NREL
NATIONAL RENEWABLE ENERGY LABORATORY





Next Generation Hydrogen Station Composite Data Products: Retail Stations

Summer 2022: Data through Quarter 2 of 2022

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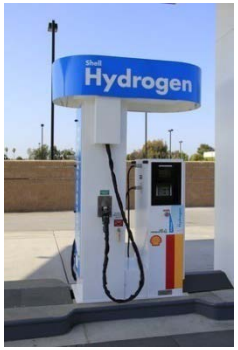
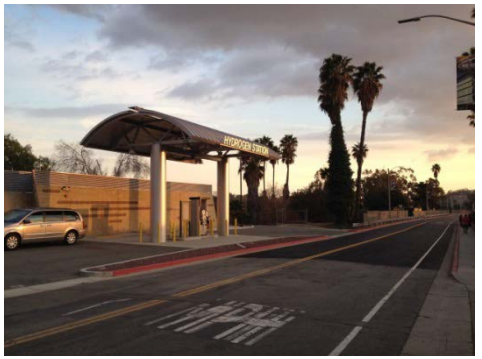
NREL/PR-5400-86247

Hydrogen Station Project Partners

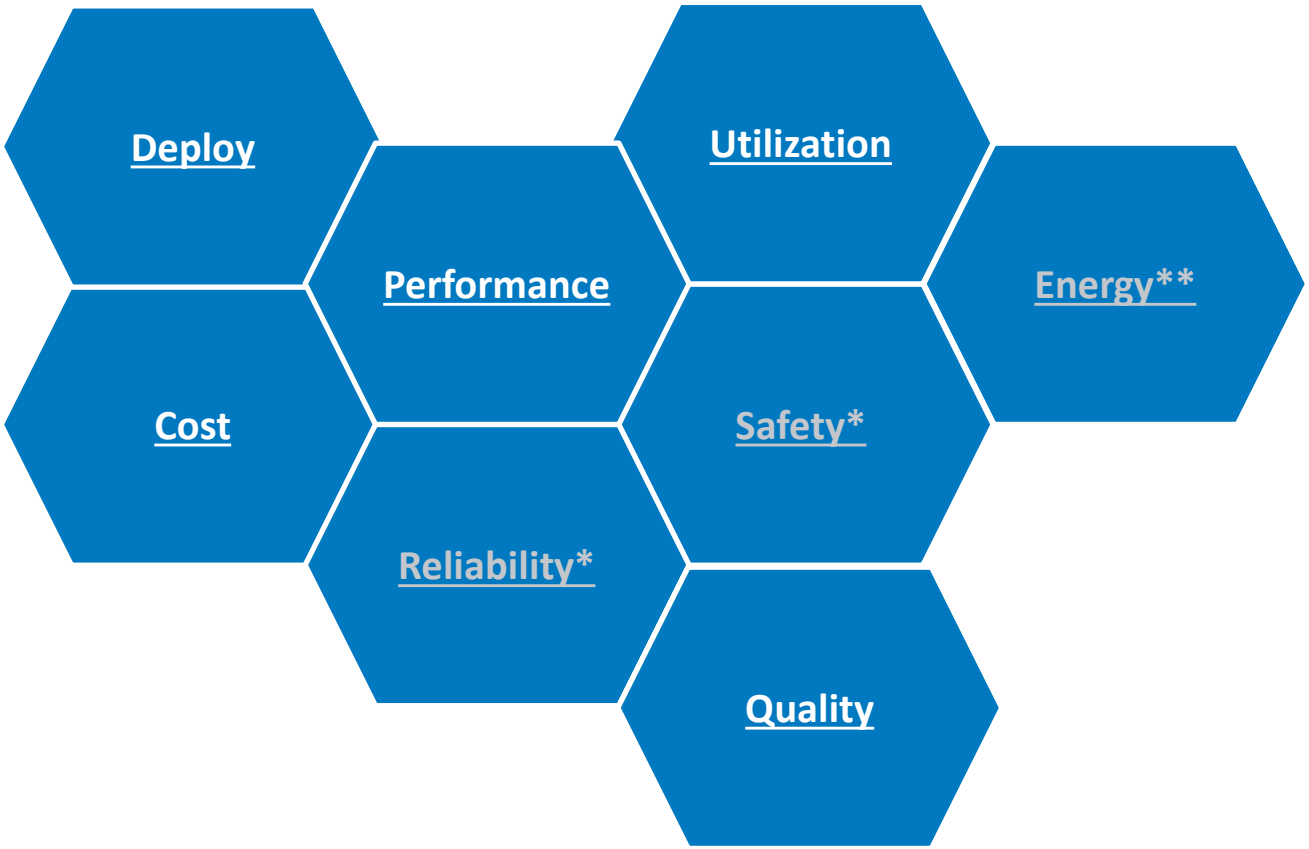
INFRASTRUCTURE

- Air Liquide
- Air Products
- California Air Resources Board
- California CDFA – Division of Measurement Standards
- California Energy Commission
- California Fuel Cell Partnership
- California State University Los Angeles
- Equilon
- FirstElement Fuel
- Gas Technology Institute
- IPHE and HySUT
- ITM Power
- Iwatani
- Linde
- H2 Frontier
- Messer
- Proton OnSite
- SCAQMD
- Shell
- University of Maryland Center for Risk and Reliability





