

Fuel Cell Electric Vehicle Evaluation



**2014 DOE Annual Merit Review
and Peer Evaluation Meeting**

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Project ID# TV001

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This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Overview

Timeline

Project start date: October 2012
Project end date: September 2014*
Percent complete: On-going

Barriers

Lack of current controlled and on-road hydrogen fuel cell vehicle data

Budget

FY13 DOE funding: \$485k
Planned FY14 DOE funding: \$415k
Total project funding: \$900k

Partners

Several fuel cell vehicle OEMs (data providers)

*Project continuation and direction determined annually by DOE

Project Objectives, Relevance, and Targets: Fuel Cell Electric Vehicle Evaluation

- **Objectives**

- Validate hydrogen fuel cell electric vehicles (FCEV) in real-world setting
- Identify current status and evolution of the technology

- **Relevance**

- Objectively assess progress toward targets and market needs
- Provide feedback to hydrogen research and development
- Publish results for key stakeholder use and investment decisions

Key Targets

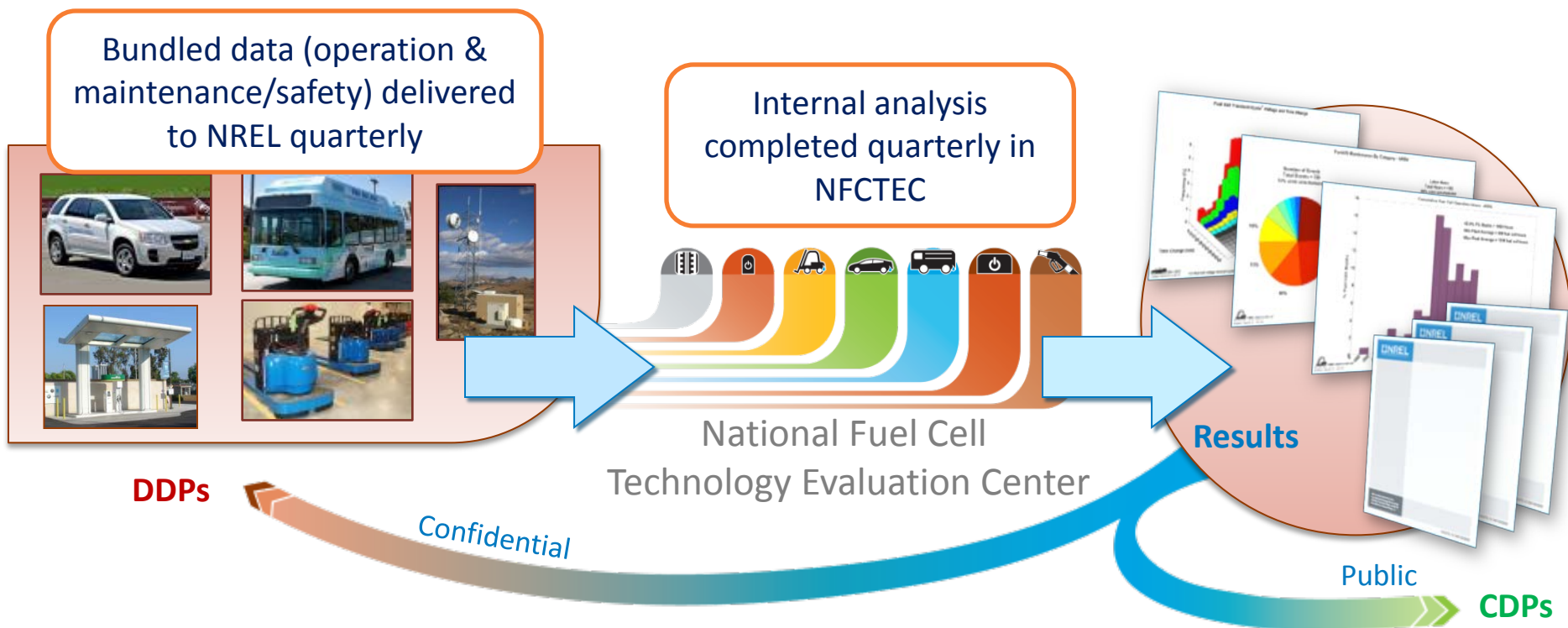
Performance Measure	Status*	Ultimate (2020)
Fuel Cell Stack Durability	2,500 hours	5,000 hours
Vehicle Range	254+ miles	300+ miles
Fill Rate	0.77 kg/min	1.0 kg/min
Efficiency	59% at 25% Power	60% at 25% Power

