

Next Generation H2 Station Analysis



**2012 DOE Annual Merit Review &
Peer Evaluation Meeting**

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Project ID# TV017

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

Overview

Timeline

- Project start date: Oct 2011
- Project end date: Sep 2012*

Budget

- Total project:
\$ 200k (planned FY12)

MYPP Barriers Addressed

- Lack of Hydrogen Refueling Infrastructure Performance and Availability Data

Partners

- Air Products
- Linde
- Hydrogen Frontiers

*Project continuation is determined annually by DOE.

Relevance: Meeting Vehicle Needs

Use metrics to clearly evaluate progress toward challenges

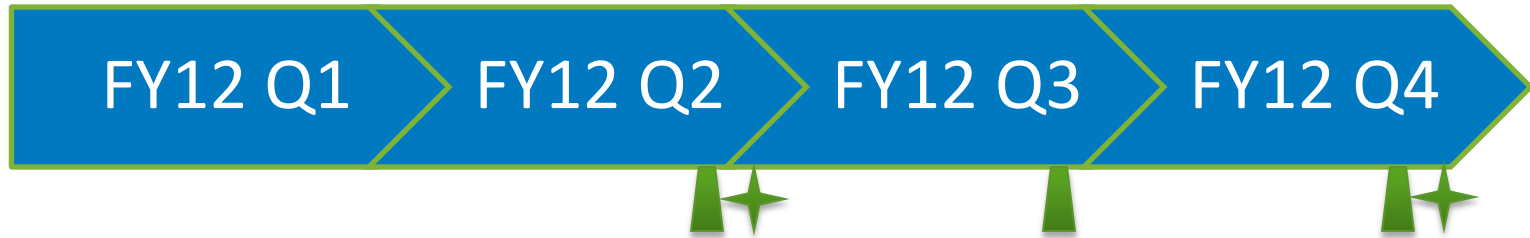
- **Location/Capacity/Utilization**
 - **Challenge:** Stations need to provide coverage to meet needs of vehicle drivers in pre-commercial stage as well as have hydrogen availability with minimal wait time.
 - **Metrics:** Station usage patterns and geographic locations.
- **Fueling**
 - **Challenge:** Vehicles need to be fueled in an acceptable amount of time.
 - **Metrics:** Fueling rates, times, amounts, back-to-back fills, communication...
- **Maintenance/Availability**
 - **Challenge:** Maintenance and other factors may cause station downtime and increase cost.
 - **Metrics:** Maintenance patterns, reliability and availability of stations.
- **Cost**
 - **Challenge:** Hydrogen cost is dependent on several factors including where produced, how delivered, efficiencies and maintenance requirements.
 - **Metrics:** Energy cost, maintenance cost...
- **Station Timing**
 - **Challenge:** Need enough lead time to build infrastructure to meet vehicle demand.
 - **Metrics:** Permitting time, building time, commissioning time...

Approach: Analysis Objectives

Analyze operational data on existing hydrogen stations to provide status and feedback in the following areas:

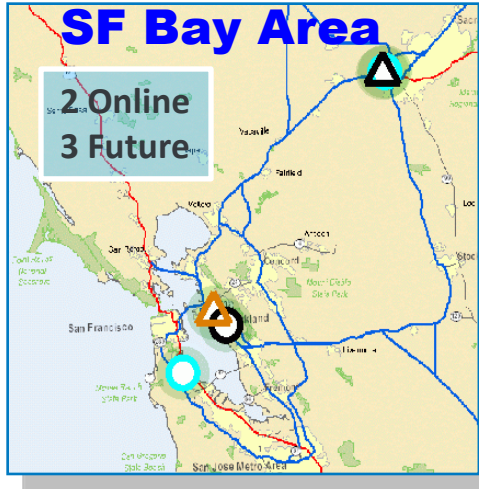
- Capacity
- Utilization
- Station build time
- Maintenance/availability
- Fueling
- Geographic coverage

Approach and Accomplishments: Milestones

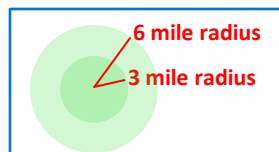
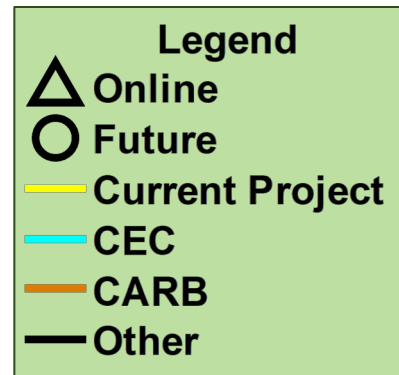
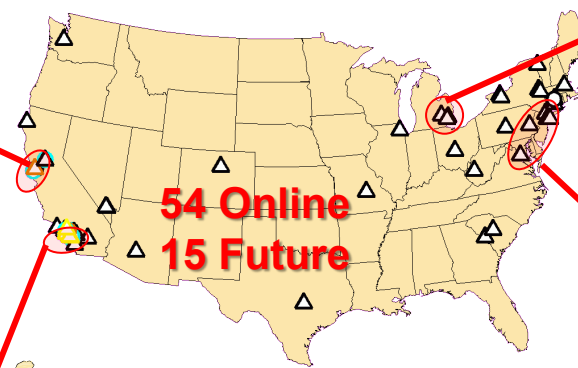
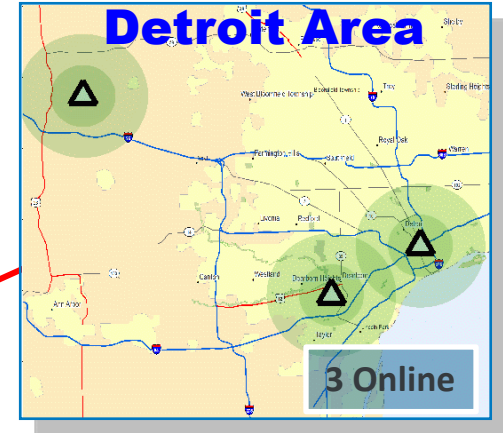


- ▲ Quarterly data analysis (based on available data)
- ★ Publication of composite data products

Approach: Station Locations



- Maintain database of current stations in the U.S.
- Station coverage



Approach and Accomplishment: Simplified and Improved Infrastructure Data Templates

Site Summary / Storage & Delivery / Compression / Dispensing / **Fuel Log** / Maintenance / H2 Cost / Safety / H2 Quality / Reformer / **Electrolyzer** / Co-Pro

Templates enable collection of similar data from all the stations
 ➤ Aggregated results

Infr Template Rev Dec02 2011 (company date).xlsx - Microsoft Excel

Home Insert Page Layout

1 **Fuel Log**

2 Template last updated on December 02, 2011 (NREL)

3 Data should be from reporting quarter

4

5 Calendar Quarter

6 Site Name

Footnotes:

(1) Refueling Rate: The capability of the on-site refueling system (from storage tank to on the vehicle) shall be tested to determine the hydrogen flow rate and reported quarterly. Refueling time starts and stops upon fuel flow starting and stopping (i.e., set-up excluded).

Date/Time (m/d/yy HH:MM:SS)	Fuel Price (\$/kg)	Dispenser ID (if multiple)	H2 Filled (kg)	Fill Time (s)	Final Pressure (bar)	Fill Type	Veh Name or Type	Comments	Fill Rate (kg/min) (kg H2/Fill Time)
5/1/01 15:30:24	\$5.00	Disp350A	2.5	180	350	Communication	ECO-FCV01		0.8
5/1/01 15:30:24	\$5.00	Disp700B	15	480	700	Non-Communication	BusCo-Transit Bus	Bus Demo	1.9
5/1/01 15:30:24	\$5.00	Disp350B							

Infr Template Rev Dec02 2011 (company date).xlsx - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Acrobat

1 **Electrolyzer Log**

2 Template last updated on December 02, 2011 (NREL)

3

4 Calendar Quarter (ex. 2011Q2)

5 Site Name

6 Electrolyzer Type

7 Electricity Source

8

9 Data should be from reporting quarter

Category	Units	Month		
		Month1	Month2	Month3
Hydrogen Produced	kg	450		
Operation Time	hours	400		
Water Consumed, Directly	gallons	4140		
Converted + Waste + Other	gallons	4140		
Electricity Used	kWhr	6000		
Electricity Cost (ex. monthly bill)	dollars	\$300		
Total Energy Consumed in Conversion (1) (Electrical, Thermal,				

Approach: Data Collected

What we collected (old templates) / will collect (new templates/projects)