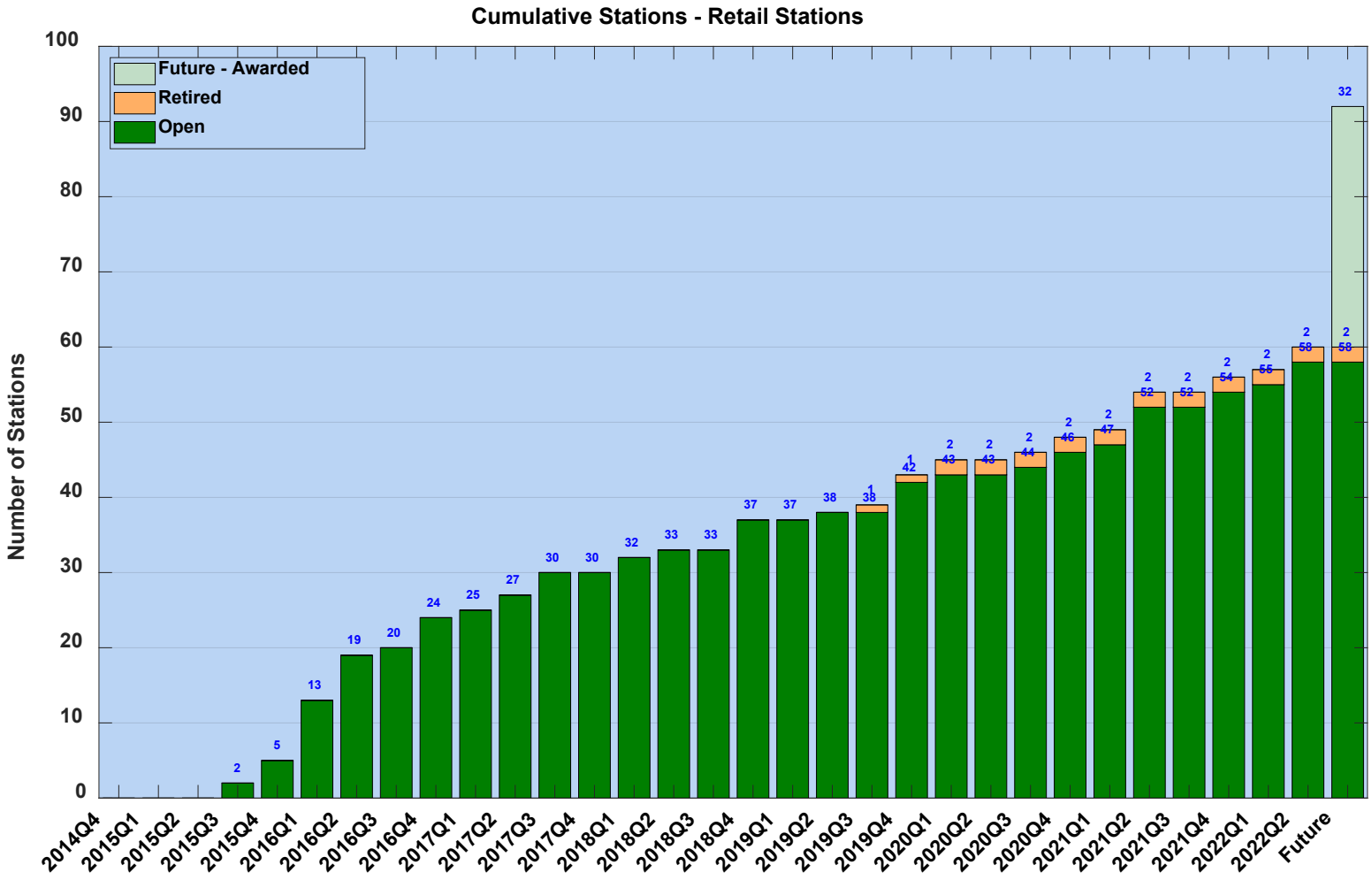
Analysis Categories



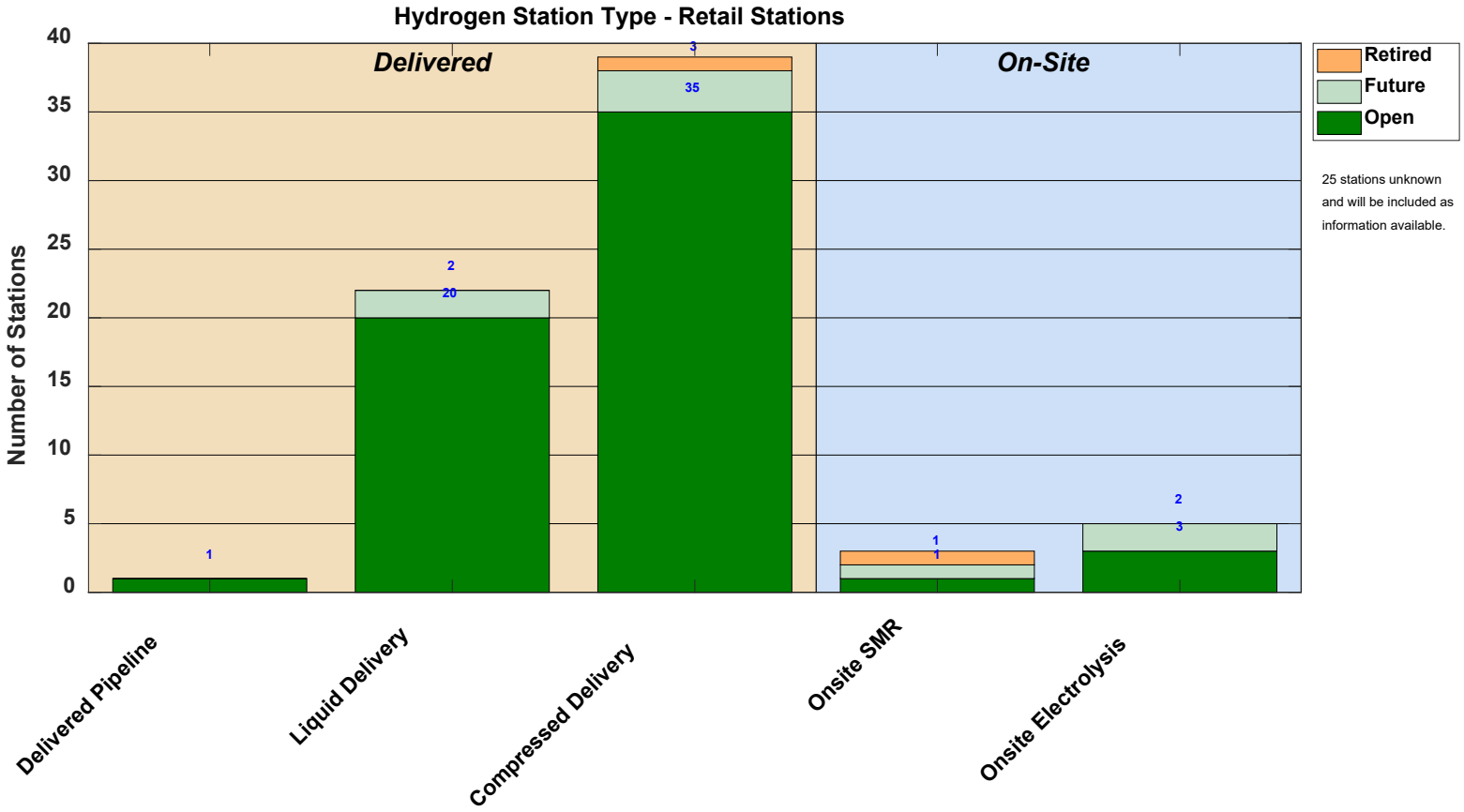
* To be published separately Summer 2023
** Not currently updated

