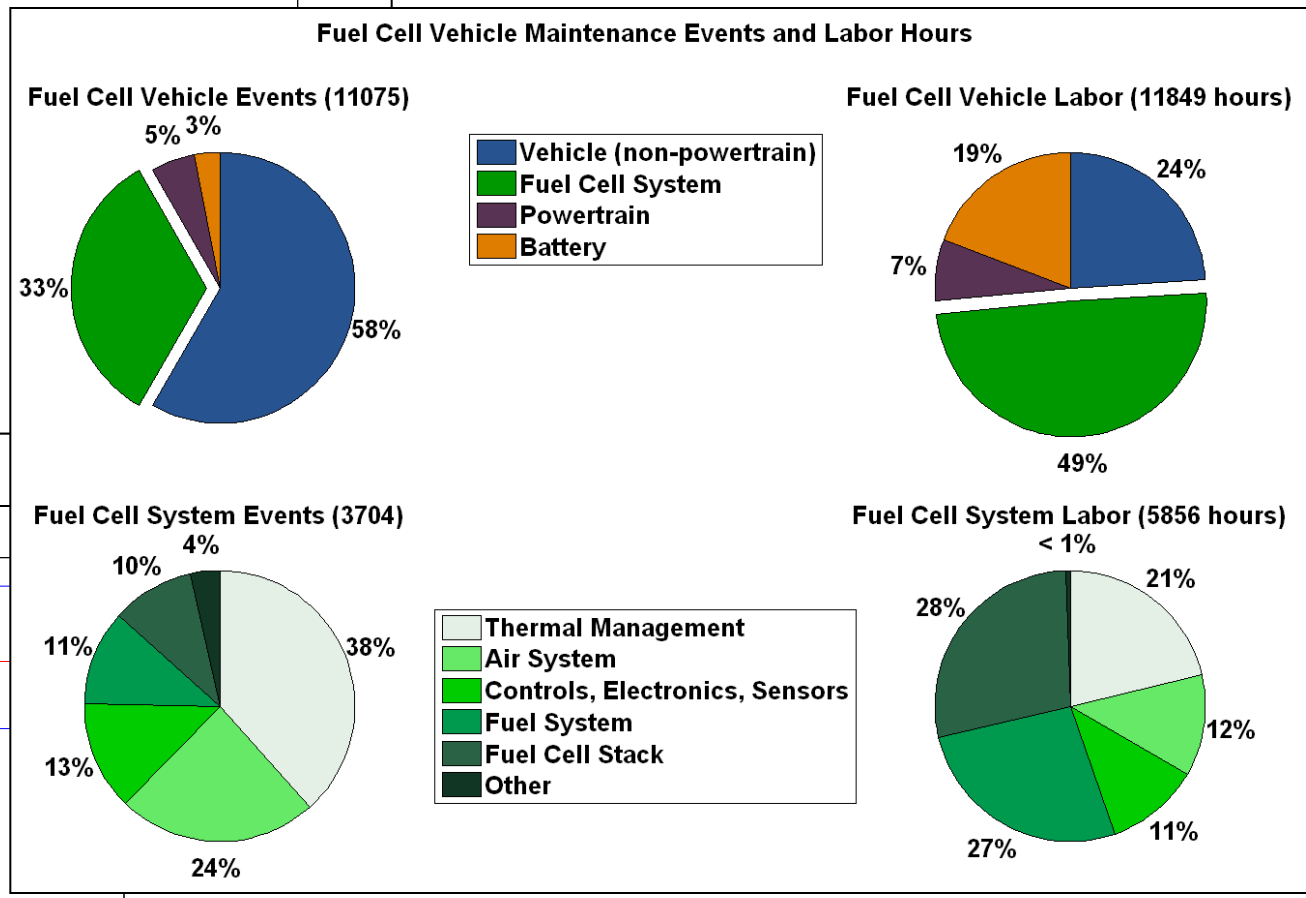


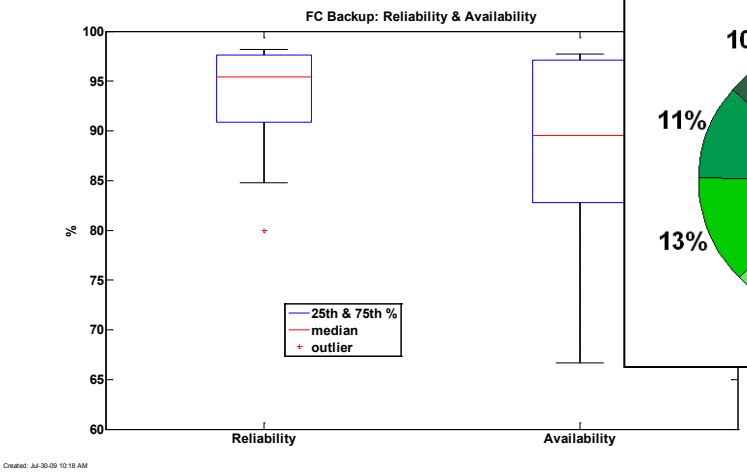




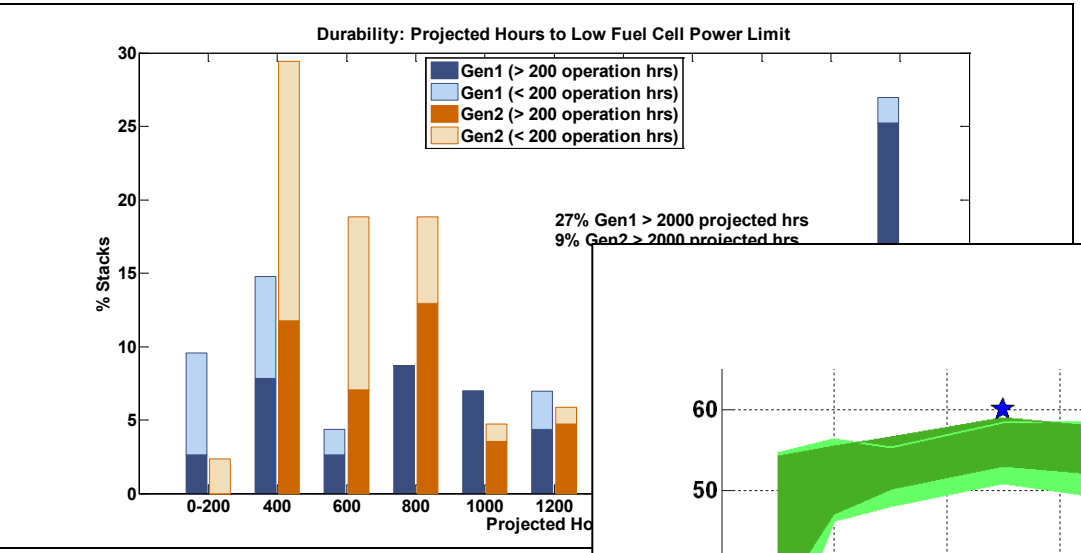