- **H2 produced or delivered by month**
 - Amount in storage by day, amount in storage at least monthly
- **On-site efficiency, conversion efficiency, compression energy, storage and dispensing energy**
- **Maintenance log**
 - Component, Category, Type, Hours, Scheduled, Failure Mode, Labor Cost, Parts Cost, Hours on Component, Safety Issue
- **Safety log**
 - Description, lessons, severity, equipment, primary factor, damages
 - Incident, near-miss, ~~non-event~~ → hydrogen leak
- **Hydrogen quality**
 - Each constituent → lab report and issues
- **Fueling**
 - Amount, Time, Comm, Final Pressure, Veh Type, Comments, \$/kg
- **Cost of non-H2 energy for compression, dispensing, conversion**
- **Cost items (by month)**
 - Non-maintenance labor, site electricity, site rent, property tax, license/permit fees, insurance, nitrogen deliveries, natural gas, water
- **Station description (one-time)**
- **Production capacity [kg/day], [kg/hour]**
- **Dispensing capacity [kg/day], [kg/hour]**
- **Survivability (max/min temperature)**
- **Nominal pre-cooling temp and SAE 2601 type (nitrogen or chiller)**
- **Storage type(s) and capacities, and at what pressure(s)**
- **Number of dispensers and at what pressure(s)**
- **Compressor(s) information**
- **Time to design, permit, construct, and commission**
- **Footprints: storage, production, dispensing**

Approach: Hydrogen Secure Data Center

Bundled data (operation & maintenance/safety) delivered to NREL quarterly

Internal analysis completed quarterly

HSDC

NREL's Hydrogen Secure Data Center

Results

Confidential

Public

CDPs

Detailed Data Products (DDPs)

- Individual data analyses
- Identify individual contribution to CDPs
- Only shared with partner who supplied data every 6 months¹

Composite Data Products (CDPs)

- Aggregated data across multiple systems, sites, and teams
- Publish analysis results without revealing proprietary data every 6 months²

1) Data exchange may happen more frequently based on data, analysis, and collaboration

2) Results published via NREL Tech Val website, conferences, and reports

Approach and Accomplishment: Analysis

- **NREL Fleet Analysis Toolkit (NRELFAT)**
 - Developed first under fuel cell vehicle Learning Demonstration
 - Restructured architecture and interface to effectively handle new applications and projects and for analyses flexibility
 - Leverage analysis already created
- **Publish results**
 - Detailed and composite results
 - Target key stakeholders such as fuel cell and hydrogen community and end users

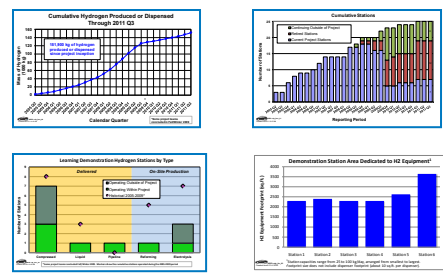




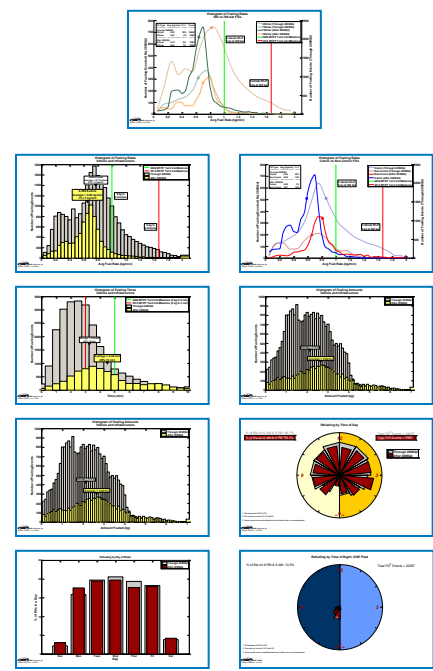
Previously Published CDPs (Learning Demo)

Infrastructure CDP # and Category

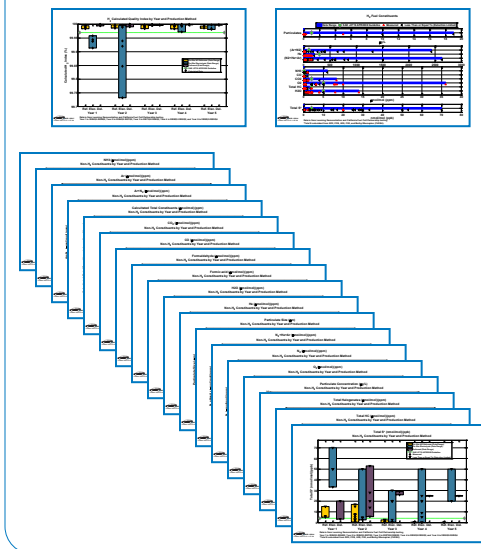
Deployment & Overview (26,31,32,93)



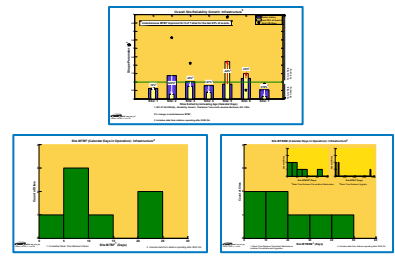
Refueling (14,18,29,38,39,42,43,50,52,72)



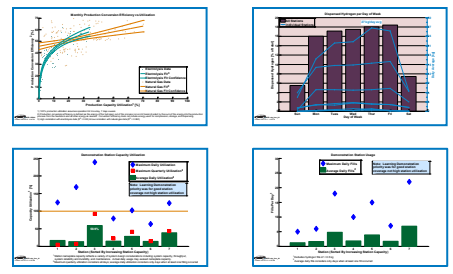
H2 Quality (27,28mult)



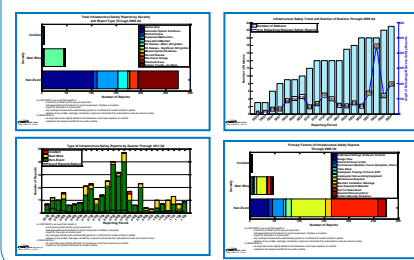
Reliability (97,98,99)



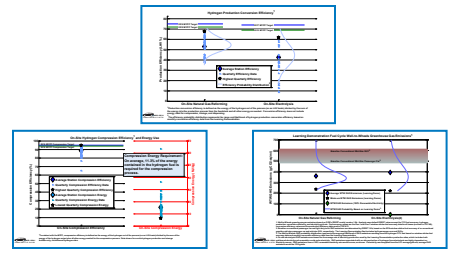
Utilization (60,83,91,92)



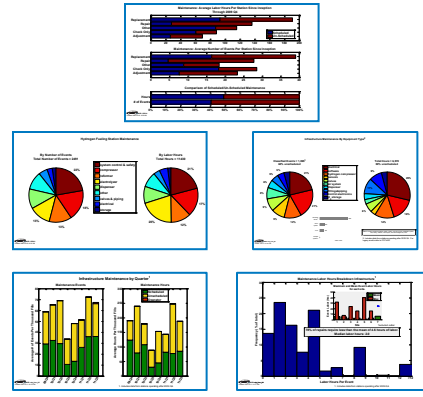
Safety (20,35,36,37)



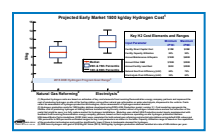
Efficiency/Emissions (13,61,62)



Maintenance (30,63,64,95,96)