Deployment

CDP-INFR-10
Cumulative Number of Stations

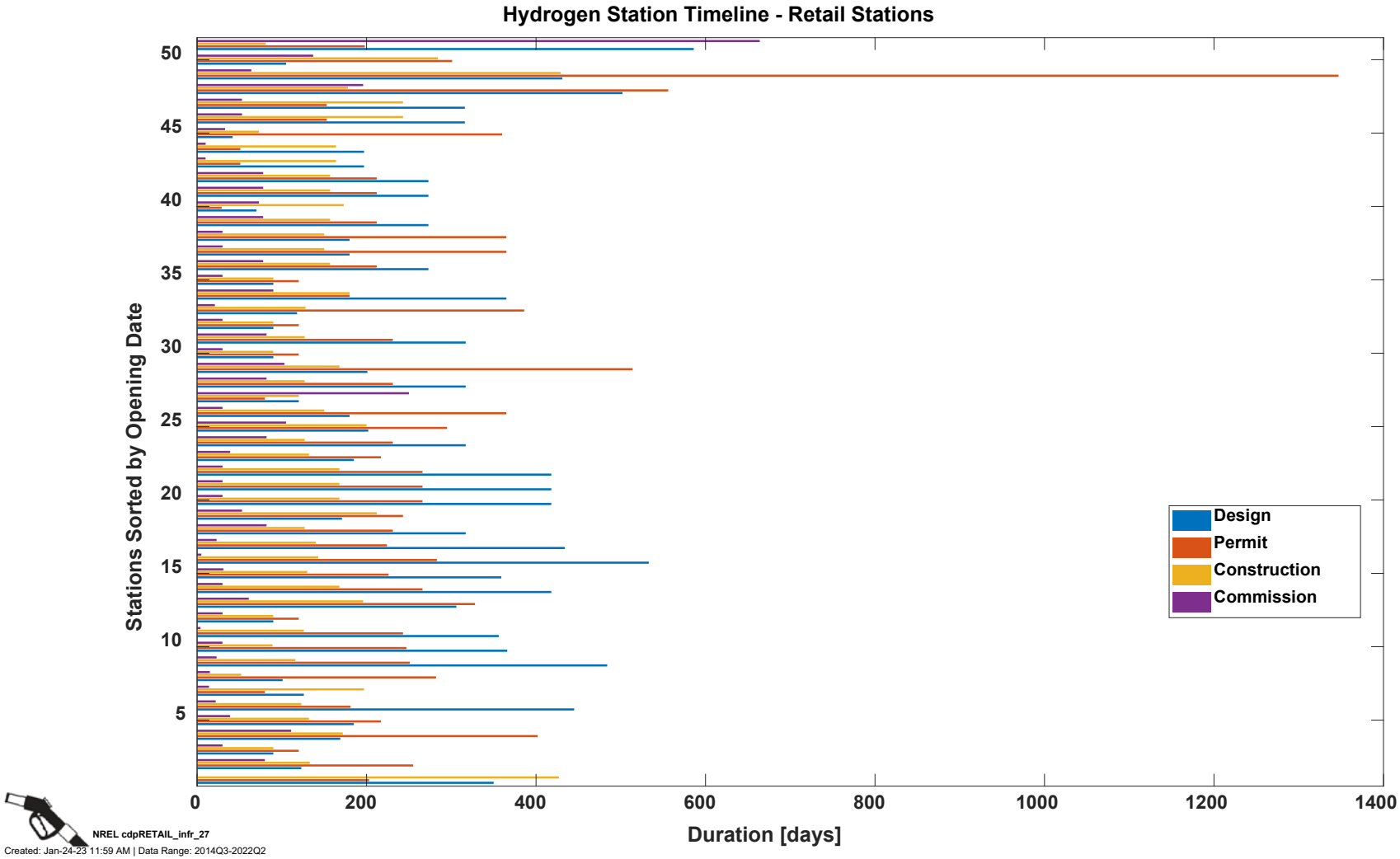


CDP-INFR-11
Hydrogen Stations by Type

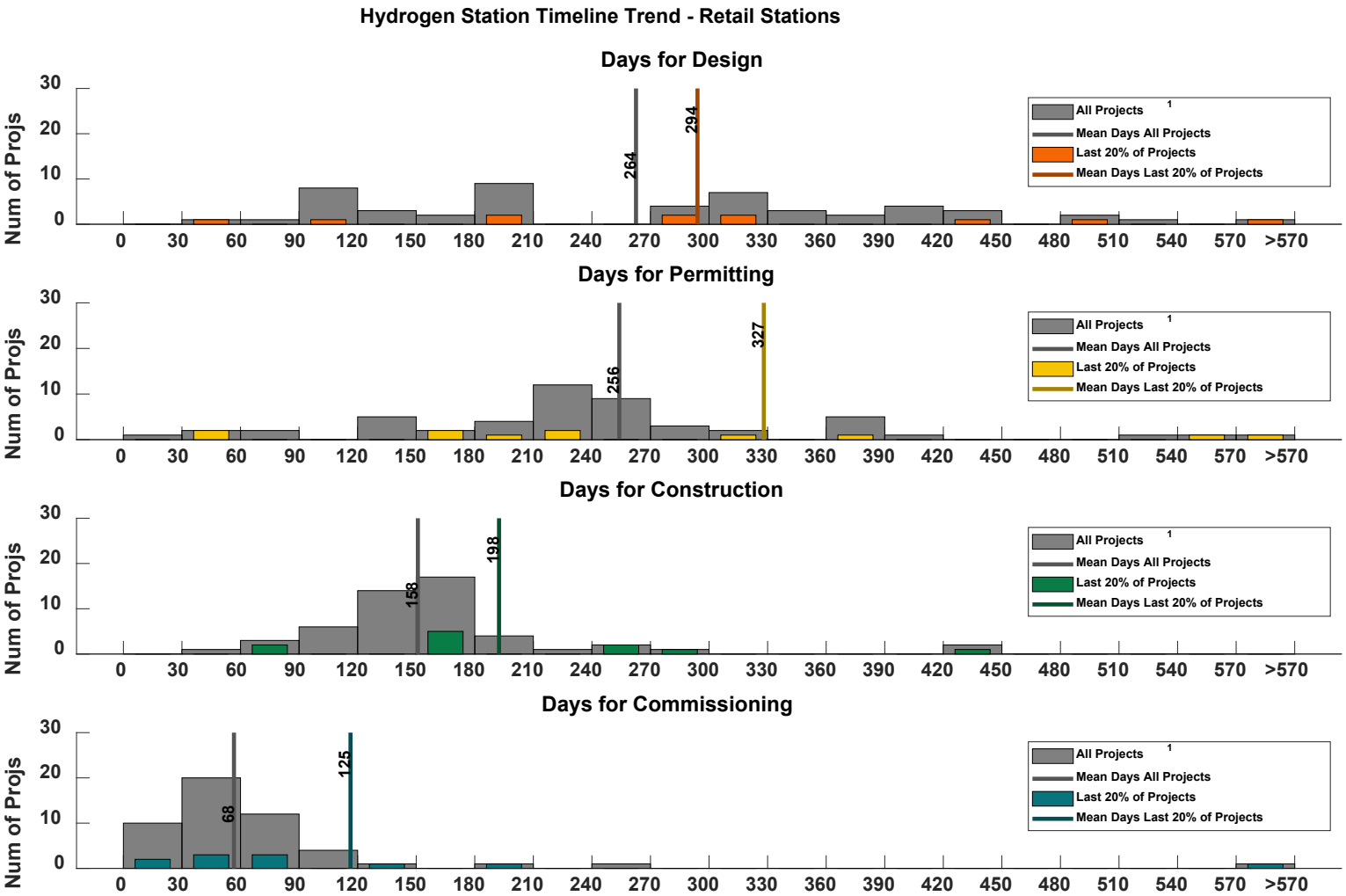


NREL cdpRETAIL_infr_11
Created: Mar-16-23 9:34 AM | Data Range: 2014Q3-2022Q2

CDP-INFR-27
Hydrogen Station Timeline



CDP-INFR-99
Hydrogen Station Timeline Trend - Retail Stations



NREL cdpRETAIL_infr_99
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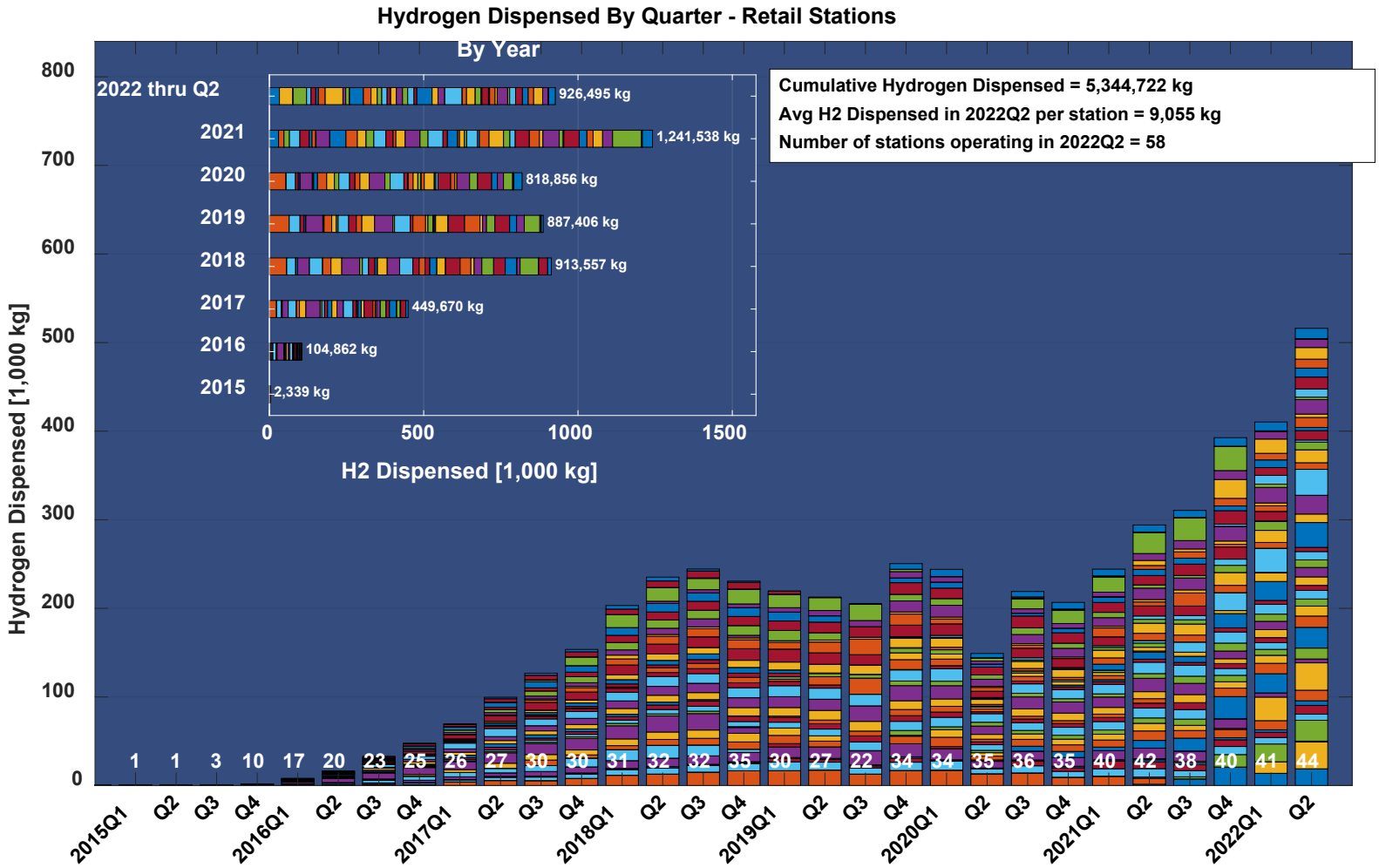
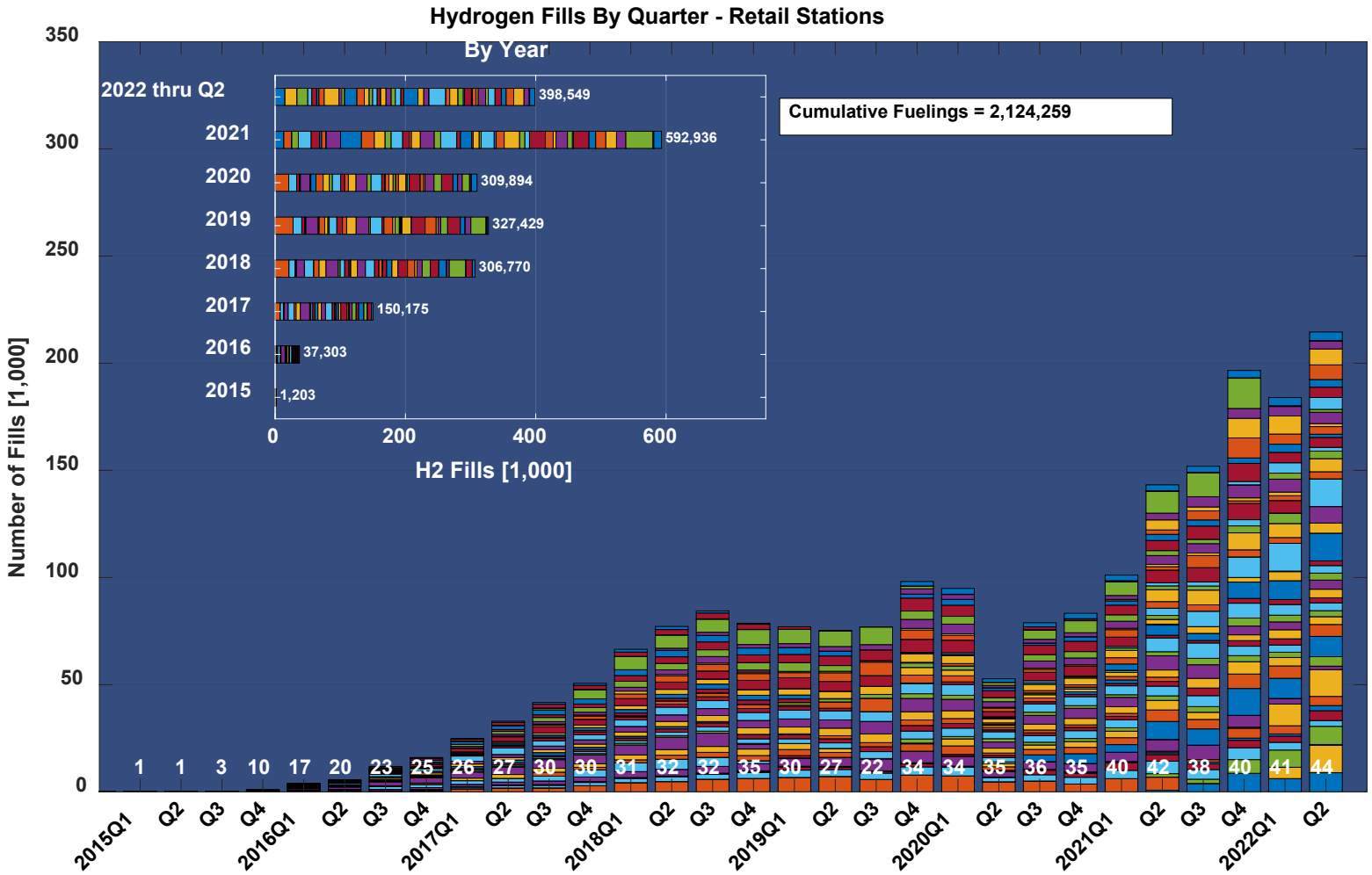
[1] 51 projects with timelines included

Performance

CDP-INFR-01
Hydrogen Dispensed by Quarter

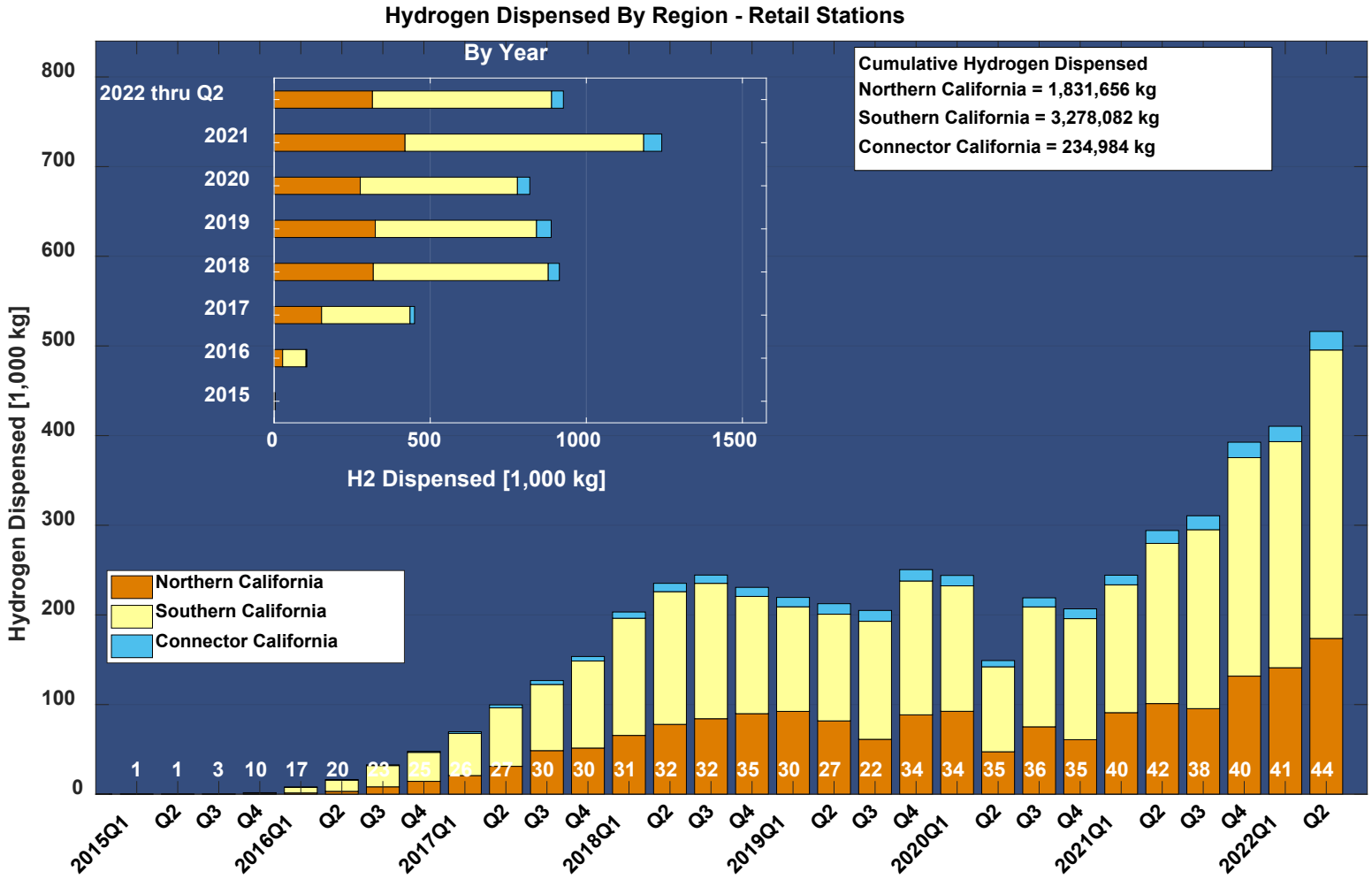


CDP-INFR-58
Hydrogen Fills by Quarter



Note: Colors represent individual stations. Stations reporting data count is number at bottom of bar.