Data on Fuel Cell Value Proposition

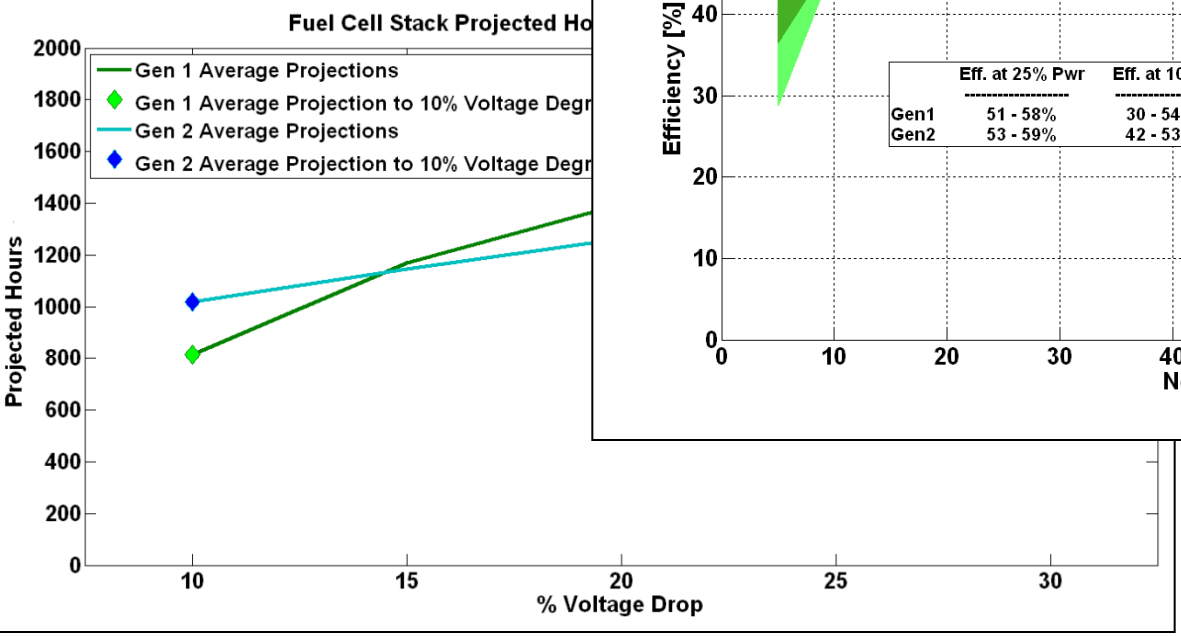


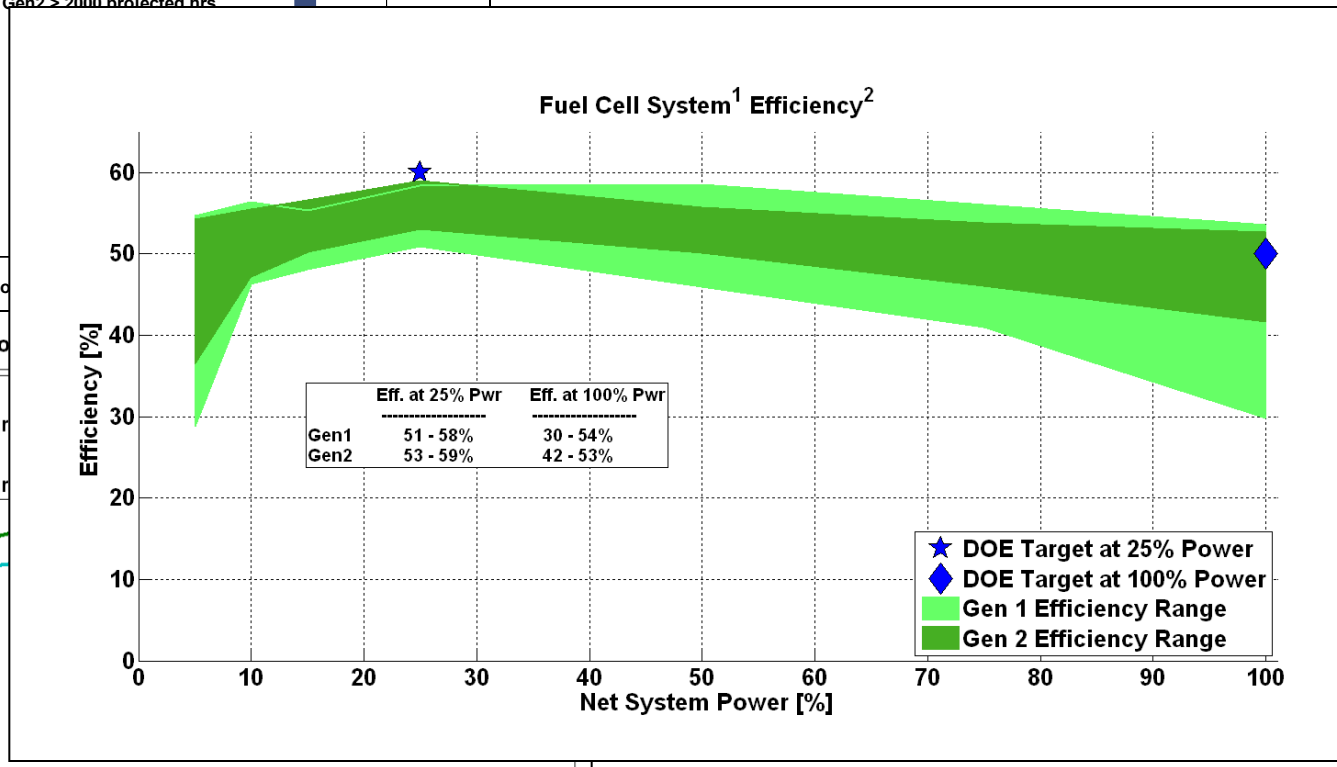