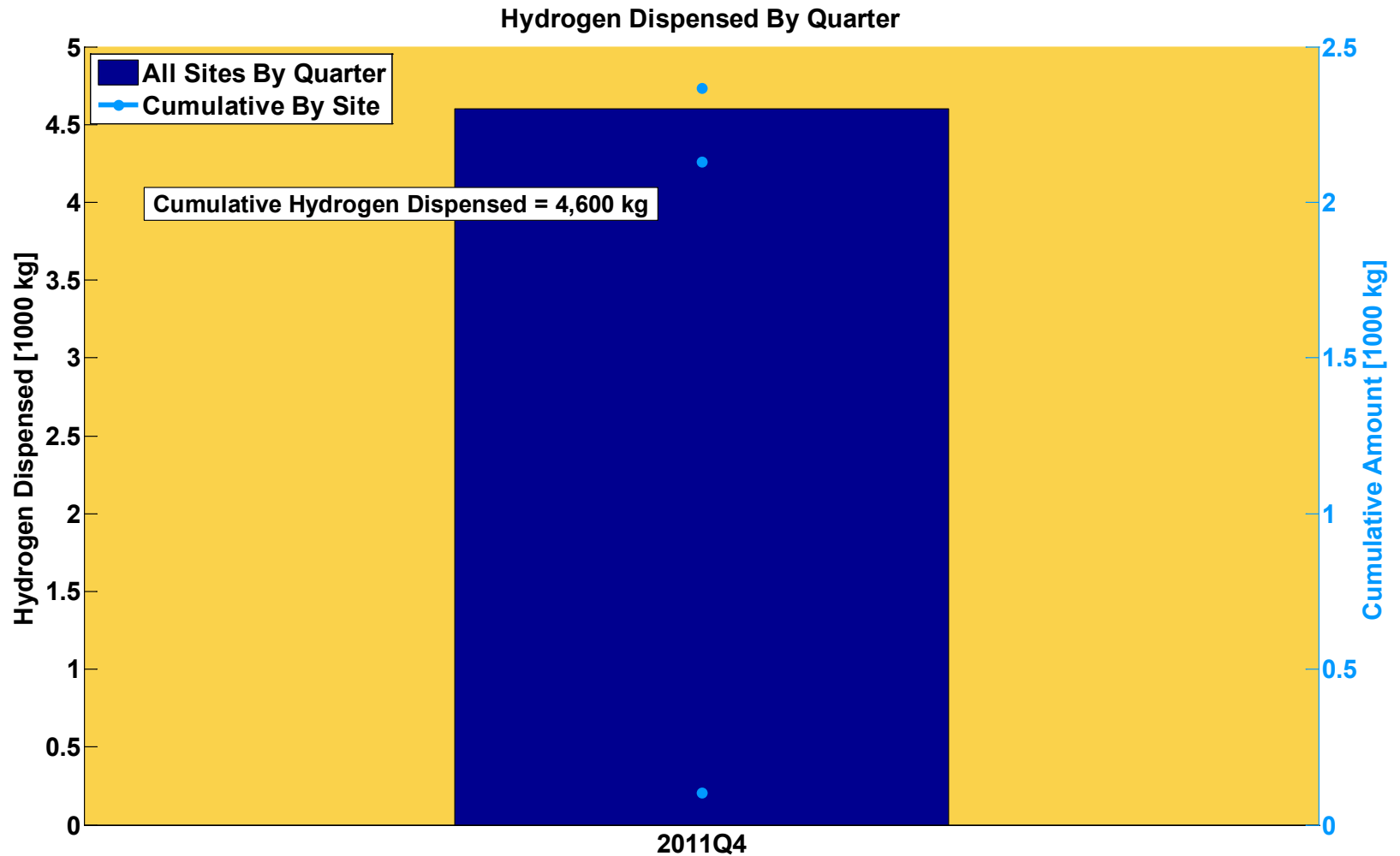


Cost (15)