CDP-INFR-81
H2 Dispensed by Region



NREL cdpRETAIL_infr_81
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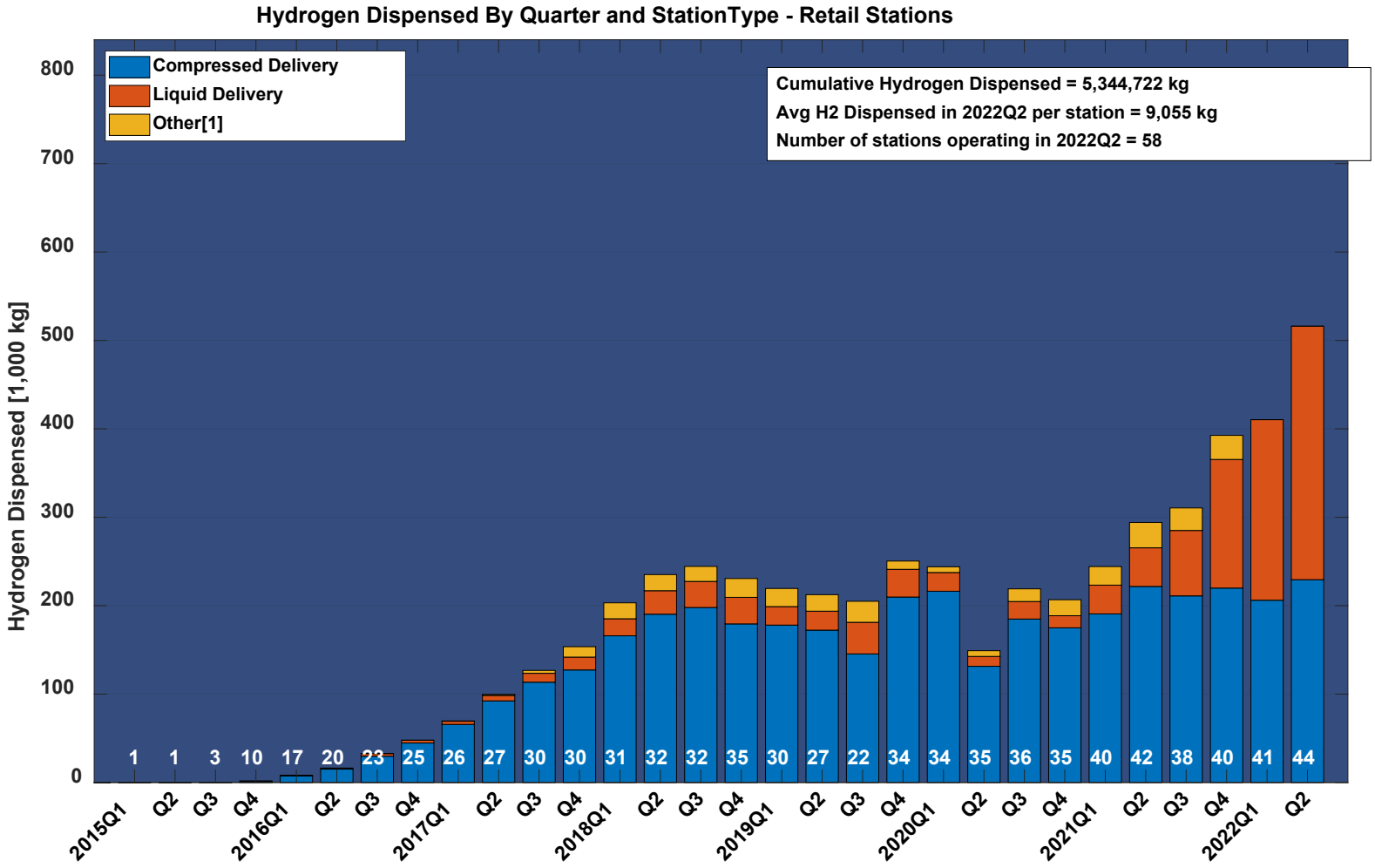
Note: Station count is number at bottom of bar.

CDP-INFR-97
Hydrogen Dispensed By Quarter and Station Type- Retail Stations

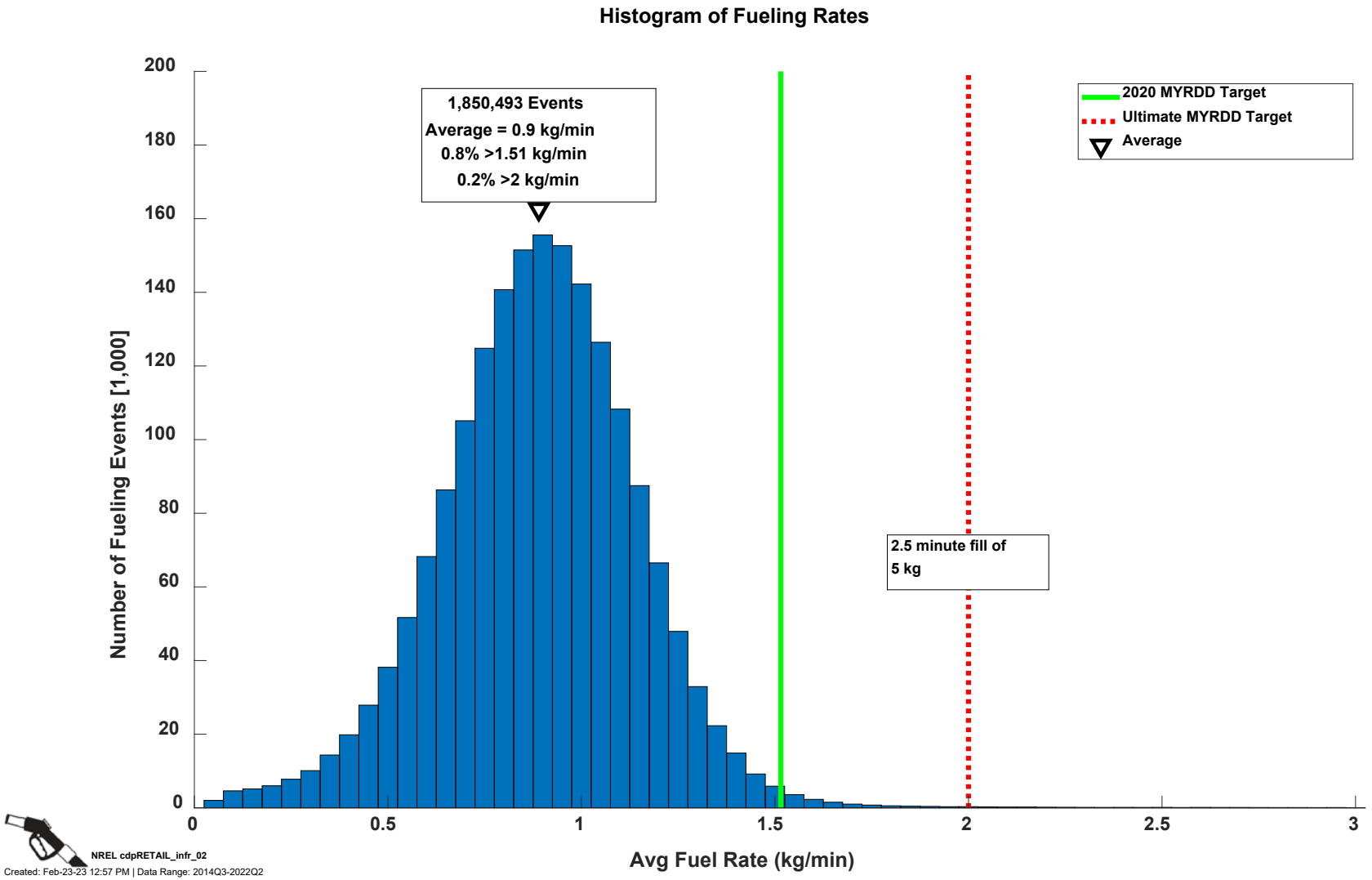


NREL cdpRETAIL_infr_97
Created: Feb-16-23 10:35 AM | Data Range: 2014Q3-2022Q2

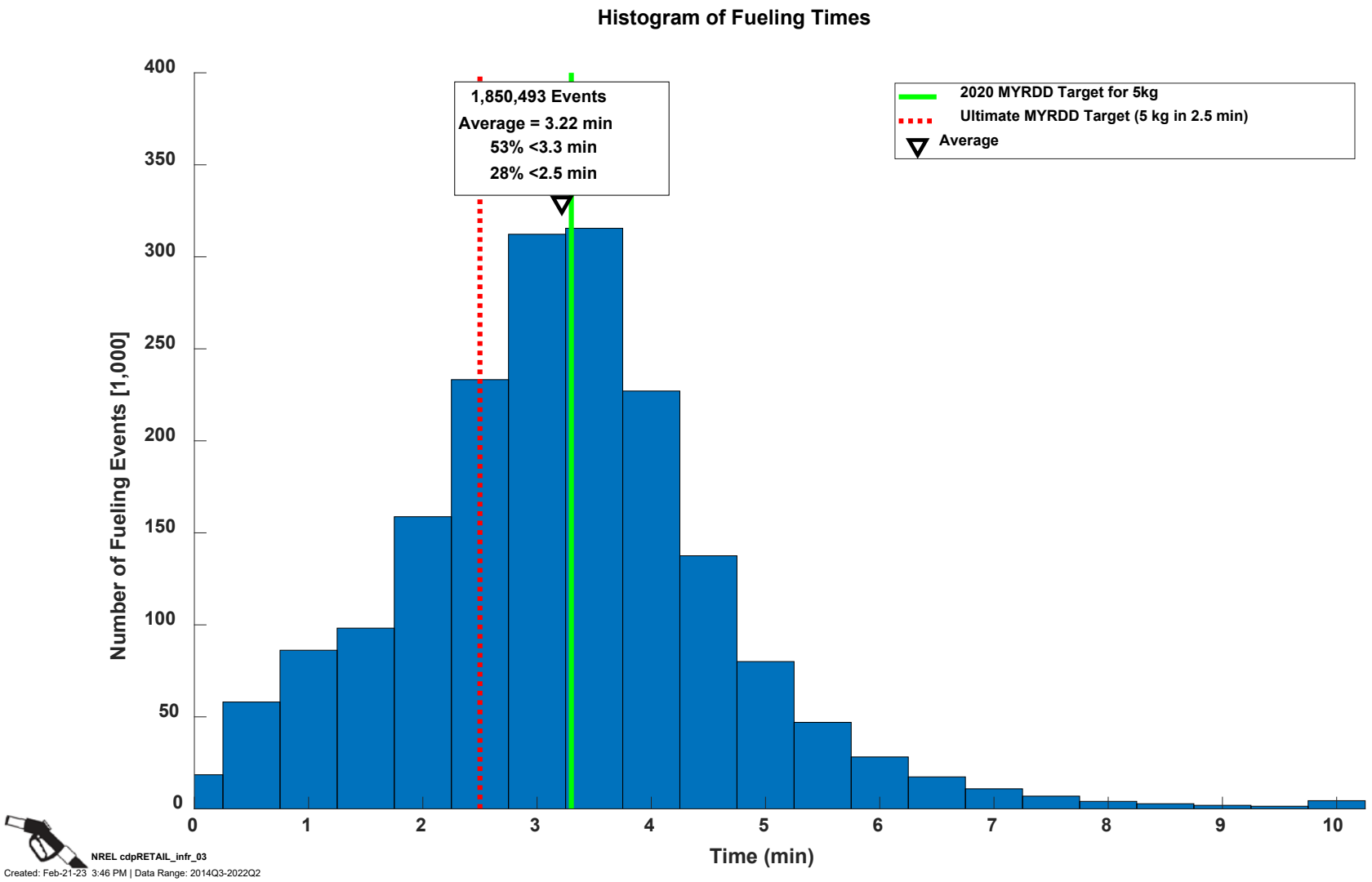
Note: Stations reporting data count is number at bottom of bar.