Data on Fuel Cell Technology

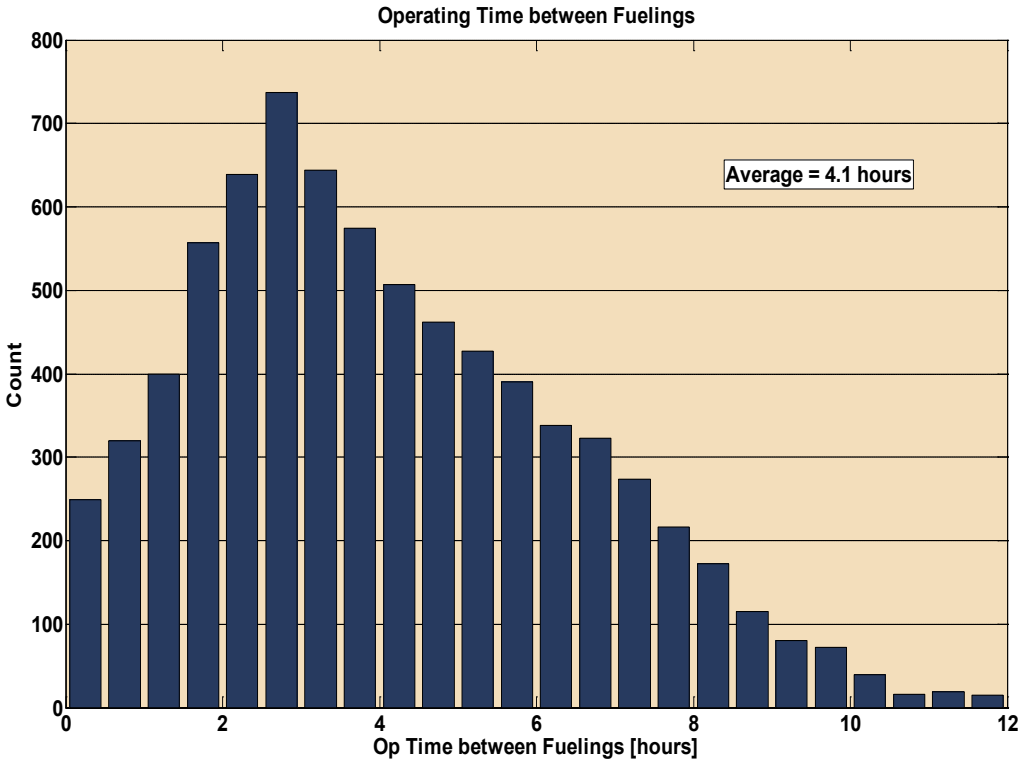