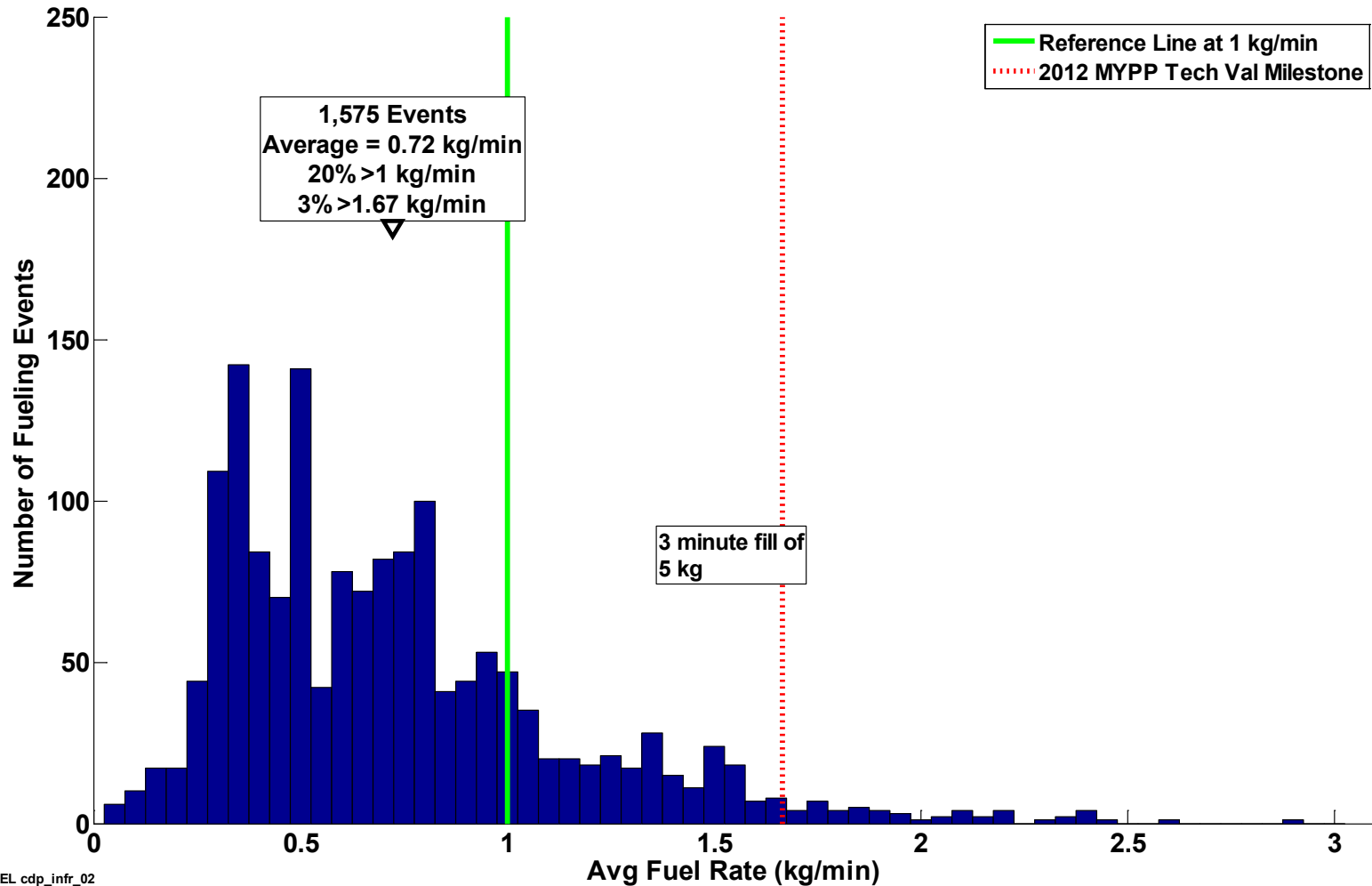
Spring 2012 Infrastructure CDPs

Hydrogen Dispensed by Quarter



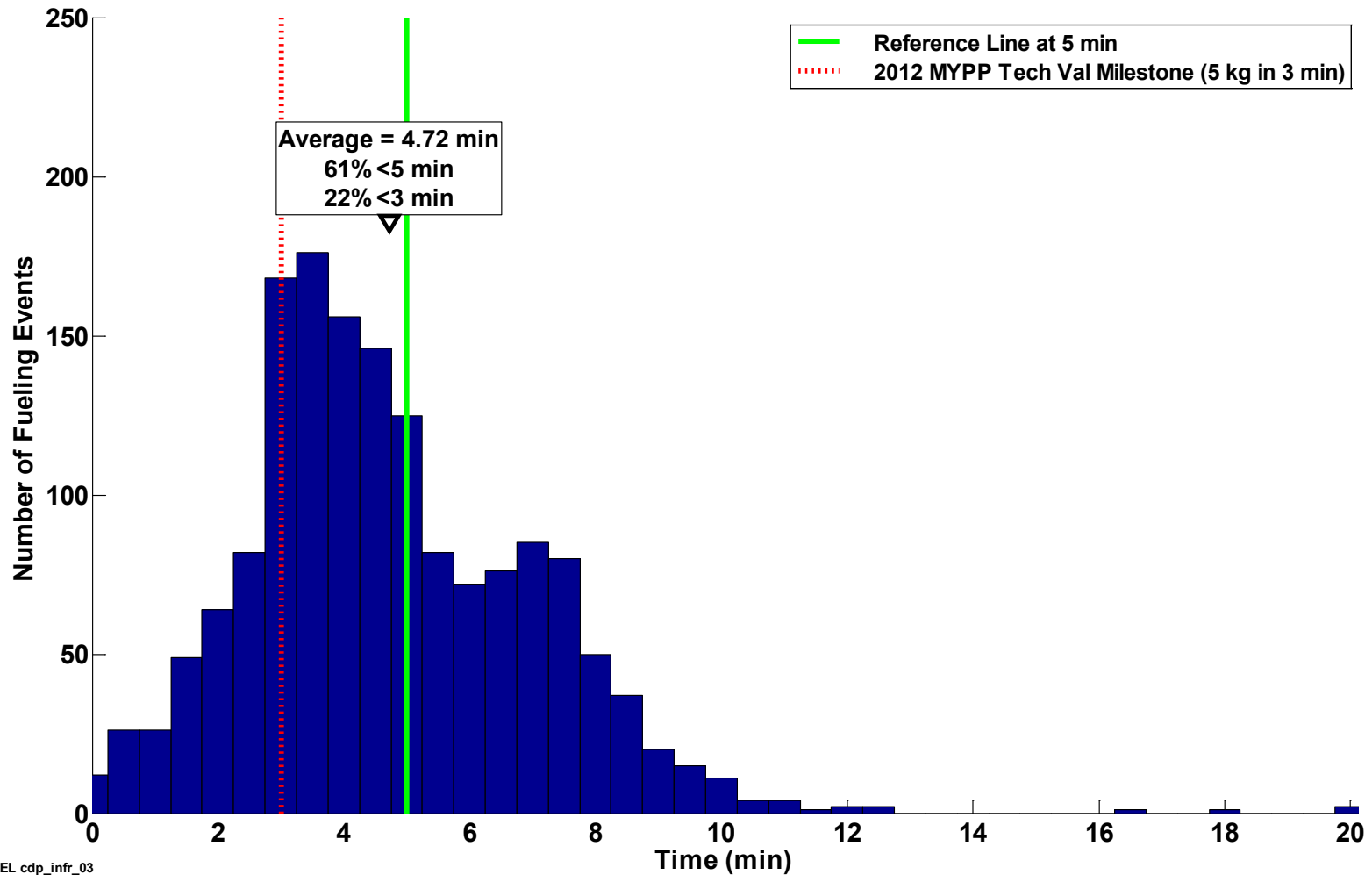
Histogram of Fueling Rates

Histogram of Fueling Rates



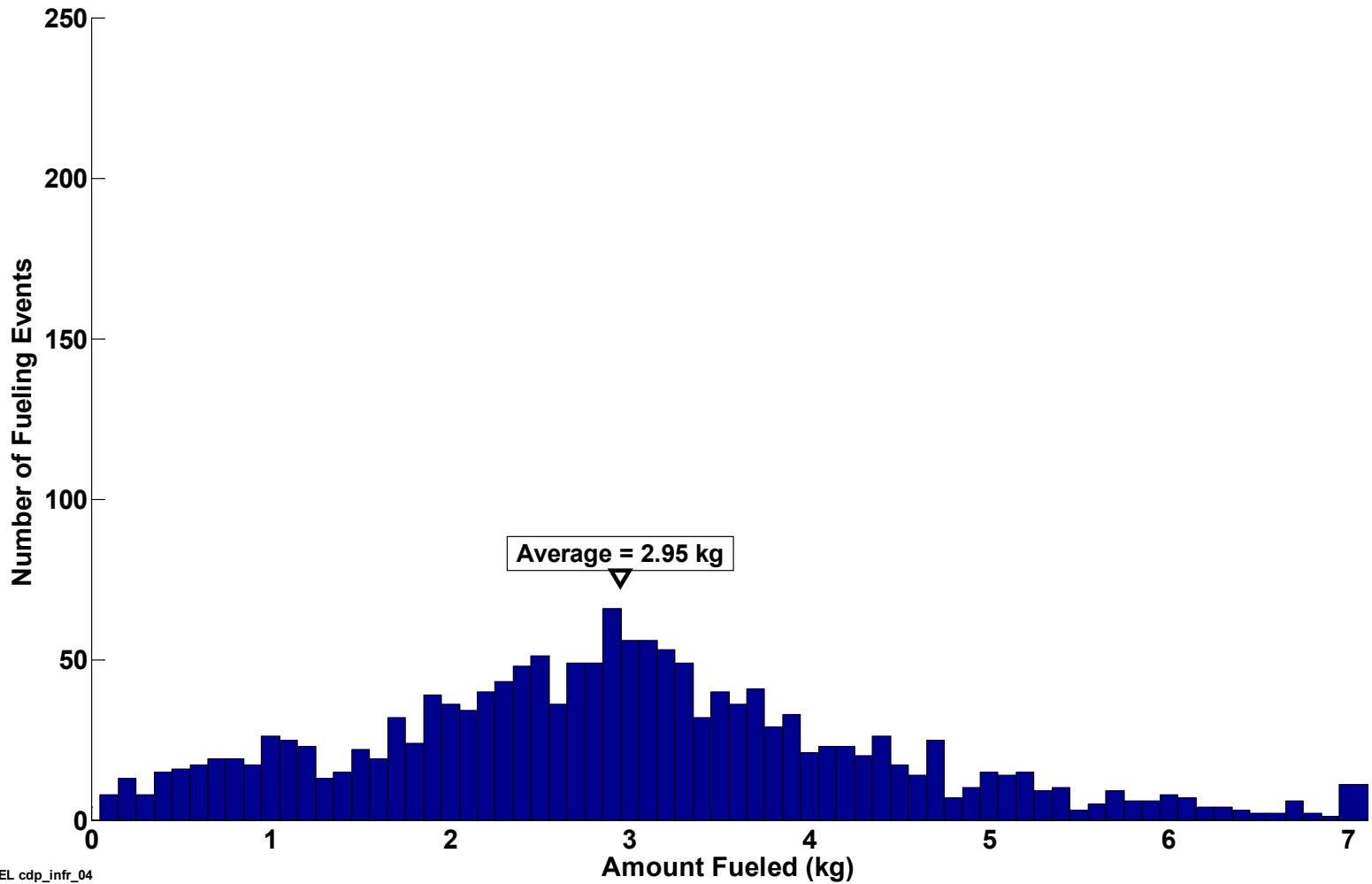
Histogram of Fueling Times

Histogram of Fueling Times



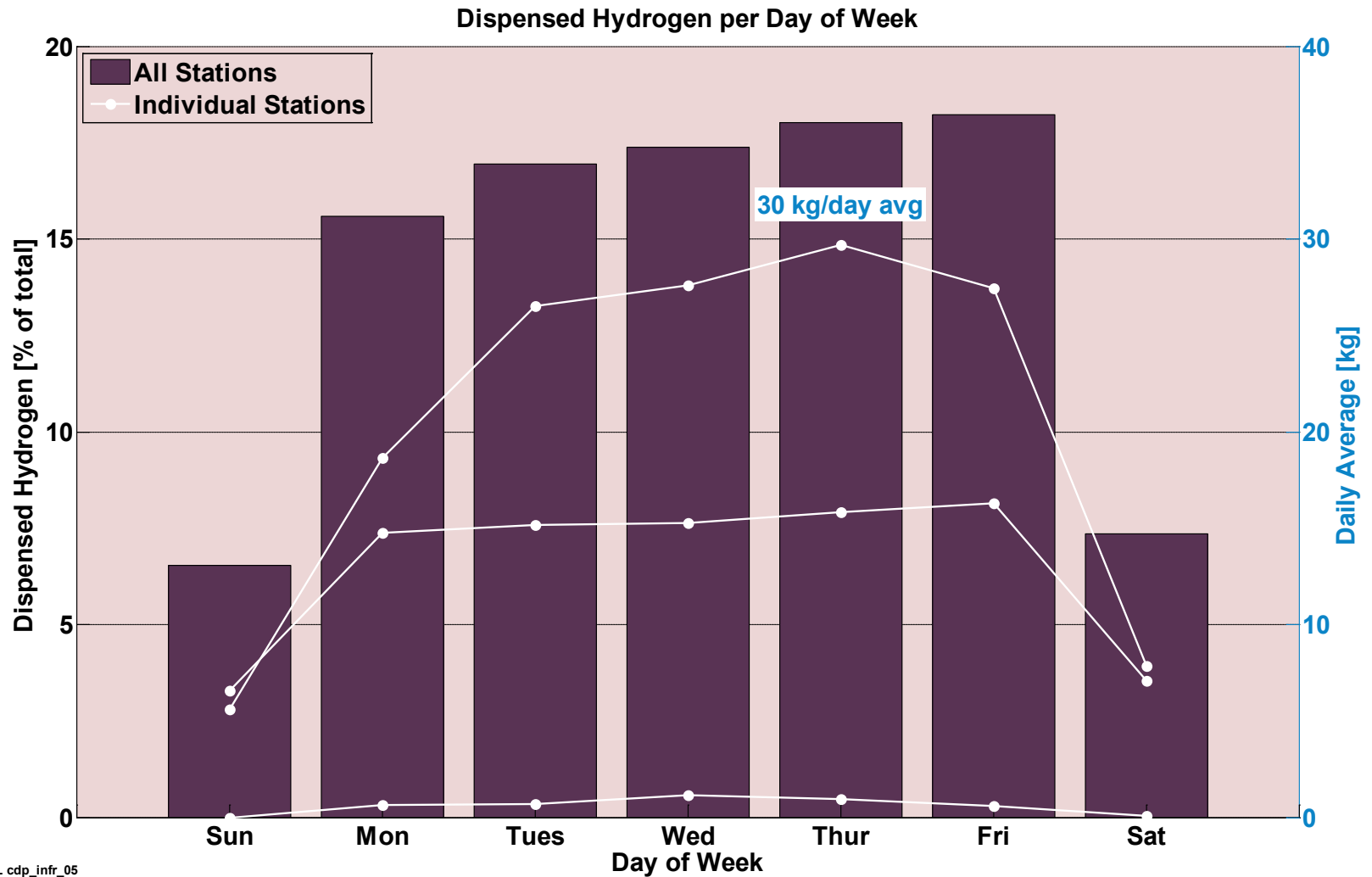
Histogram of Fueling Amounts

Histogram of Fueling Amounts