*As reported in previous Learning Demonstration results



APC/Shell Pipeline station, Torrance, CA. Photo: NREL

Approach: NFCTEC Analysis and Reporting of Real-World Operation Data



Detailed Data Products (DDPs)

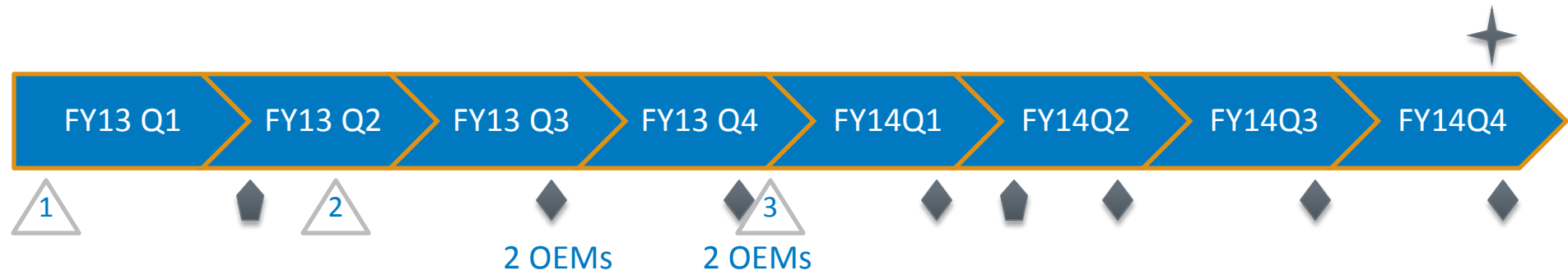
- Individual data analyses
- Identify individual contribution to CDPs
- Shared every six months only with the partner who supplied the data

Composite Data Products (CDPs)

- Aggregated data across multiple systems, sites, and teams
- Publish analysis results every six months without revealing proprietary data