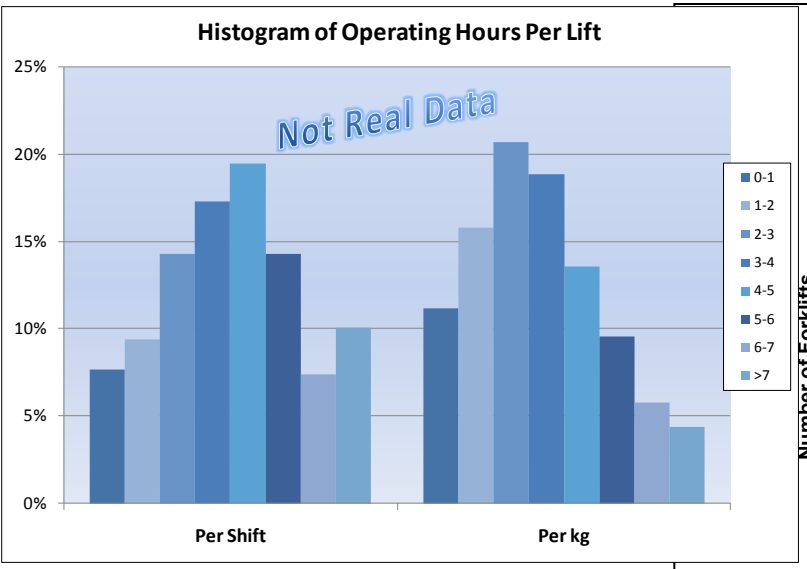


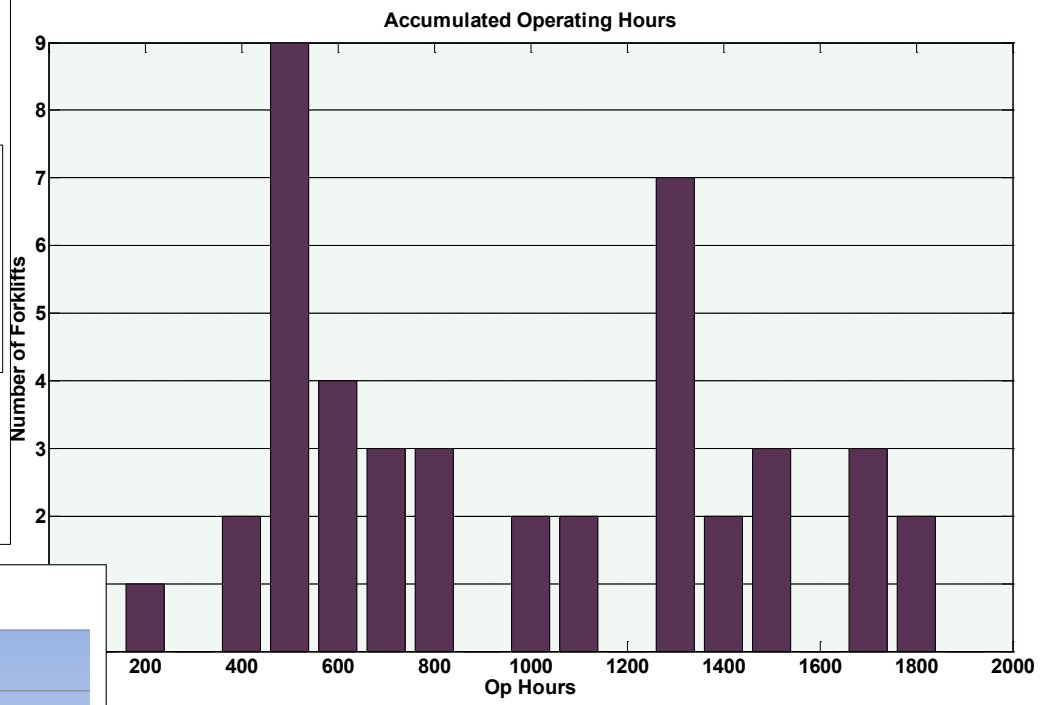
Understanding H2 Tank Cycle Life in FC Forklifts