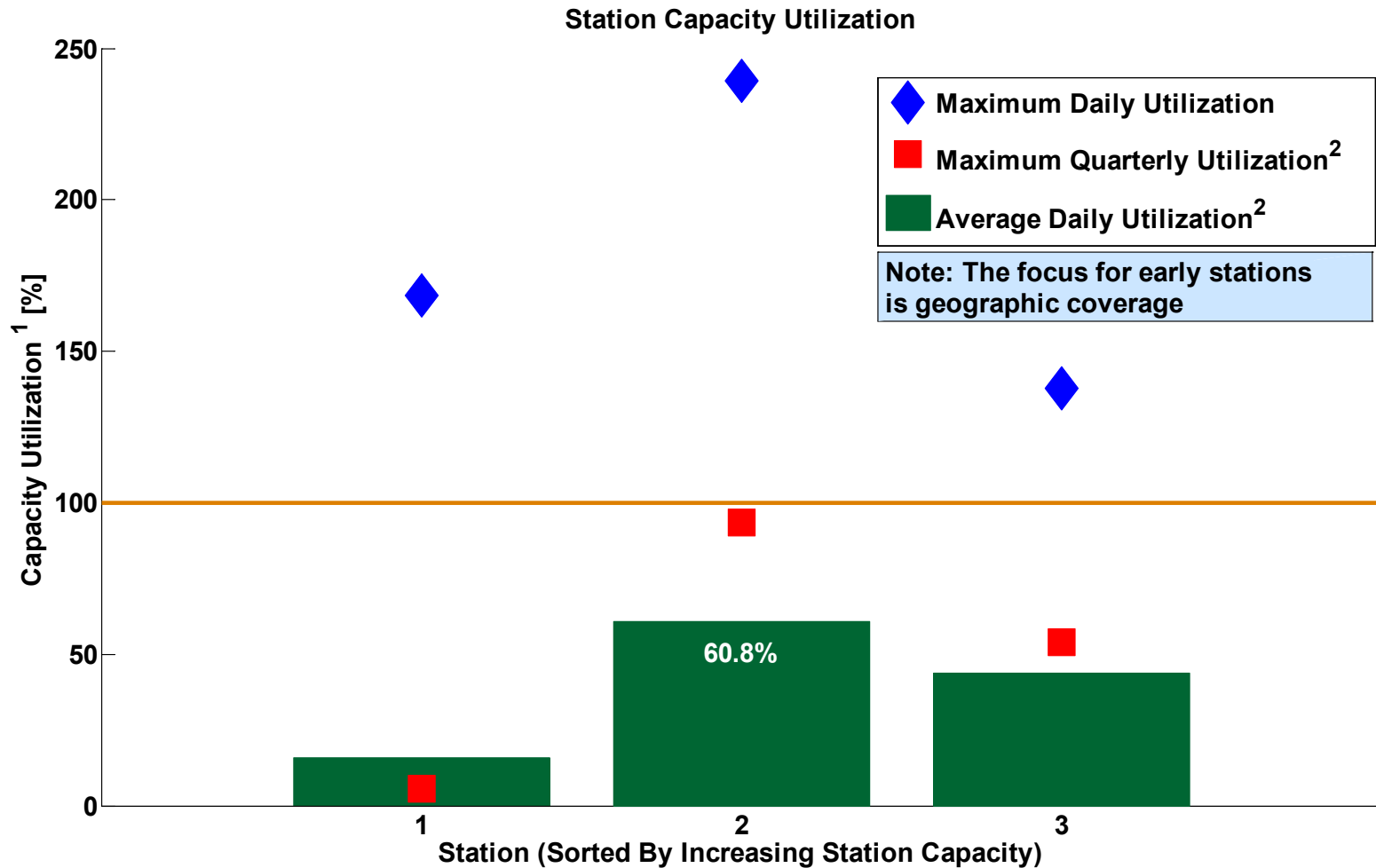


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Dispensed Hydrogen per Day of Week



Station Capacity Utilization

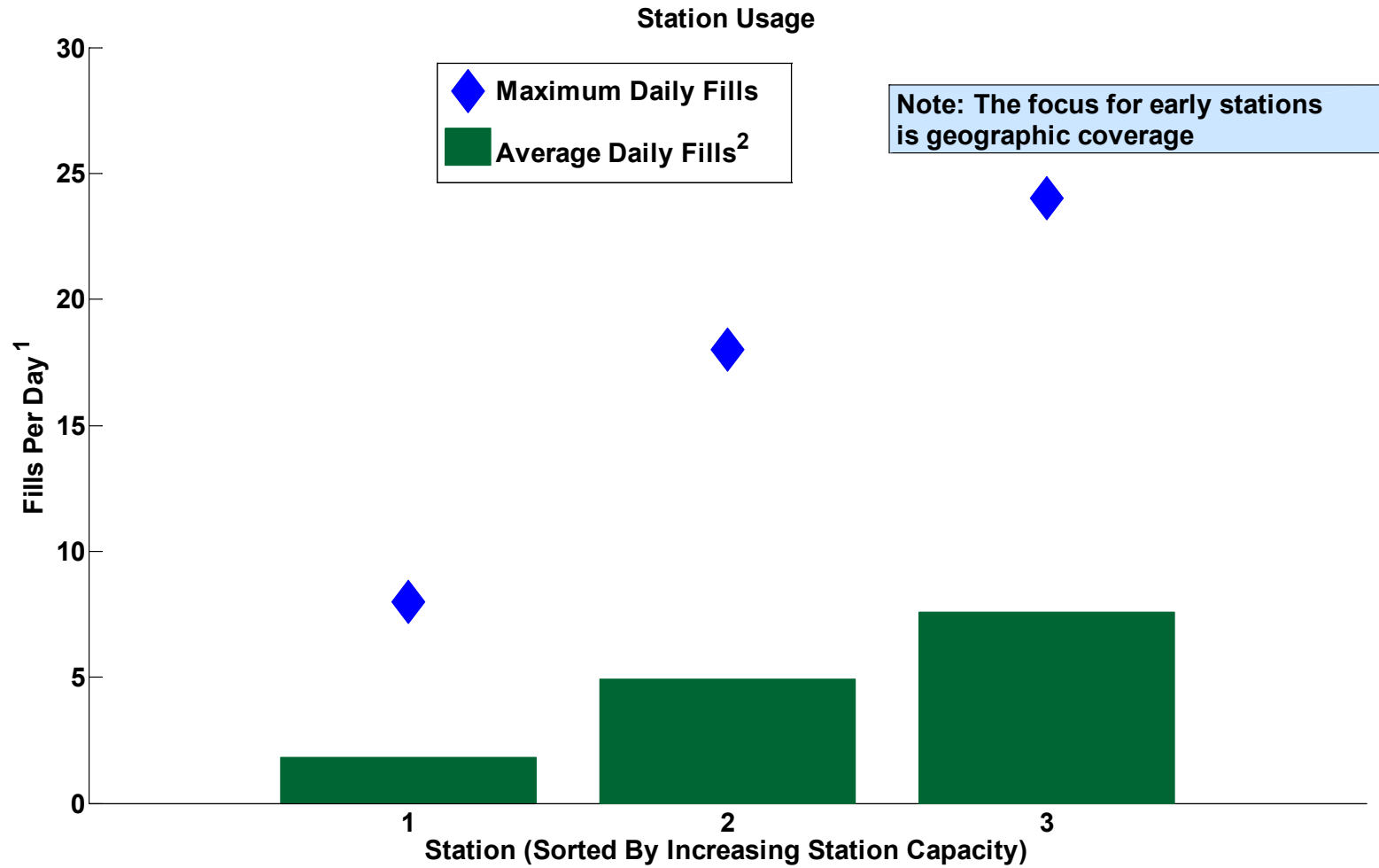


¹Station nameplate capacity reflects a variety of system design considerations including system capacity, throughput, system reliability and durability, and maintenance. Actual daily usage may exceed nameplate capacity.