www.nrel.gov/hydrogen/proj_tech_validation.html

Approach and Accomplishments: Milestones



1 Finalize data collection and analysis plans through communications with DOE and industry partners

2 Move HSDC to Energy Systems Integration Facility

3 Rebrand HSDC to National Fuel Cell Technology Evaluation Center (NFCTEC)

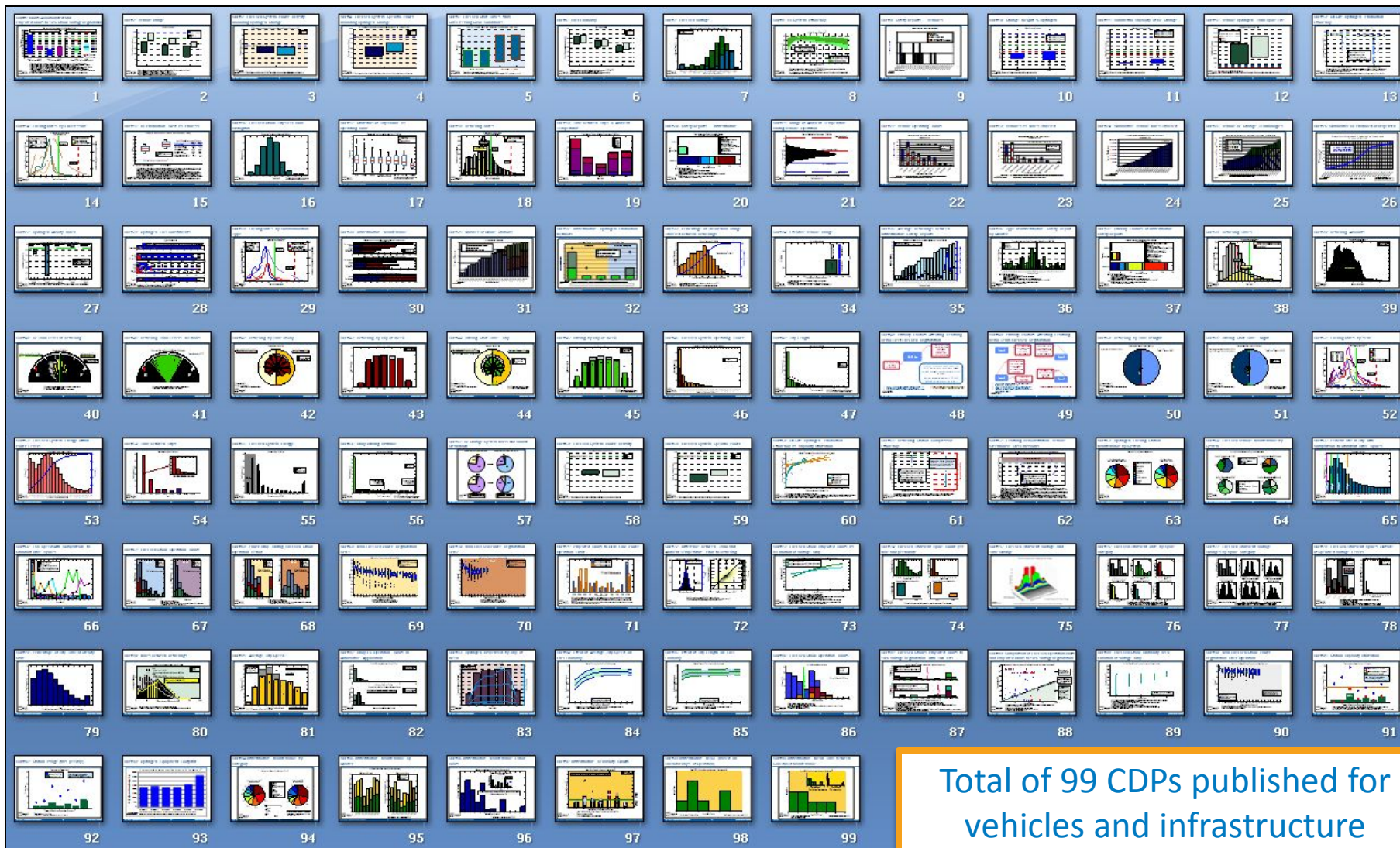
Site visits

Quarterly analysis of operation and maintenance data for fuel cell systems and hydrogen infrastructure

Bi-annual technical composite data products

5-year project evaluation planned

Approach: Benchmarking Current FCEV Performance Against Learning Demonstration Status



Total of 99 CDPs published for vehicles and infrastructure

Approach: Tracking Future Progress Against Previous Demonstration Results

Vehicle Performance Metrics	Gen 1 Vehicle	Gen 2 Vehicle	2009 Target	After 2009Q4
Fuel Cell Stack Durability			2,000 hours	
Max Team Projected Hours to 10% Voltage Degradation	1,807 hours	<u>2,521</u> hours		--
Average Fuel Cell Durability Projection	821 hours	1,062 hours		1,748 hours
Max Hours of Operation by a Single FC Stack to Date	2,375 hours	1,261 hours		1,582 hours
Driving Range			250 miles	
Adjusted Dyno (Window Sticker) Range	103-190 miles	196- <u>254</u> miles		--
Median On-Road Distance Between Fuelings	56 miles	81 miles		98 miles
Fuel Economy (Window Sticker)	42 – 57 mi/kg	43 – 58 mi/kg	no target	--
Fuel Cell Efficiency at ¼ Power	51% – 58%	53% – <u>59</u> %	60%	--
Fuel Cell Efficiency at Full Power	30% – 54%	42% – <u>53</u> %	50%	--

Infrastructure Performance Metrics			2009 Target	After 2009Q4
H₂ Cost at Station (early market)	On-Site Natural Gas Reformation \$7.70 – \$10.30/kg	On-Site Electrolysis \$10.00 – \$12.90/kg	\$3/gge	--
Average H ₂ Fueling Rate	0.77 kg/min		1.0 kg/min	0.65 kg/min

Outside of this project, DOE independent panels concluded at 500 replicate stations/year:

Distributed natural gas reformation at 1,500 kg/day: **\$2.75–\$3.50/kg** (2006)

Distributed electrolysis at 1,500 kg/day: **\$4.90–\$5.70** (2009)

Outside
review
panel



Approach: NREL Fleet Analysis Toolkit

NREL Fleet Analysis Toolkit

Company: EcoCars
Project: H2 Coupe
Data Range: YYYYGG 201304

MASTER:

CRUNCH
THINK
CORRELATE
PUBLISH

Analysis

Processing to Perform:

- ProcessRaw
- GetTripInfo
- StackInfoFromExcel
- FuelEconomyRaw
- FuelEconomy
- DataCompleteRaw
- DataComplete
- RangeRaw
- Range
- FCDegRaw
- FCDeg
- TripData
- Stack Summary
- DriveDetails
- MaintenanceRaw
- Maintenance