[1] Other includes pipeline and stations with multiple hydrogen sources.

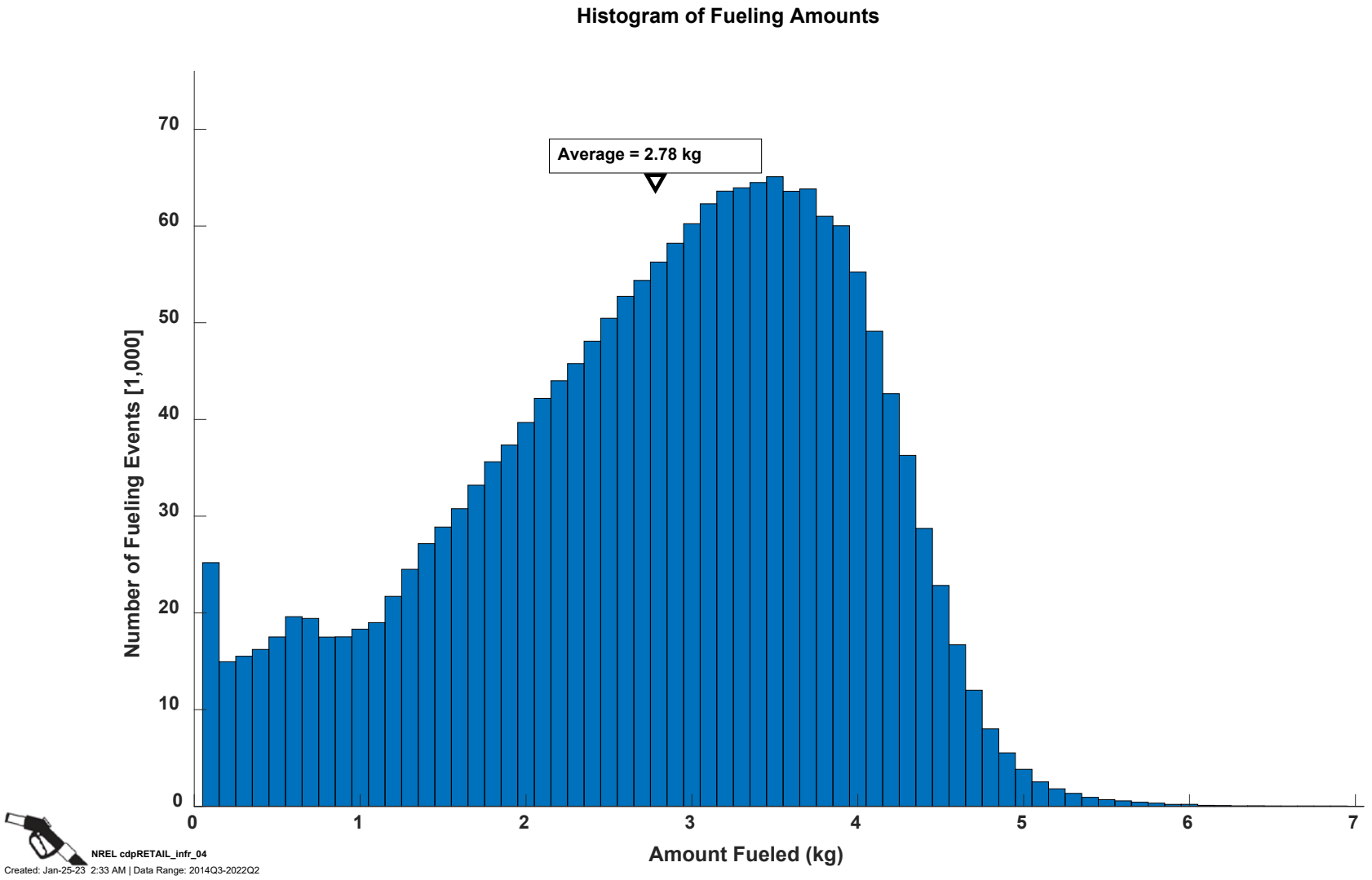
CDP-INFR-02
Histogram of Fueling Rates



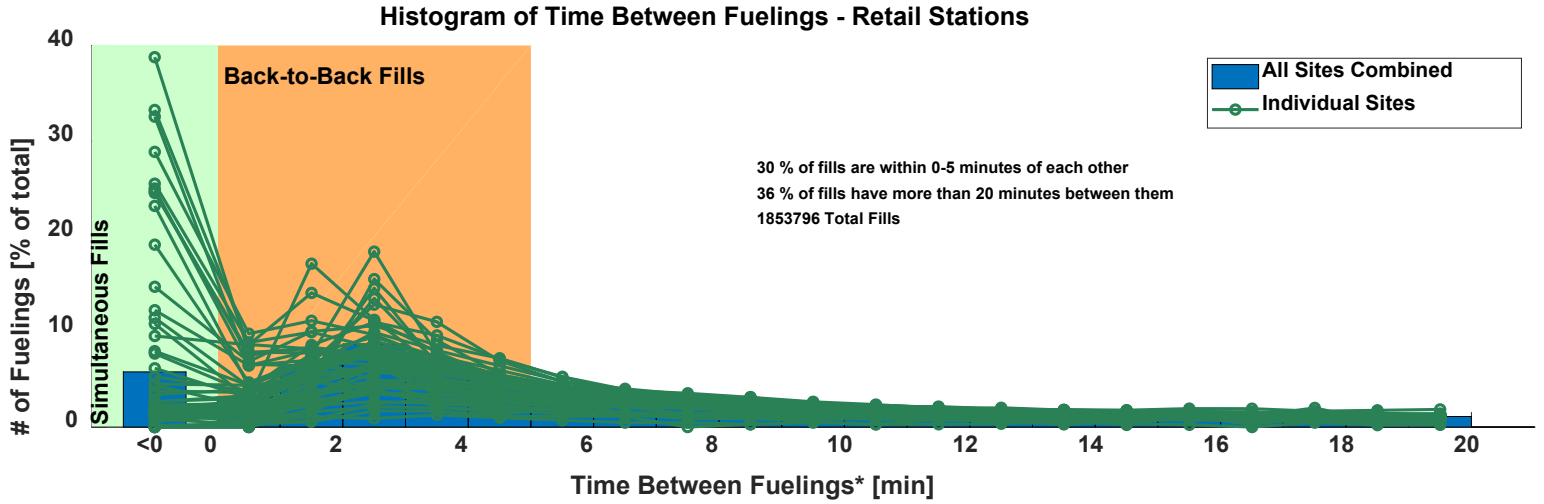
CDP-INFR-03
Histogram of Fueling Times

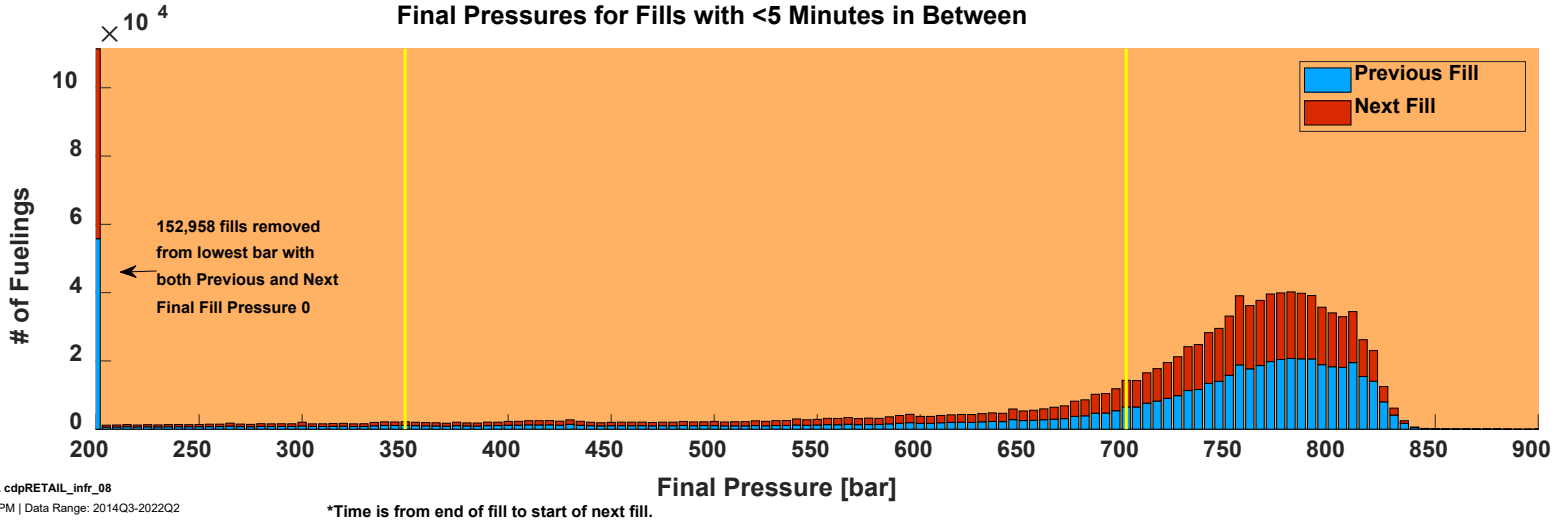


CDP-INFR-04
Histogram of Fueling Amounts



CDP-INFR-08
Time Between Fueling

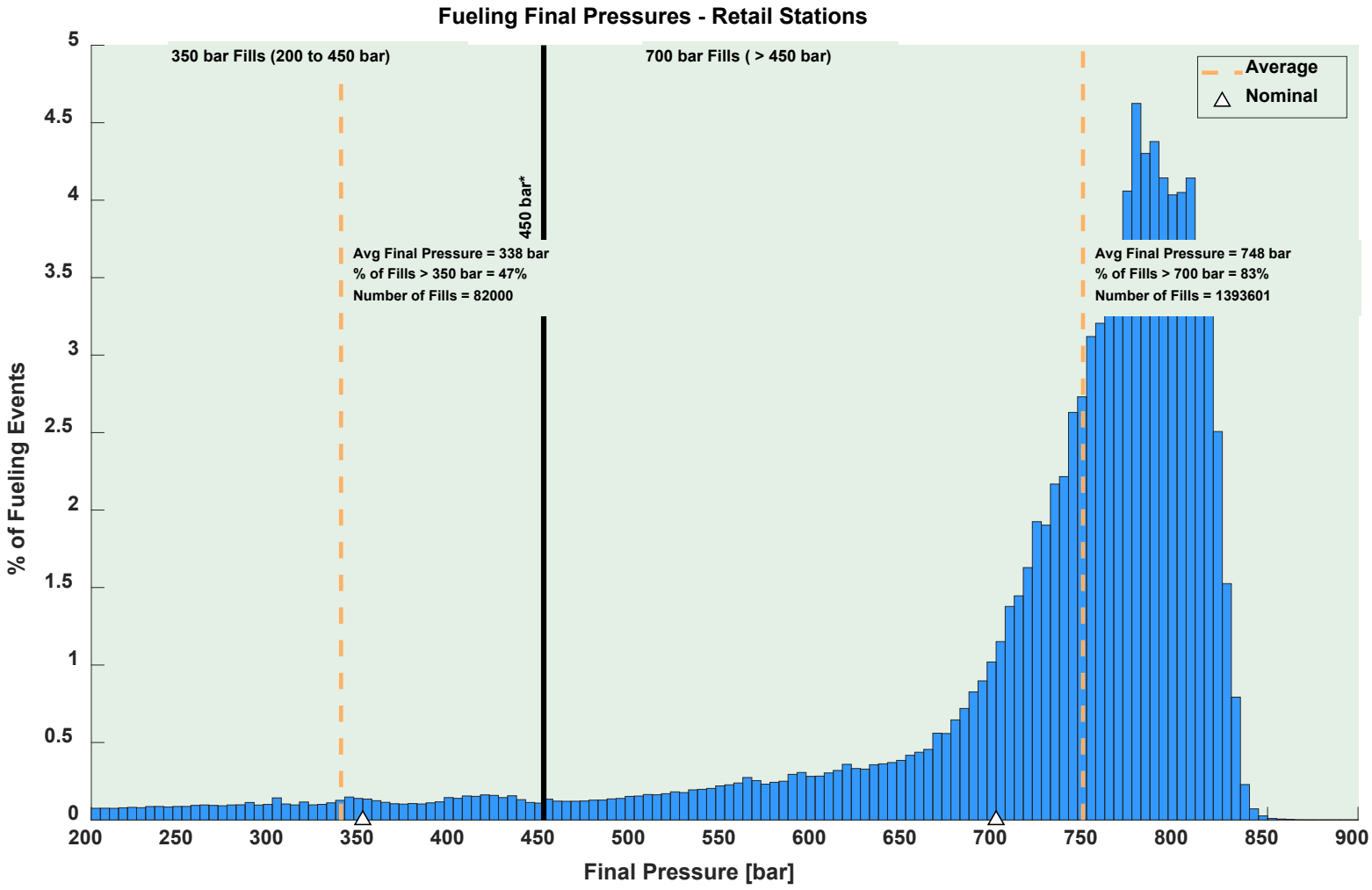