²Maximum quarterly utilization considers all days; average daily utilization considers only days when at least one filling occurred

CDP-INFR-07

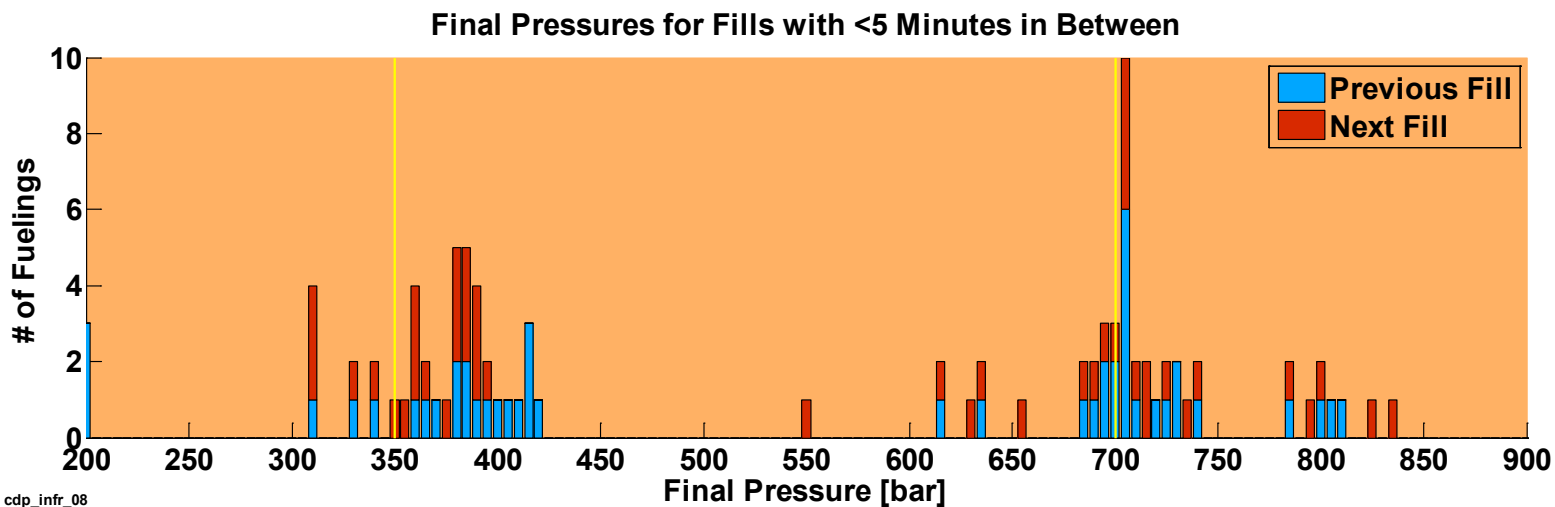
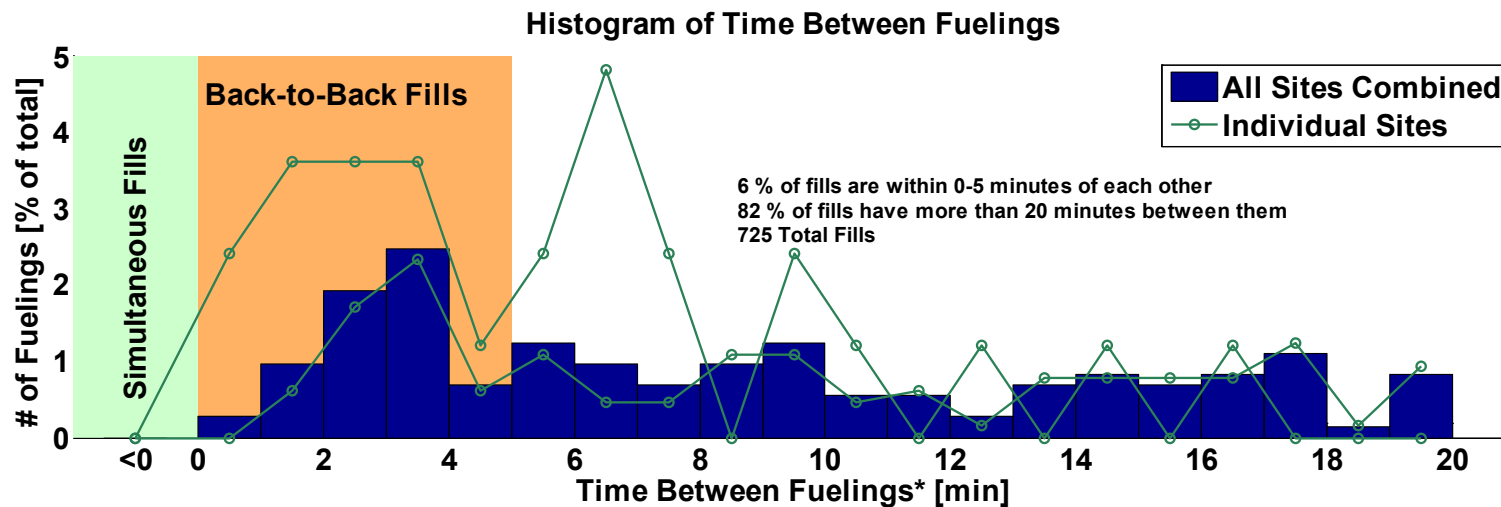
Station Usage



¹Excludes hydrogen fills of < 0.5 kg

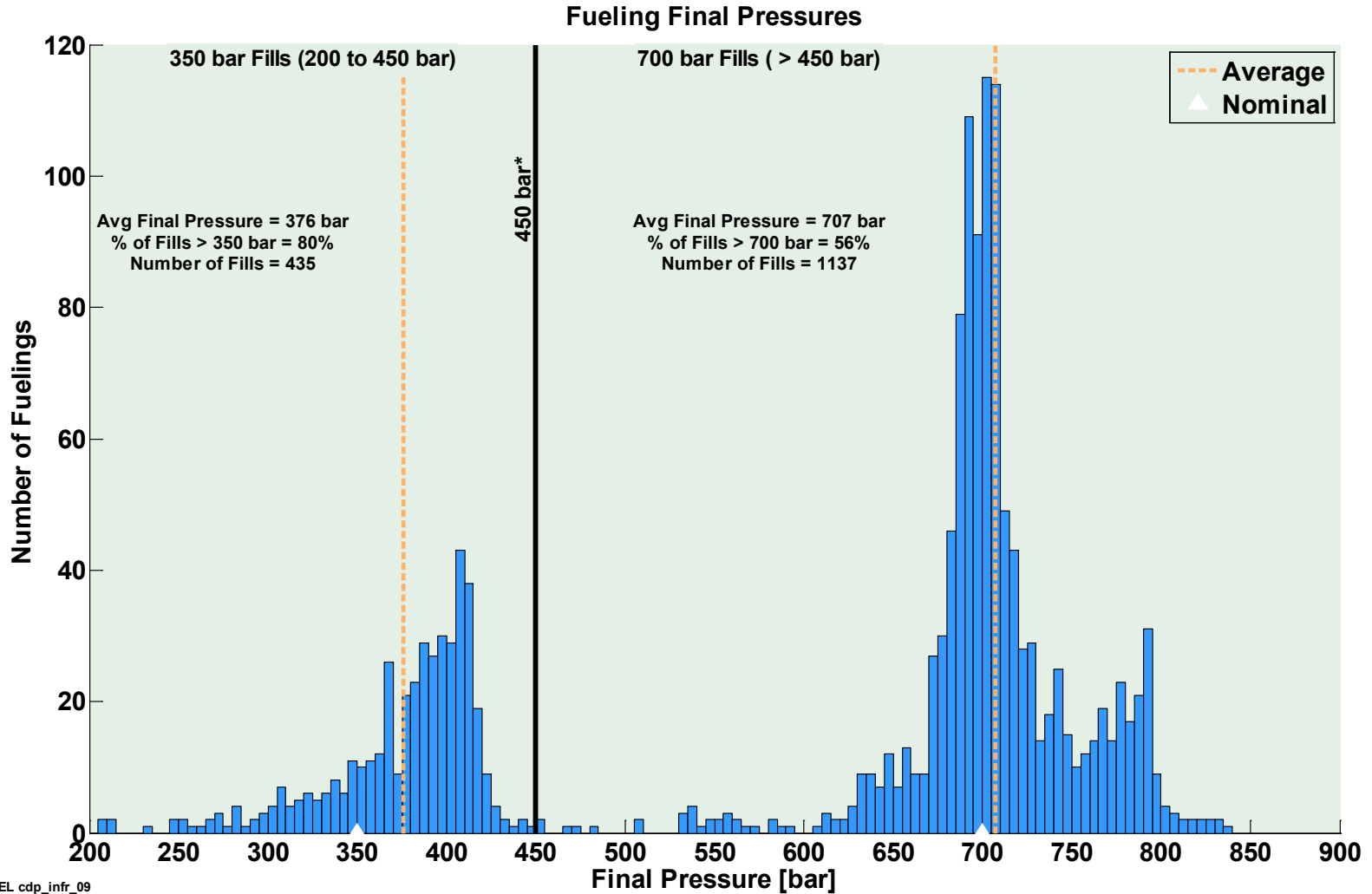
²Average daily fills considers only days when at least one fill occurred

Time Between Fueling



*Time is from end of fill to start of next fill.