Utility

GIT SCC RUN BATCH TRANSMIT ARCHIVE CDP

Max Fuel Cell Stack Power Degradation Over Operation

Median power difference from 0 hour segment to 1300 hour segment = -18.2%

of Refueling

Refueling Rate (kg H2/minute)

5 minute fill of 5 kg at 350 bar
3 minute fill of 5 kg at 350 bar

Data processing, analyses, review, aggregation, and publication through internally developed tool

Accomplishment: Key Analysis Topics Identified

Critical

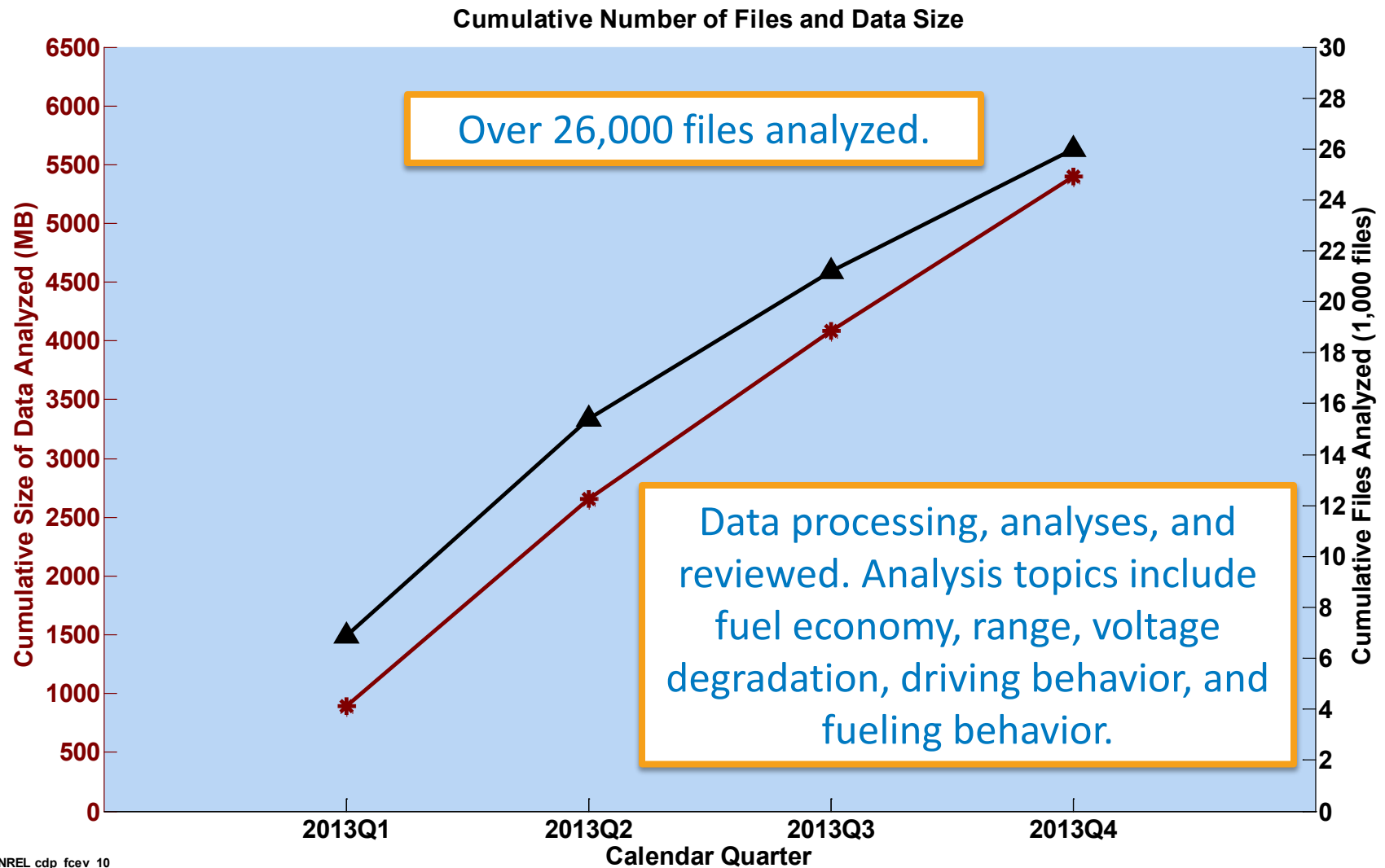
- Fuel cell durability
- Vehicle operation (hours, miles)
- Specs (power density, specific power)
- Range, fuel economy, and efficiency
- Fill performance
- Reliability