NREL cdpRETAIL_infr_08
Created: Jan-24-23 10:28 PM | Data Range: 2014Q3-2022Q2

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

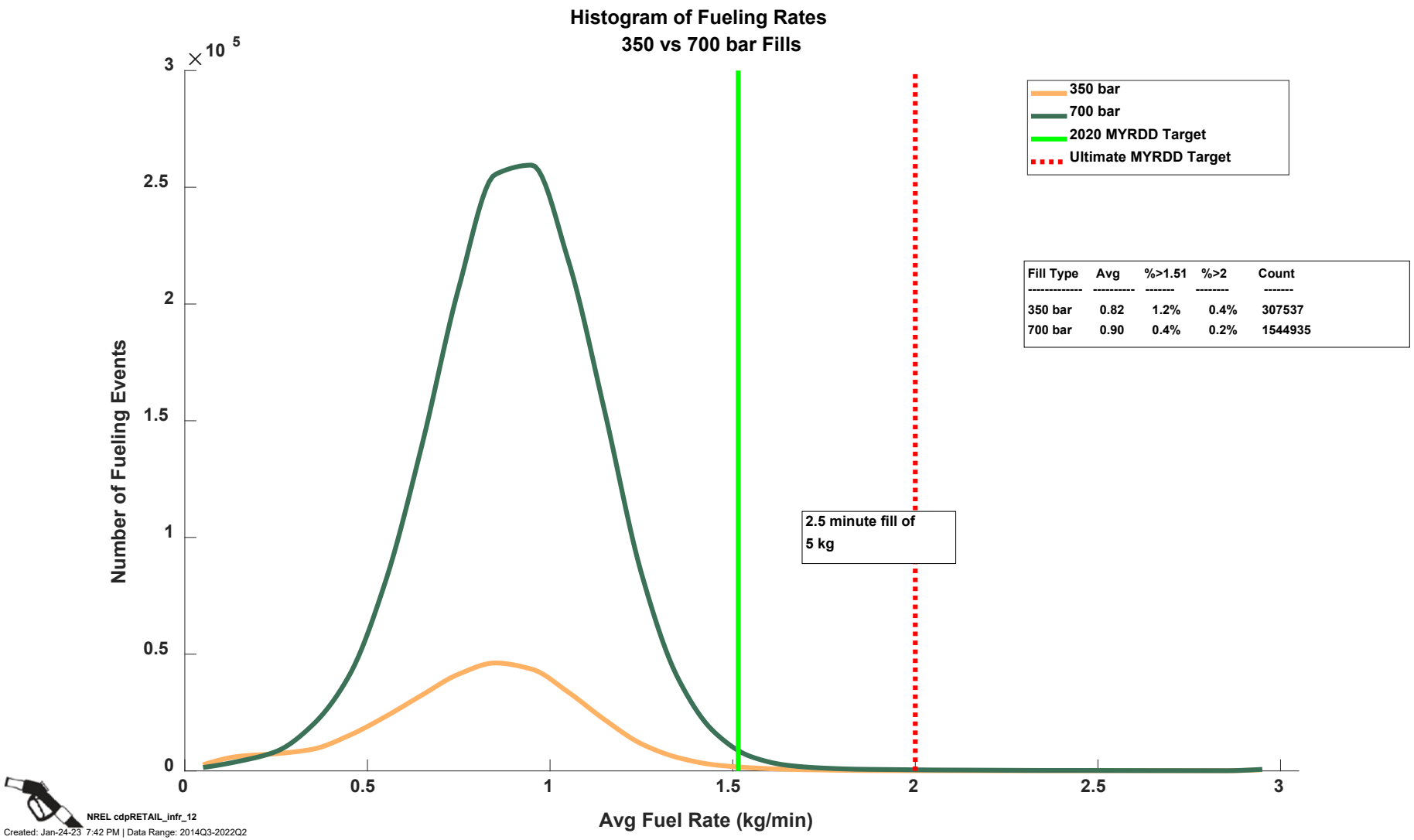
CDP-INFR-09
Fueling Final Pressures



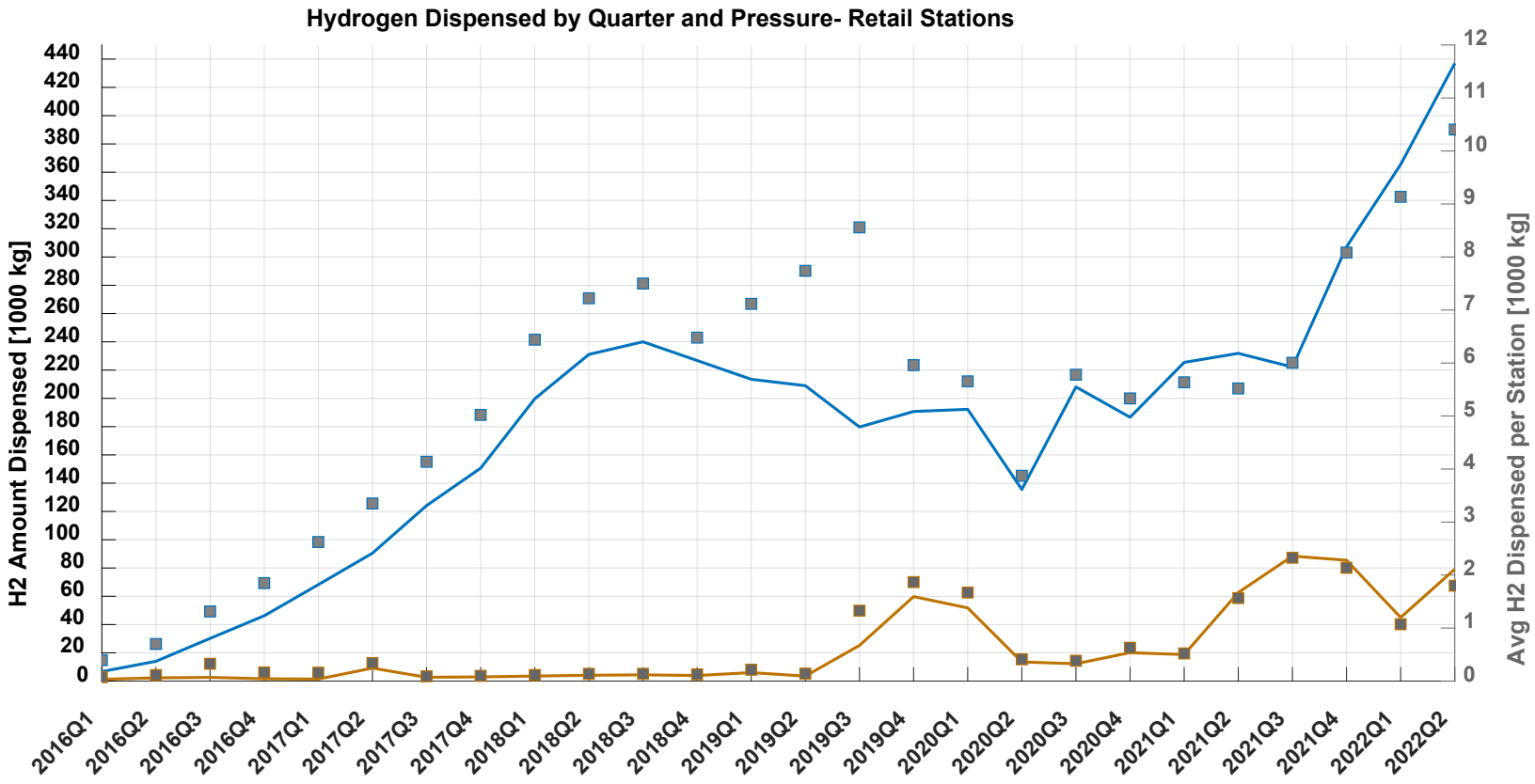
NREL cdpRETAIL_infr_09
Created: Jan-24-23 9:12 PM | Data Range: 2014Q3-2022Q2

*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.