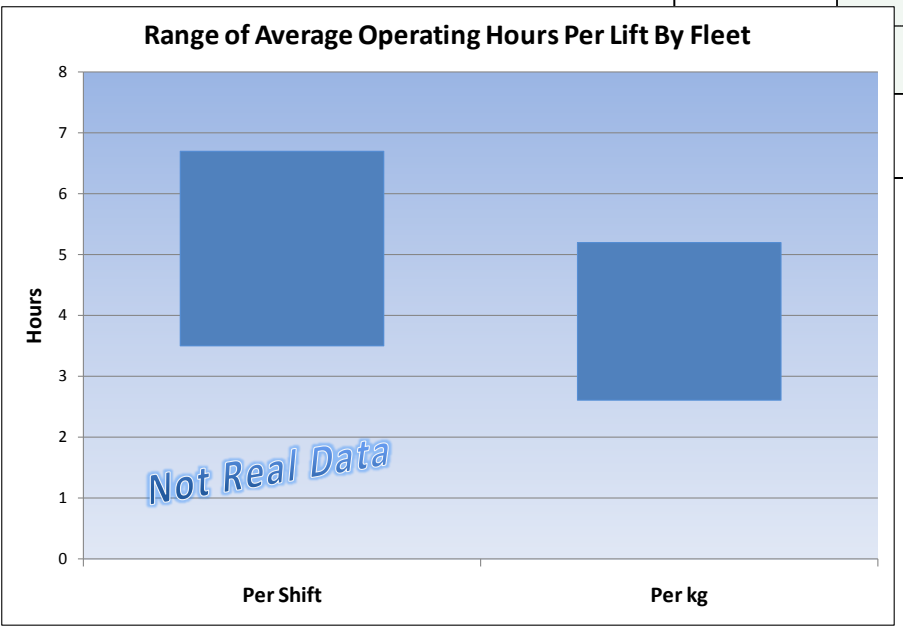
- Need to better understand expected H2 tank filling cycles in forklift applications
- Data currently being collected can inform that discussion
- Can aggregate data on operating hours per fill and per shift to better predict tank cycling
- Tank life is important factor in business case if shorter than the life of the lift



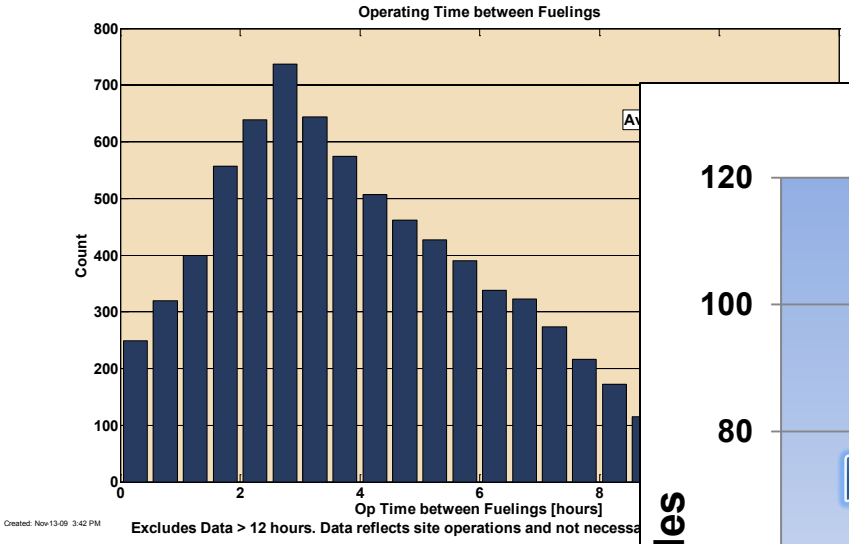
Tank Cycling: Forklift Operations Per Shift & Per kg