Important

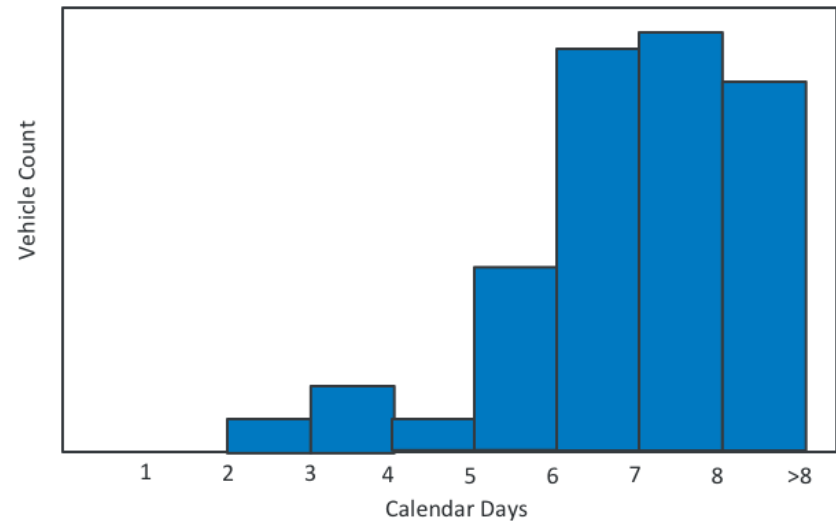
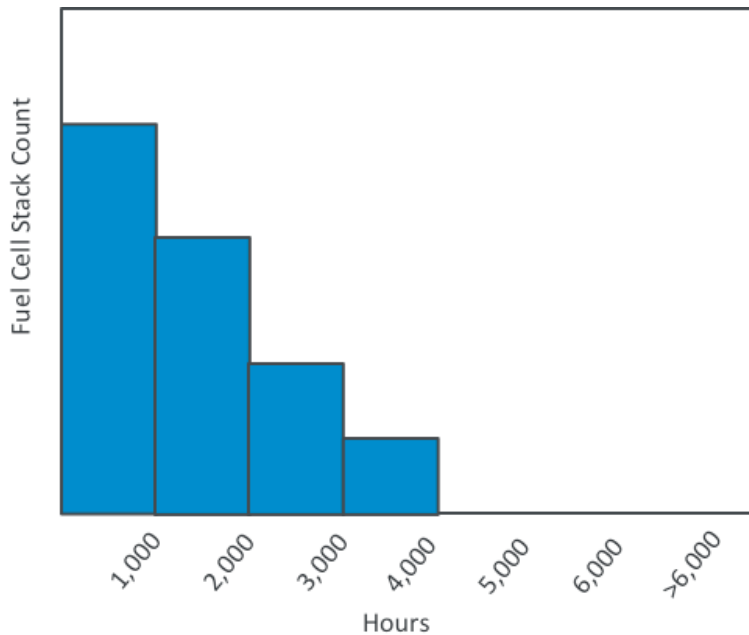
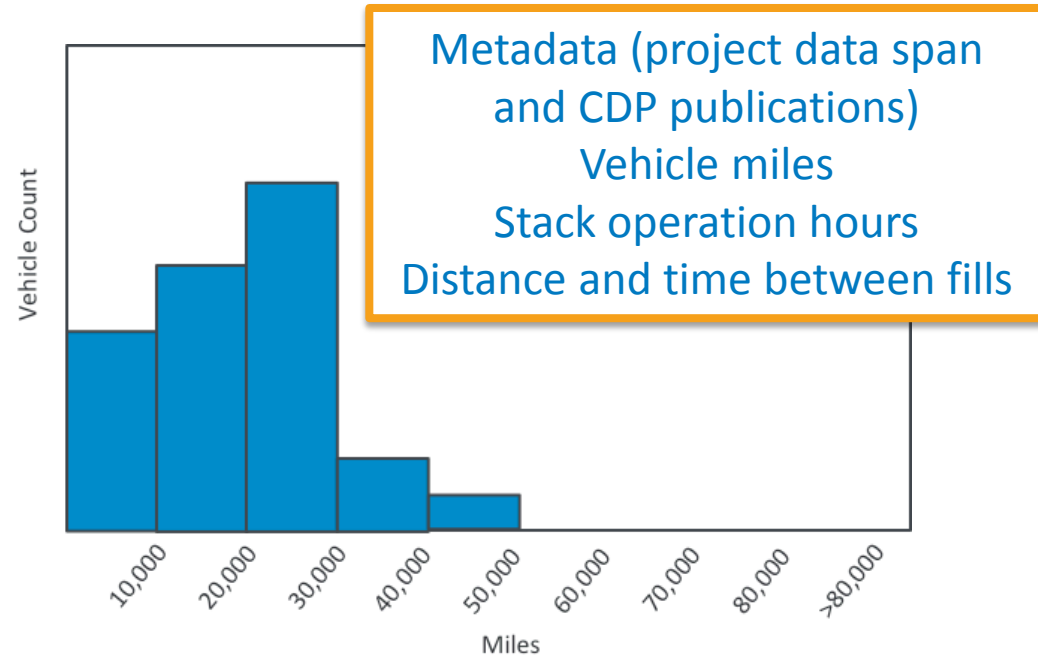
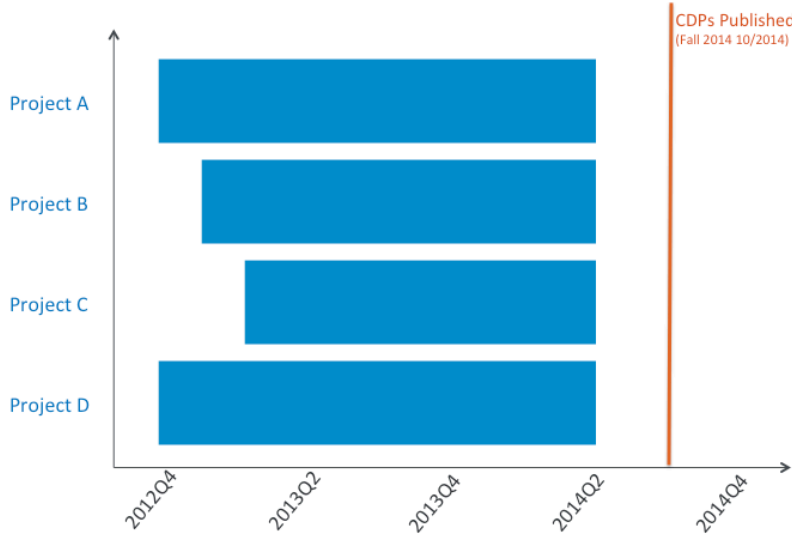
- Drive behaviors
- Fill behaviors
- Power management
- Energy
- Transients
- Comparisons to conventional vehicles