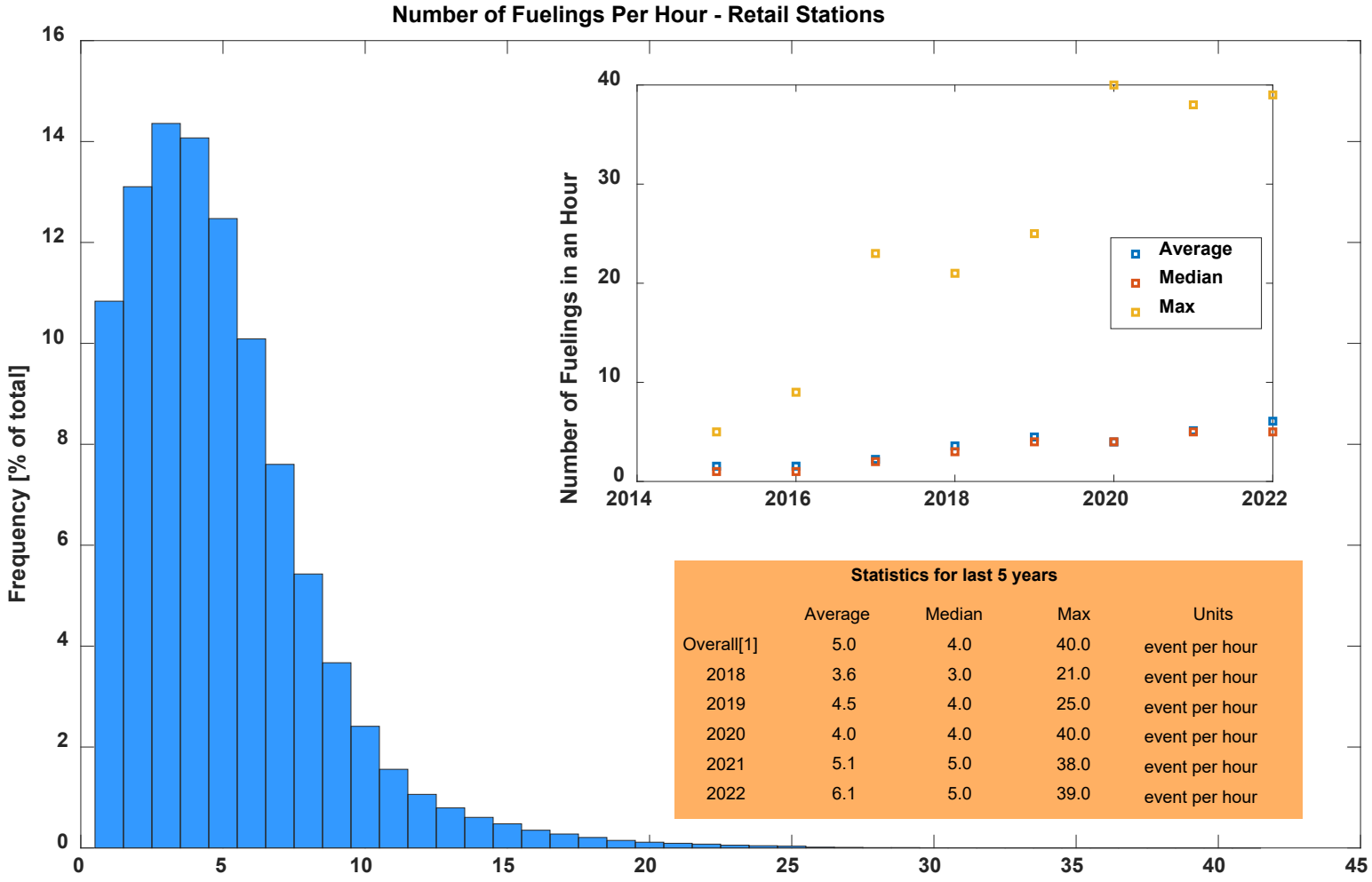
CDP-INFR-12
Fueling Rates 350 bar vs. 700 bar



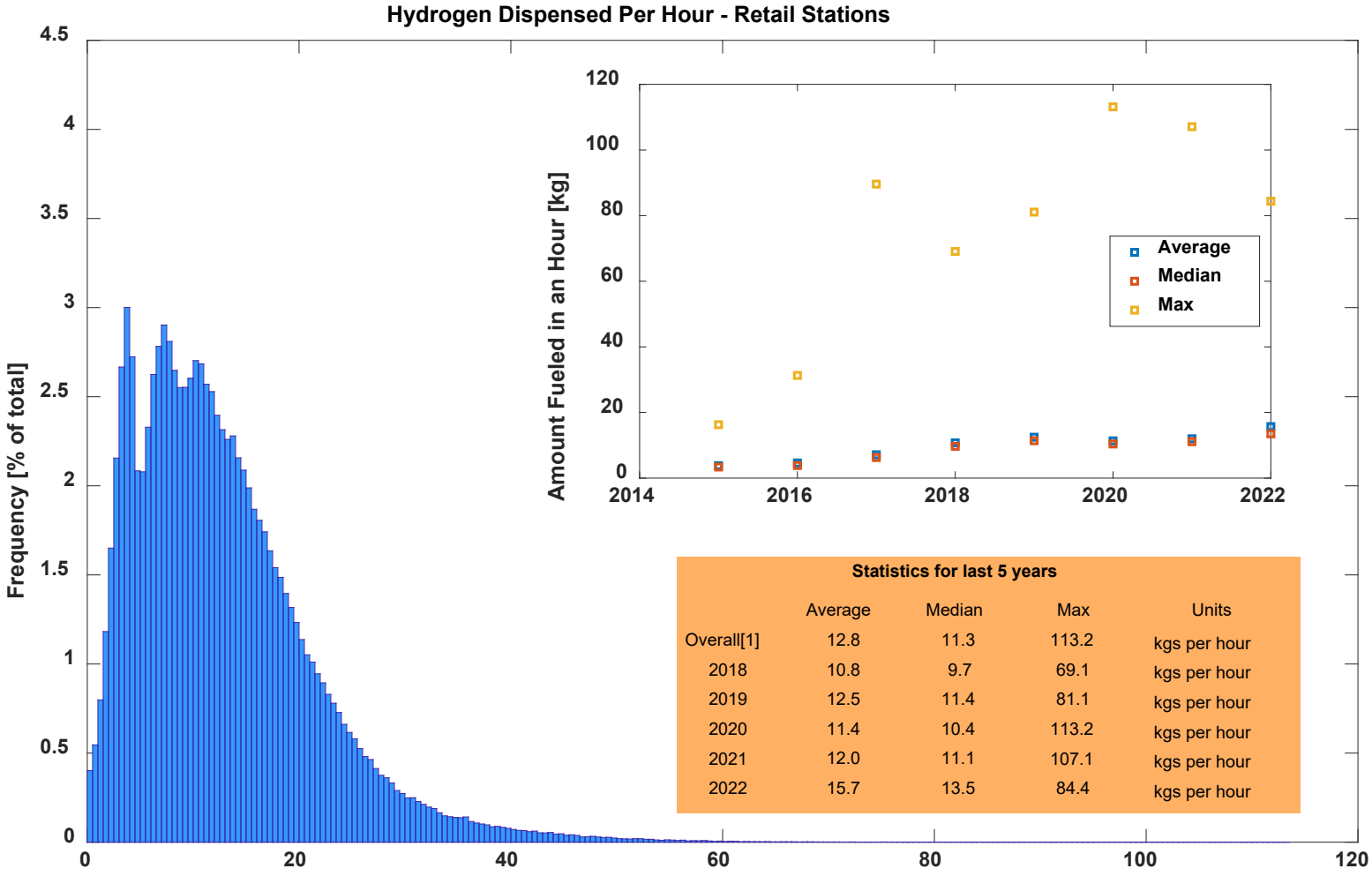
CDP-INFR-90
Hydrogen Dispensed by Quarter and Pressure