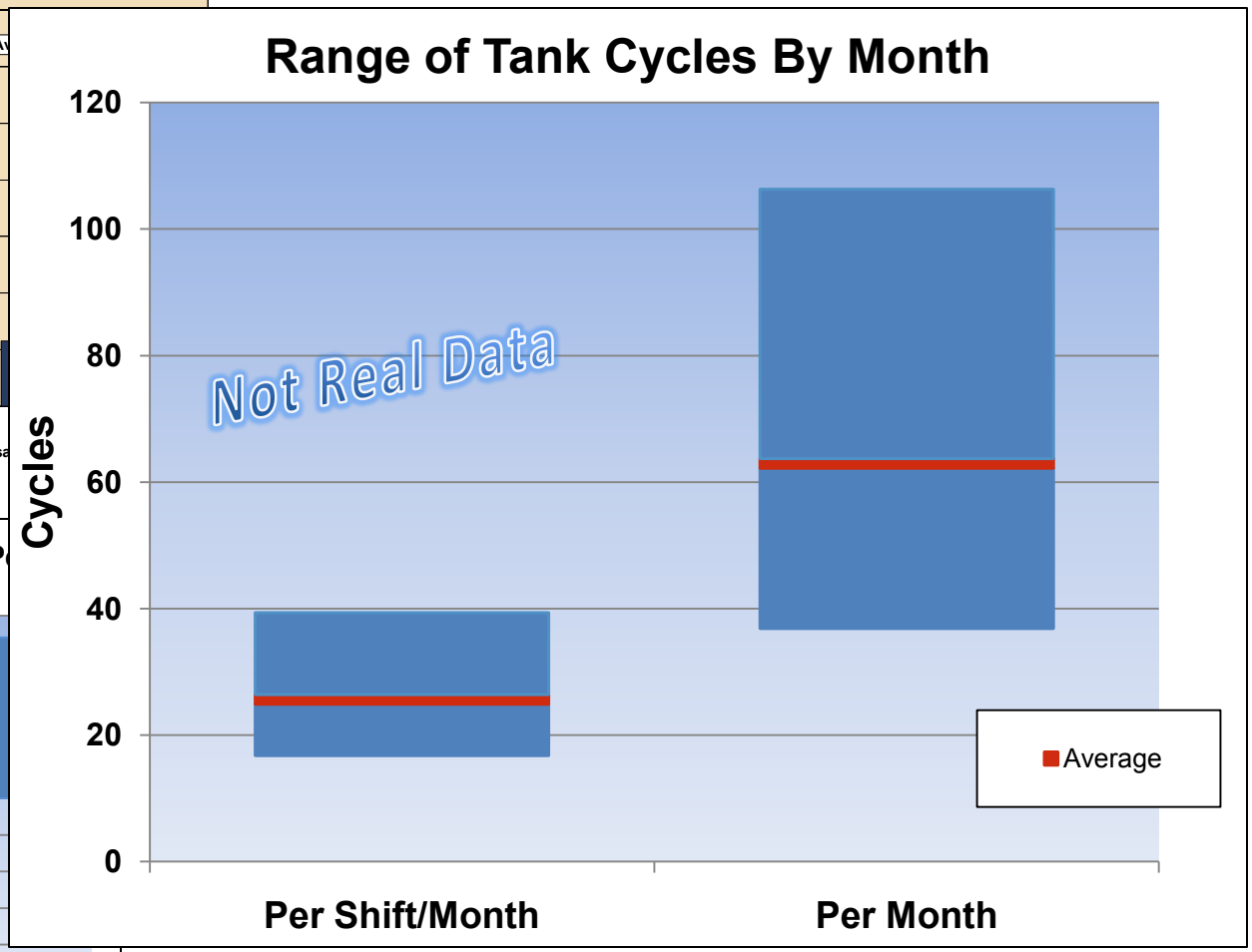


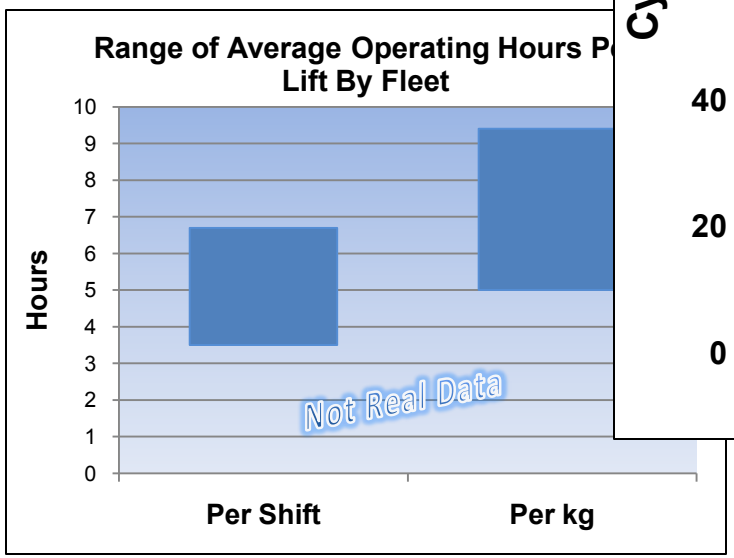




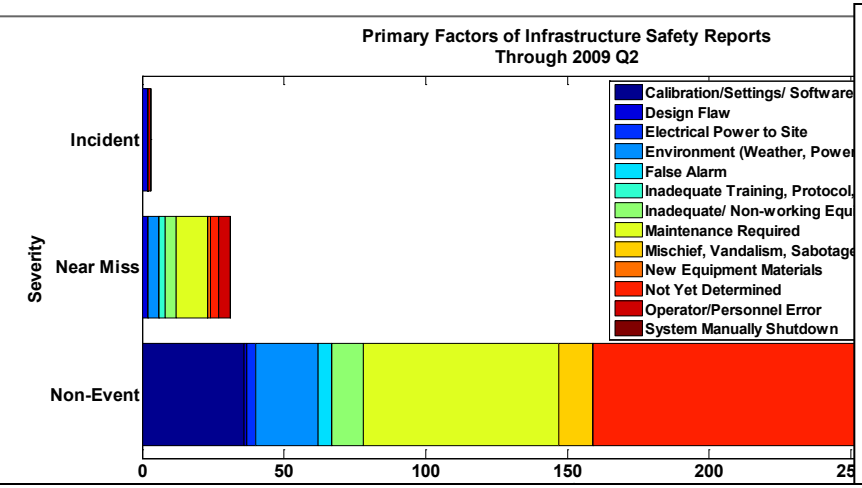
Tank Cycling: Real-World Tank Cycles Per Month