These key topics were selected based on review of past CDPs, targets, most common referenced topics, and DOE feedback.

Accomplishment: Individual OEM Fleet Processing (Four OEMs)



Accomplishment: Fake CDPs Created



Accomplishments: Responses to Previous Year Reviewers' Comments

- This project was not reviewed in FY13.

Highlights of Interactions and Collaborations

- **Auto industry partners**

- Detailed discussion of NFCTEC procedures
- Discussion of data priorities, templates, and methods
- Detailed data analyses individual reviews
- Review of all results prior to publication

- **U.S. DRIVE technical teams**

- Provide briefing when requested of FCEV performance results to the Hydrogen Storage and Fuel Cell technical teams



- **FCHEA technical working groups**

- Participate in Transportation Working Group
- Participate in Joint H₂ Quality Task Force



- **California organizations**

- California Fuel Cell Partnership and California Hydrogen Business Council: NREL actively participating as member
- California Air Resources Board and California Energy Commission: New stations offer potential to provide future data to NREL



Future Work

- **Perform quarterly analysis of data**
- **Conduct detailed data reviews with OEMs**
- **Identify first set of FCEV CDPs for publication scheduled at the end of FY14**
- **Identify new opportunities to document fuel cell and hydrogen progress publicly**

Summary

- **Relevance**

- Validate FCEV performance against DOE and industry targets

- **Approach**

- Collaborate with industry partners
- Continue to develop core NFCTEC and analysis capability and tools
- Leverage 7+ years of analysis and experience from the Learning Demonstration

- **Technical Accomplishments and Progress**

- Analyzed data from four OEMs
- Performed detailed reviews of individual OEM data results

- **Collaborations**

- Working closely with industry partners to validate methodology, and with other key stakeholders to ensure relevance of results

- **Future Work**

- Identify first set of FCEV CDPs for publication scheduled at the end of FY14
- Identify new opportunities to document fuel cell and hydrogen progress publicly