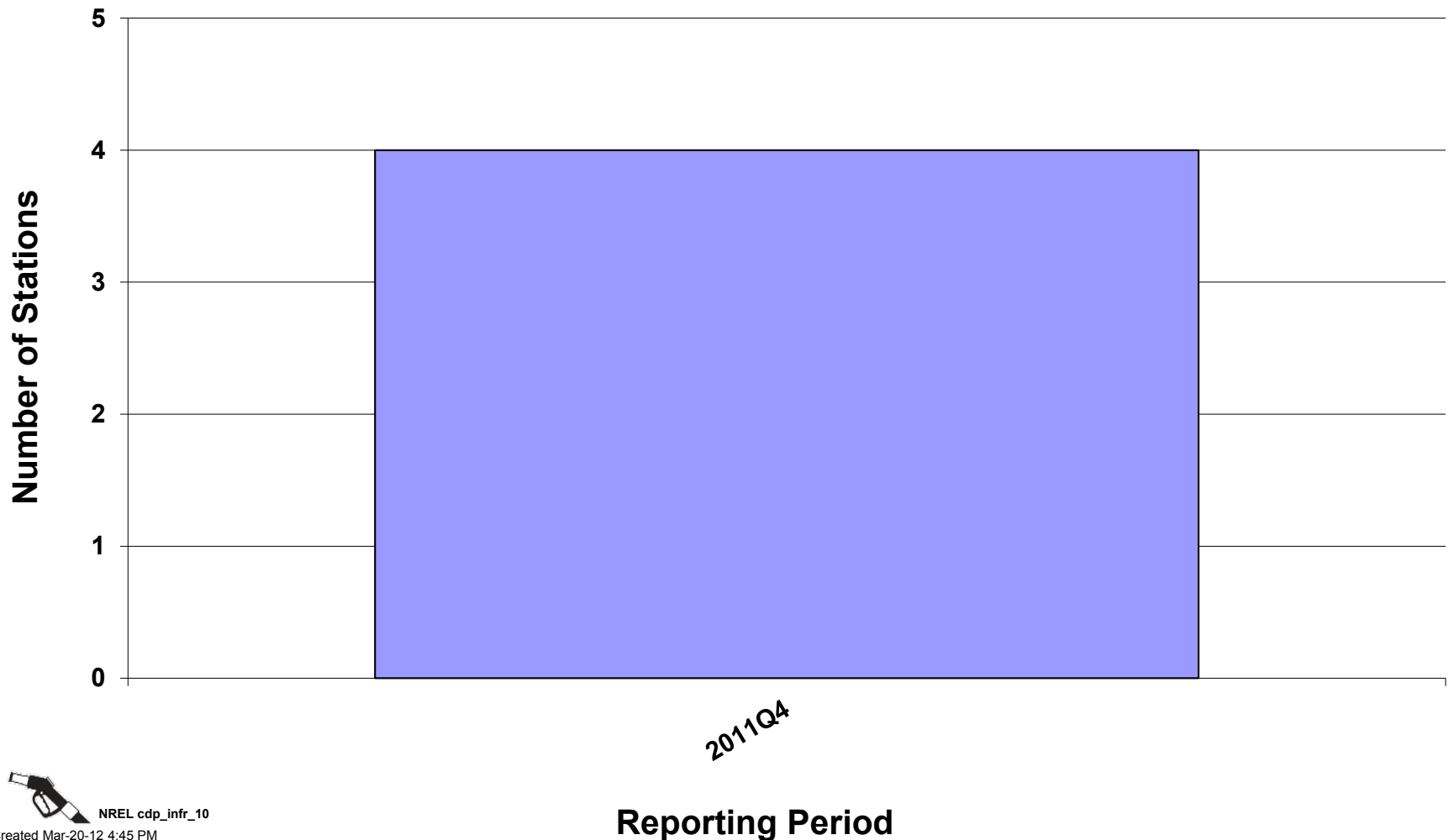
Fueling Final Pressures



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*The line at 450 bar separates 350 bar fills from 700 bar fills. It is slightly over the allowable 125% of nominal pressure (437.5 bar) from SAE J2601.