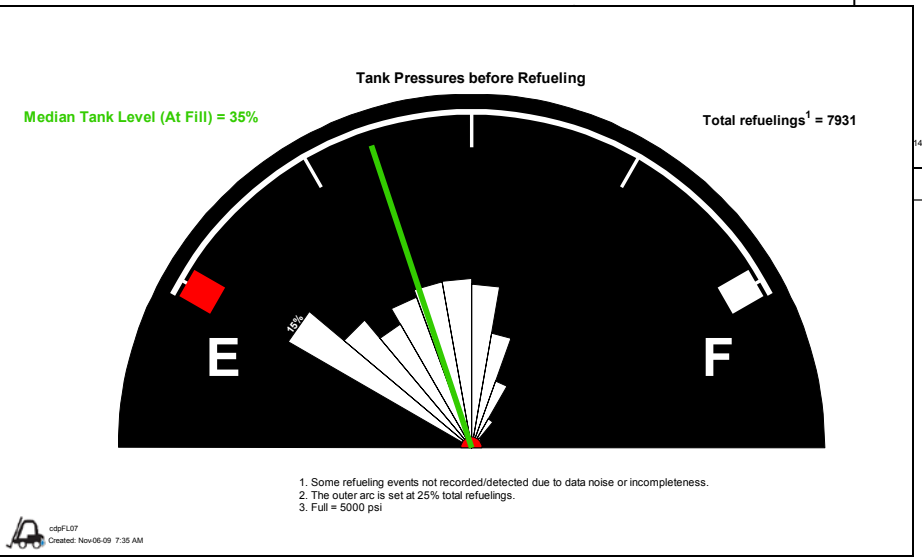


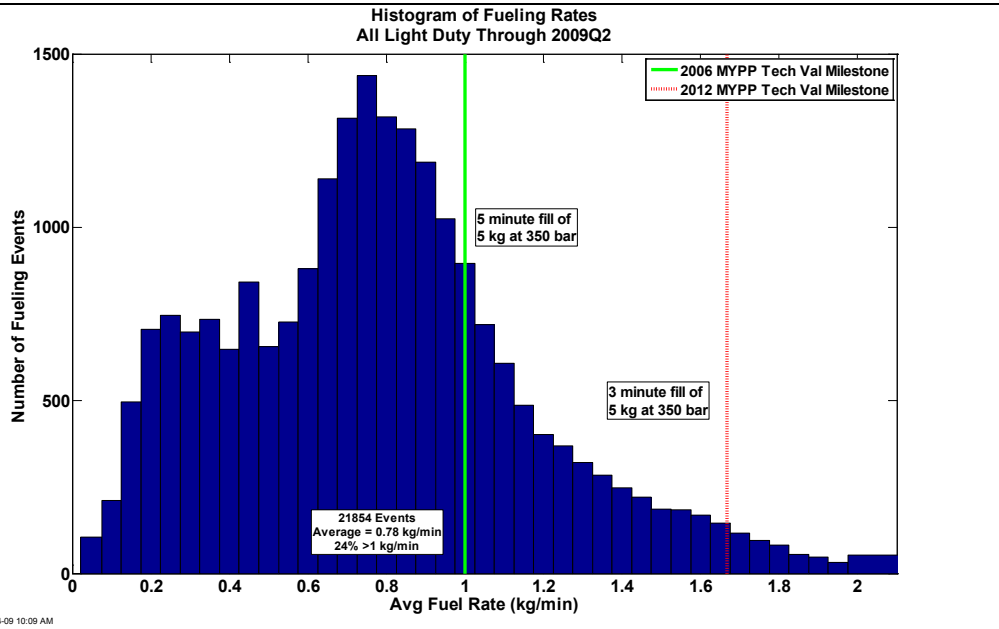




Likely CDPs & Comparable FC Vehicle CDPs





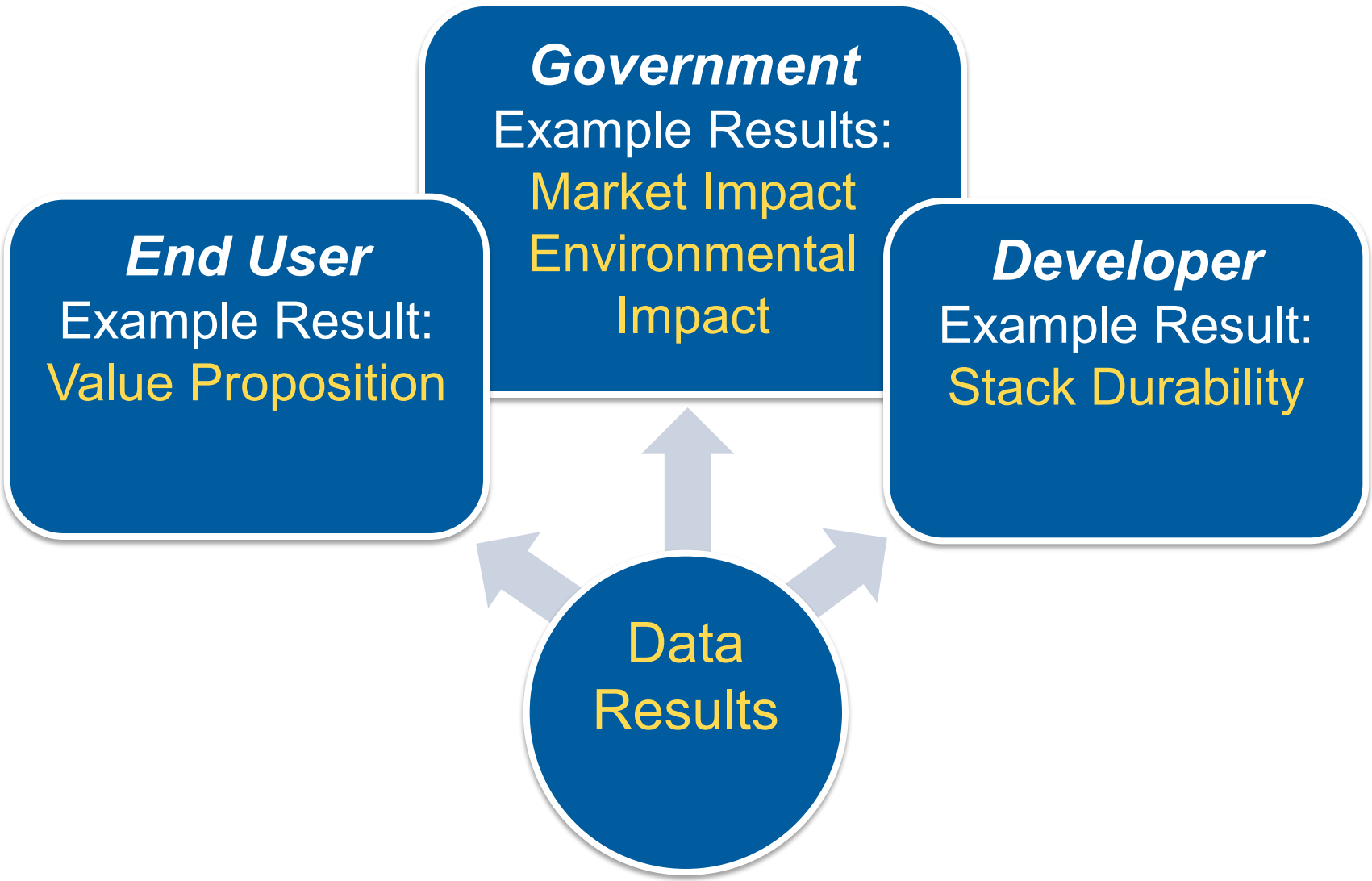


Other Likely CDPs

Durability
Efficiency
Power, Voltage, Energy
Safety
Reliability
Maintenance
Cost (installation and operation)
Market Application Comparisons

*FCV Learning Demo has **72** Data Results*

Data Results Reported to Multiple Stakeholders



Comparison of Fuel Cell and Battery Powered Forklifts – Cost Metrics

PEM Fuel Cell Powered Class 1 Forklift to Comparable Battery Powered Forklift		
Parameter	Performance/Cost of Fuel Cell Version Compared to Battery	Fuel Cell Advantage
Forklift Vehicle Cost & Life	No Difference	N/A
Powerpack Cost (FC or Battery)	3x – 6x Higher	-
Powerpack Life (FC or Battery)	1 – 1.7x Longer	+
# Powerpacks Needed	1/Lift vs 1/Shift/Lift	+
H2/Electricity Fuel Costs	4x – 6x Higher	-
H2 Fueling vs Battery Change	3x – 5x Faster	+
Powerpack Maintenance/Repair	??	TBD
H2 vs Charger Infrastructure (Capital + O&M)	??	TBD

Source: Assessments based on *Identification and Characterization of Near-term Direct Hydrogen Proton Exchange Membrane Fuel Cell Markets* [Battelle Memorial Institute (April 2007)] coupled with forklift manufacturer industry information. Future progress reporting will be based on actual data from DOE and DOD fuel cell forklift demonstrations as reported to NREL.

Comparison of Fuel Cell Forklifts – Other Performance Metrics

PEM Fuel Cell Forklift to Conventional Forklift	
Parameter	Advantage for Fuel Cell vs. Battery
Ambient Operating Temperature Range	+
Consistent Power Availability Over Shift	+
Continuous Runtime	+
Ease of Use	+
Safety	?
Parameter	Advantage for FC vs. Diesel/Propane
Direct Emissions (Criteria Air Pollutants)	+
Lifecycle Greenhouse Gas Emissions	+
Noise	+

Source: Assessments based on relevant literature coupled with forklift manufacturer industry information. Future progress reporting will be based on actual data from DOE and DOD fuel cell forklift demonstrations as reported to NREL.

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www.nrel.gov/hydrogen/proj_tech_validation.html