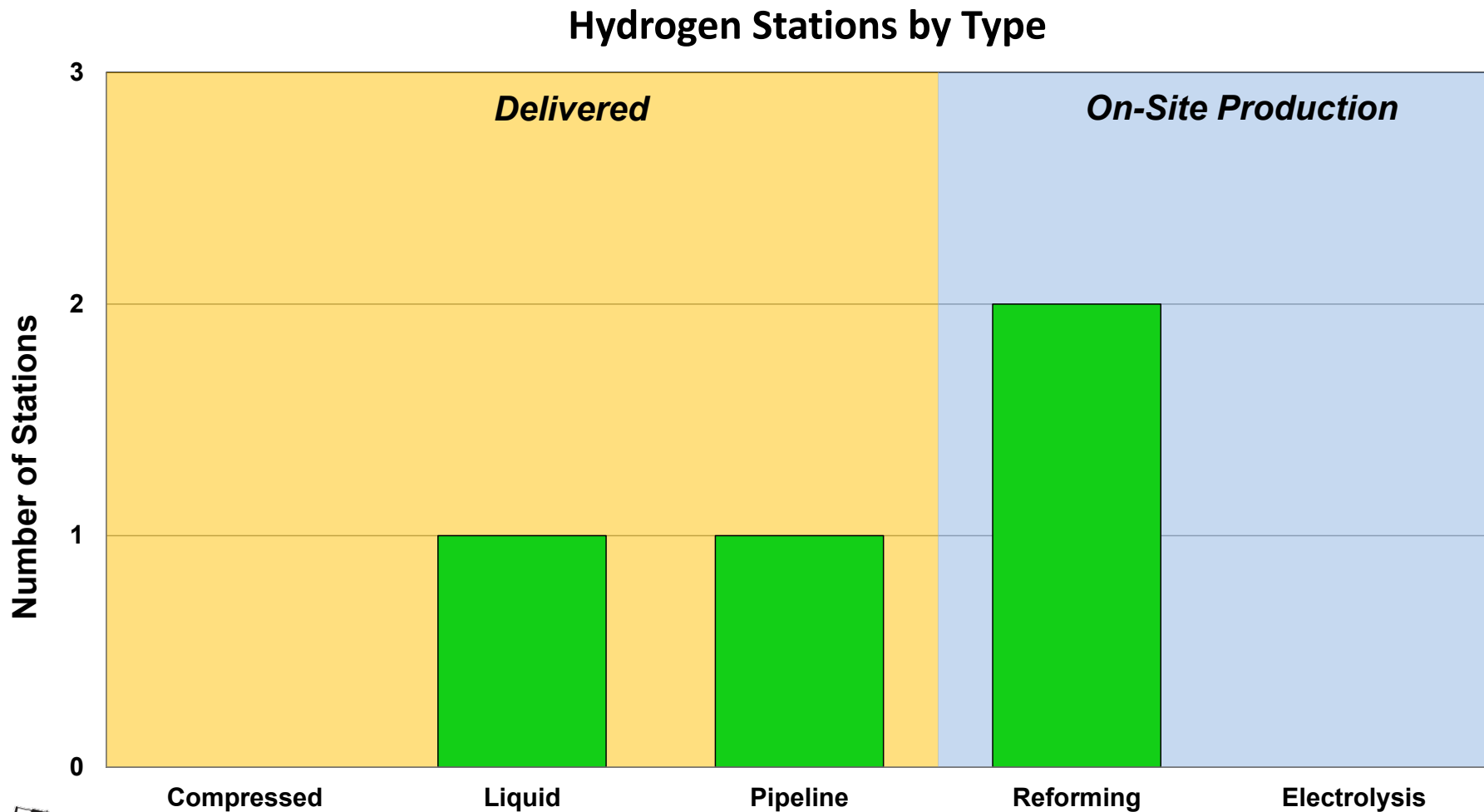
Cumulative Stations



NREL cdp_infr_10

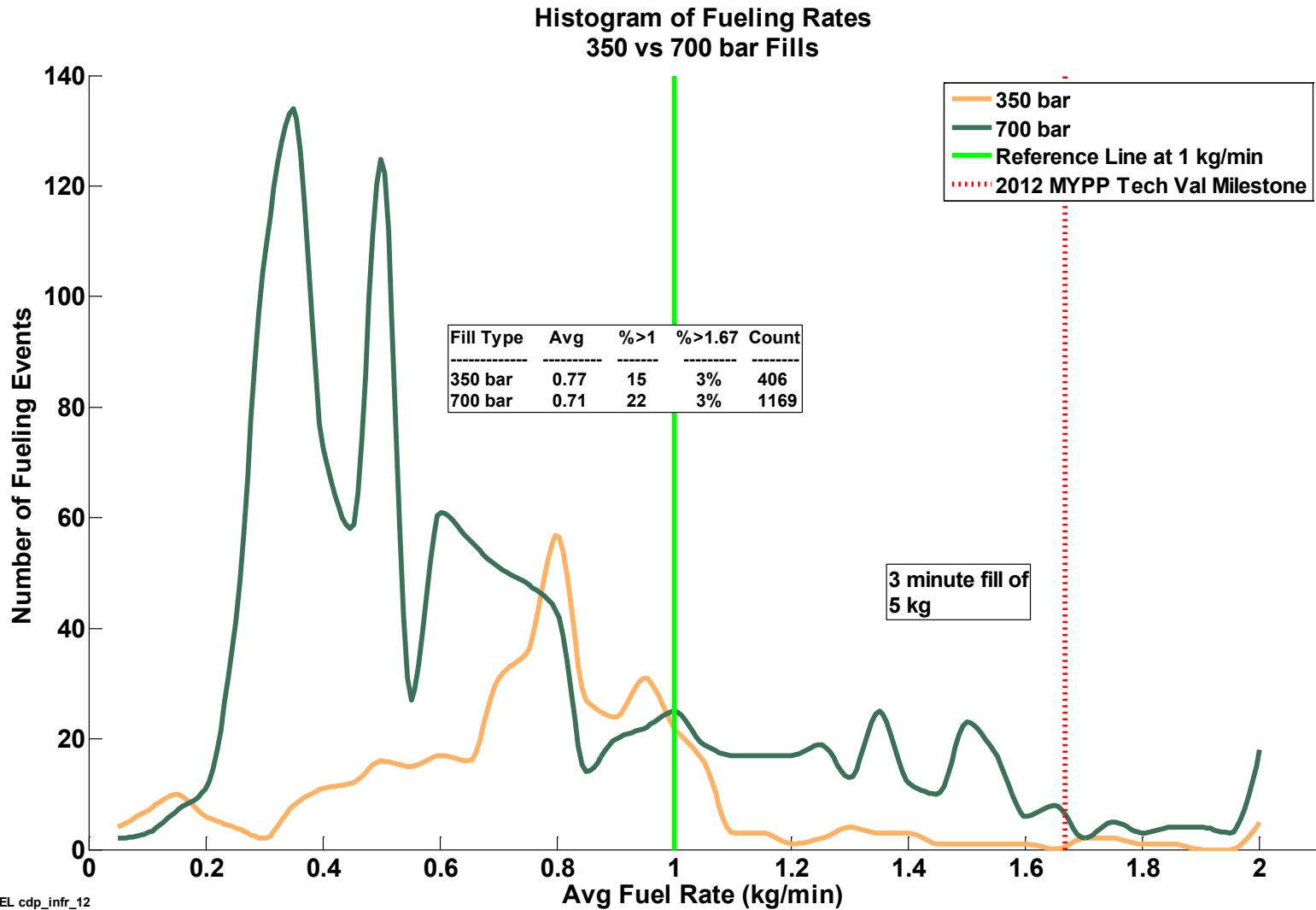
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Hydrogen Stations by Type



CDP-INFR-12

Fueling Rates 350 vs. 700 bar



Accomplishments

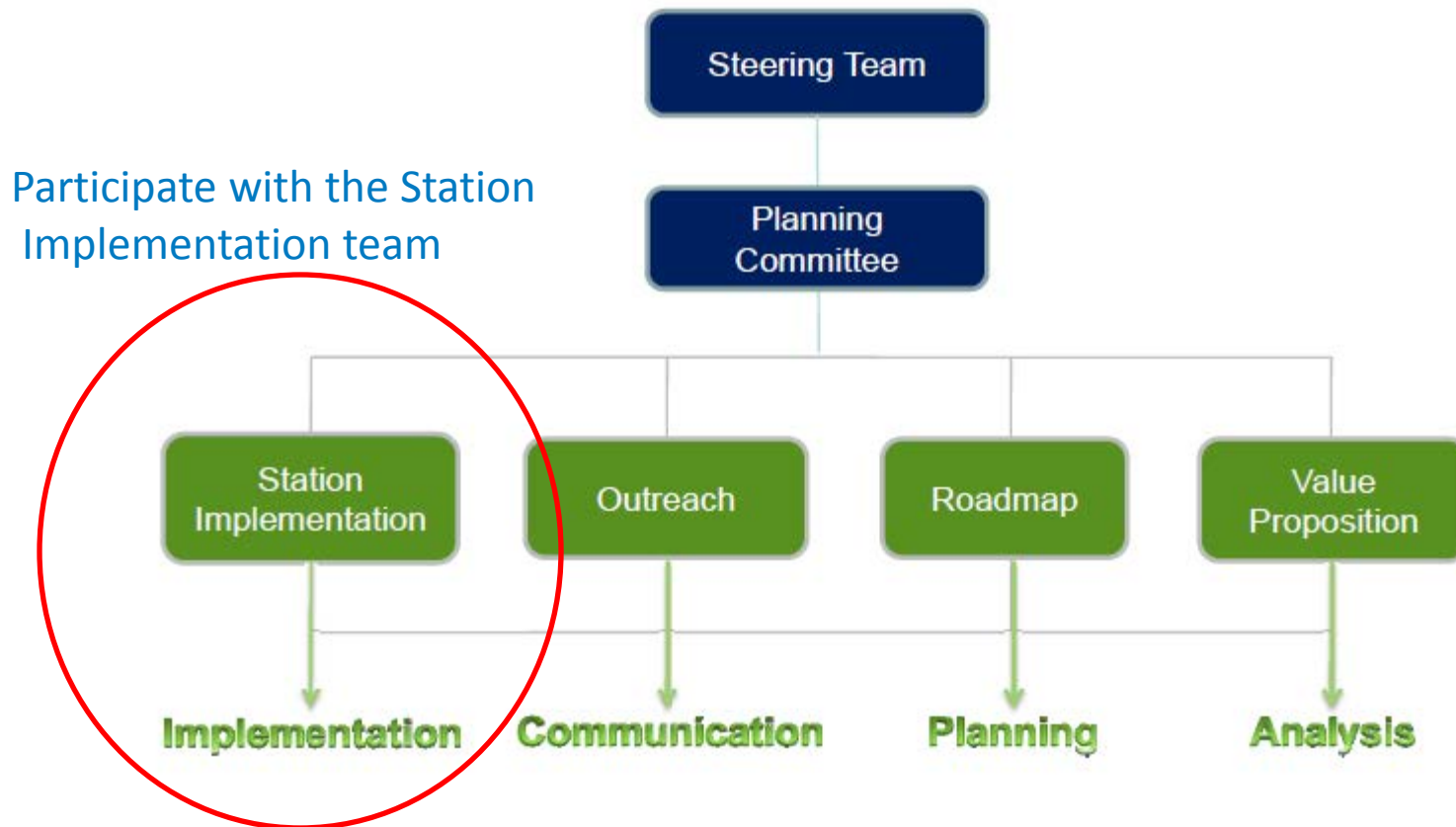
- Analyzed data for four stations providing data through CY2011Q4
- Visited all the current stations and some future ones
- Published first set of Spring 2012 CDPs
- Tracked current stations in database
- Updated/simplified new infrastructure data collection templates

Collaborations

- **Station Operators**
 - Air Products
 - Linde
 - Hydrogen Frontiers
 - Shell
- **Organizations**
 - California Fuel Cell Partnership
 - California Air Resources Board
 - California Energy Commission

Collaborations: CAFCP Station Implementation Team

Project team structure



Objective: Facilitate new station deployment and maintain existing stations in operation.

Proposed Future Work

- Add stations to the analysis as they come online.
- Create new CDPs that describe the current state of pre-commercial stations.
- Provide feedback on infrastructure status to stakeholders, continue collaborations, and seek feedback on important metrics
- Feed shortfalls back to developers, track consumer behavior

Project Summary

- **Relevance:** Hydrogen stations need to be able to meet vehicle needs.
- **Approach:** Analyze station operational data building upon tools and capabilities from Learning Demo.
- **Accomplishments and Progress:** Database of stations, analysis of current station data, infrastructure data templates.
- **Collaborations:** Currently working with station operators and California organizations.
- **Future Work:** As new stations open and provide data, add them to the analysis to get a good picture of the current state of hydrogen infrastructure.