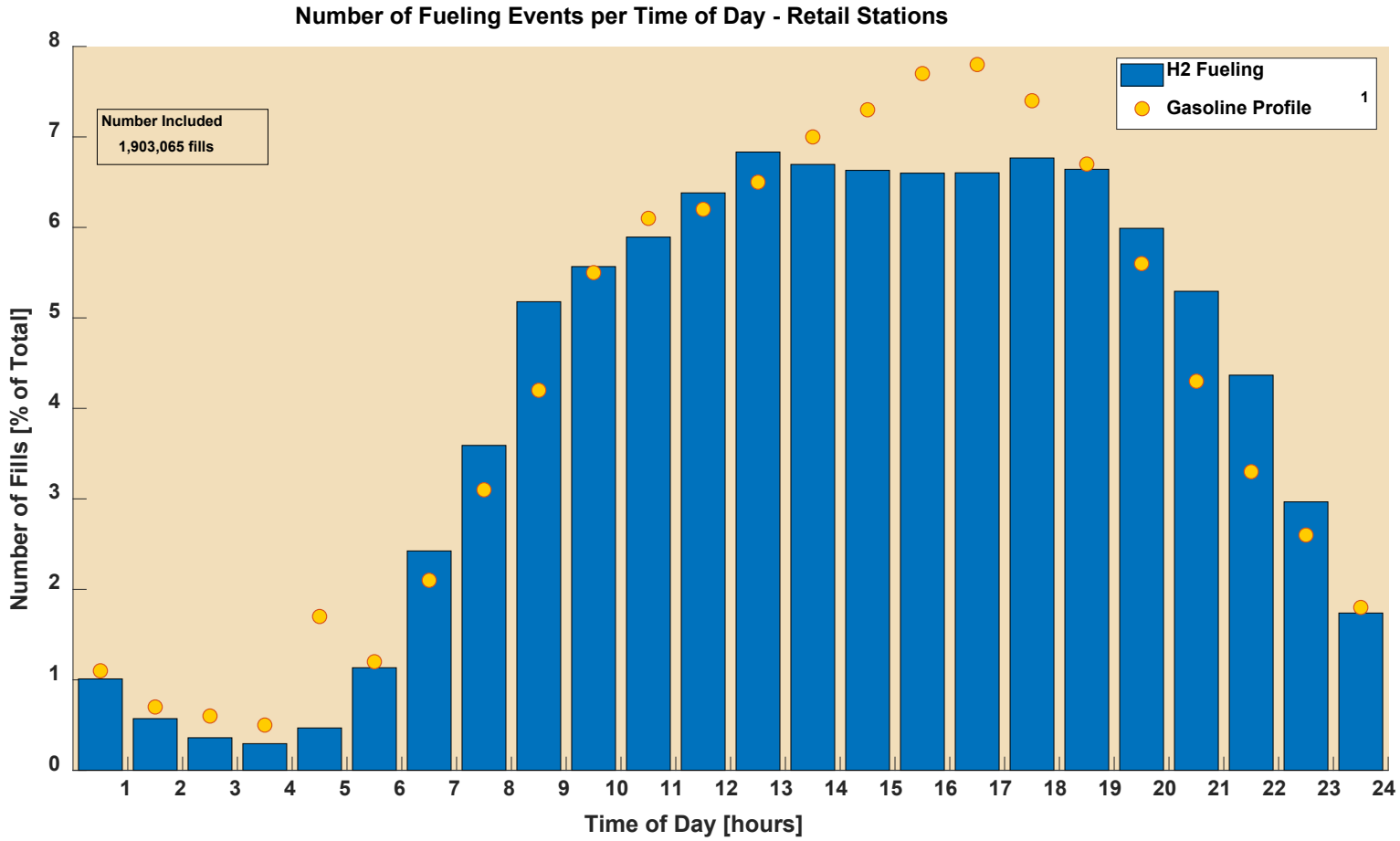
CDP-INFR-13
Number of Fueling Events per Hour



CDP-INFR-14
Hydrogen Dispensed per Hour



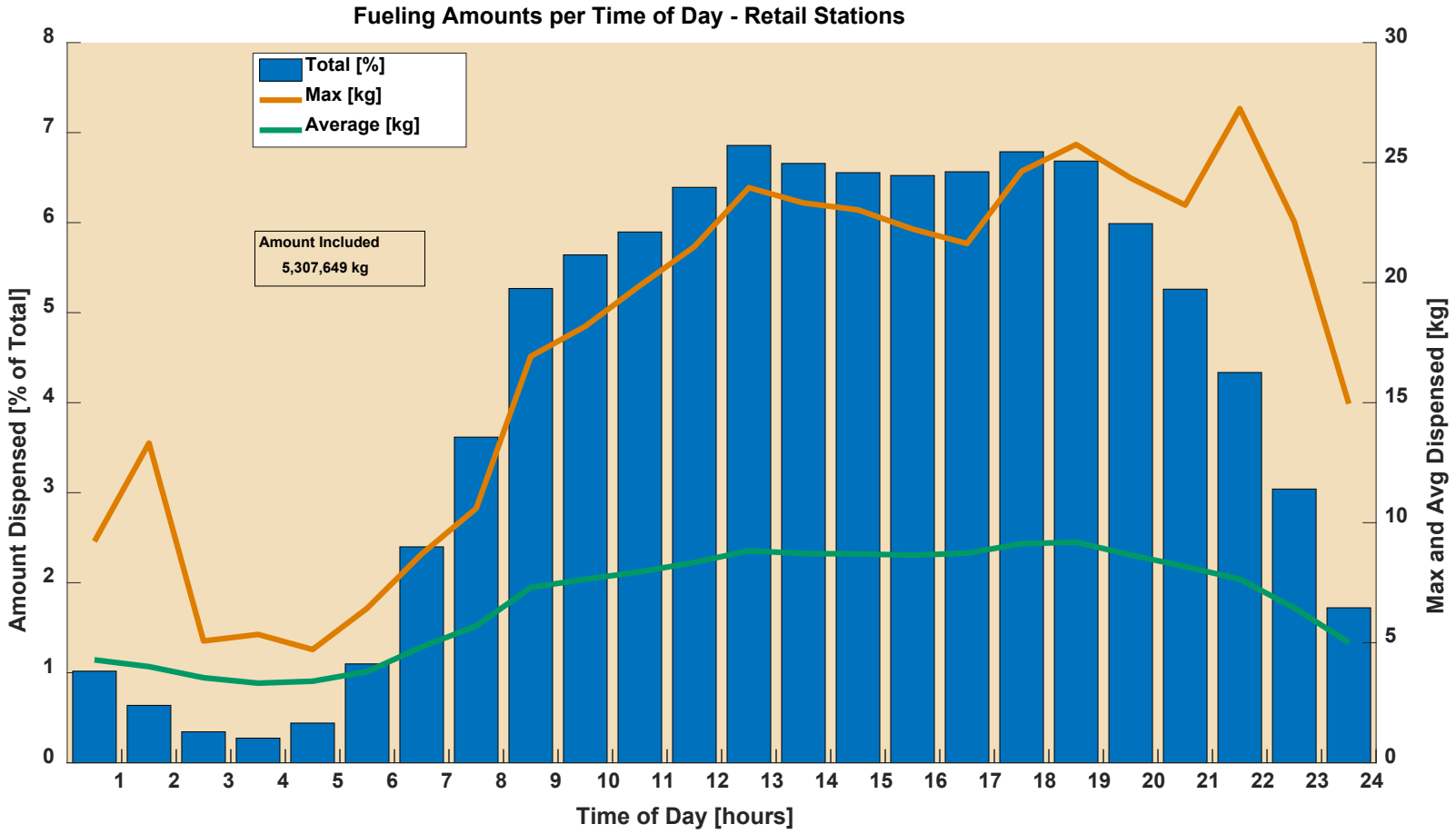
CDP-INFR-15
Number of Fills by Time of Day



NREL cdpRETAIL_infr_15
Created: Jan-31-23 1:42 PM | Data Range: 2014Q3-2022Q2

1. Friday Chevron profile "Hydrogen Delivery Infrastructure Options Analysis", T. Chen, 2008.

CDP-INFR-16
Fueling Amounts per Time of Day



NREL cdpRETAIL_infr_16
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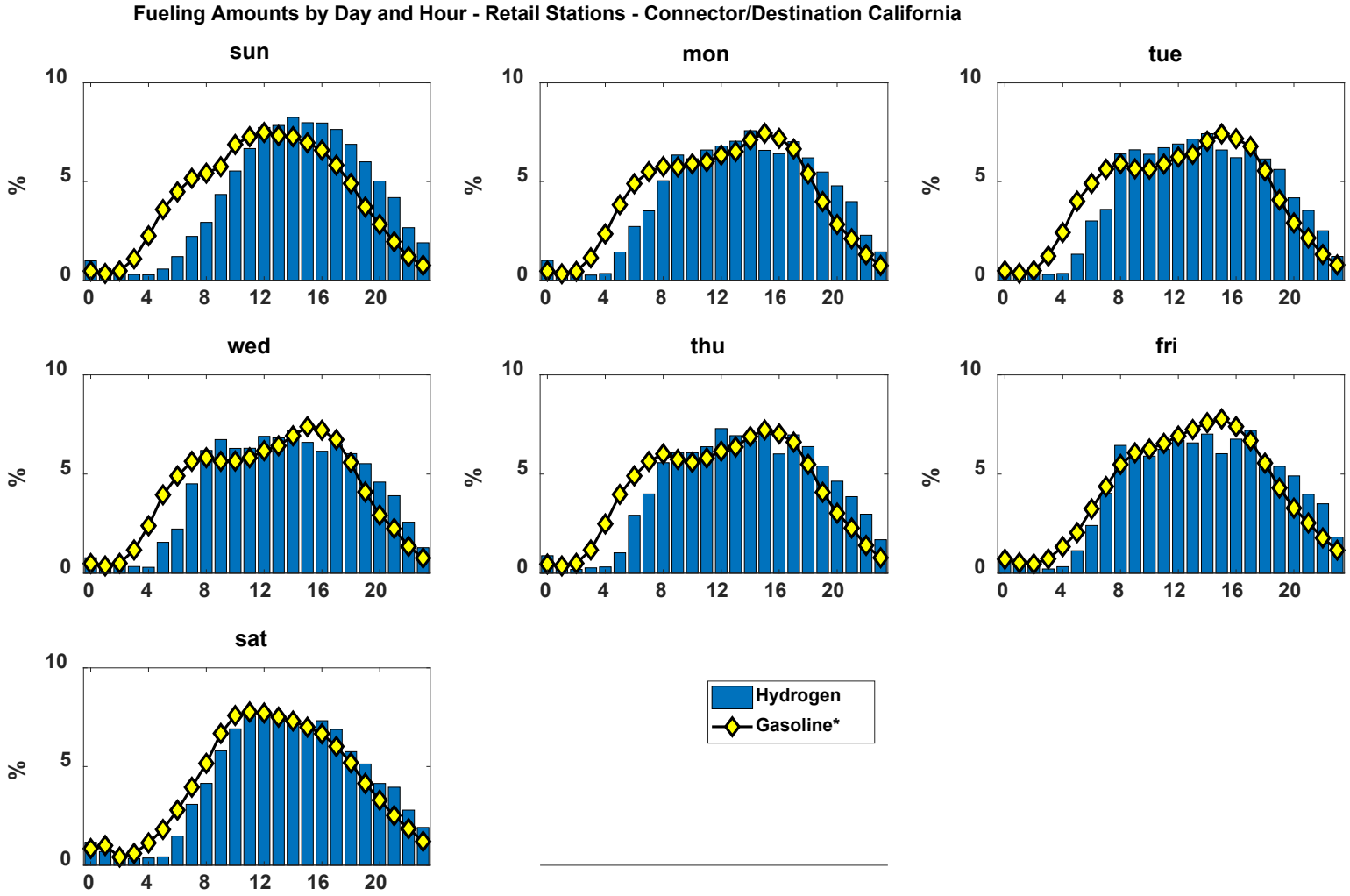
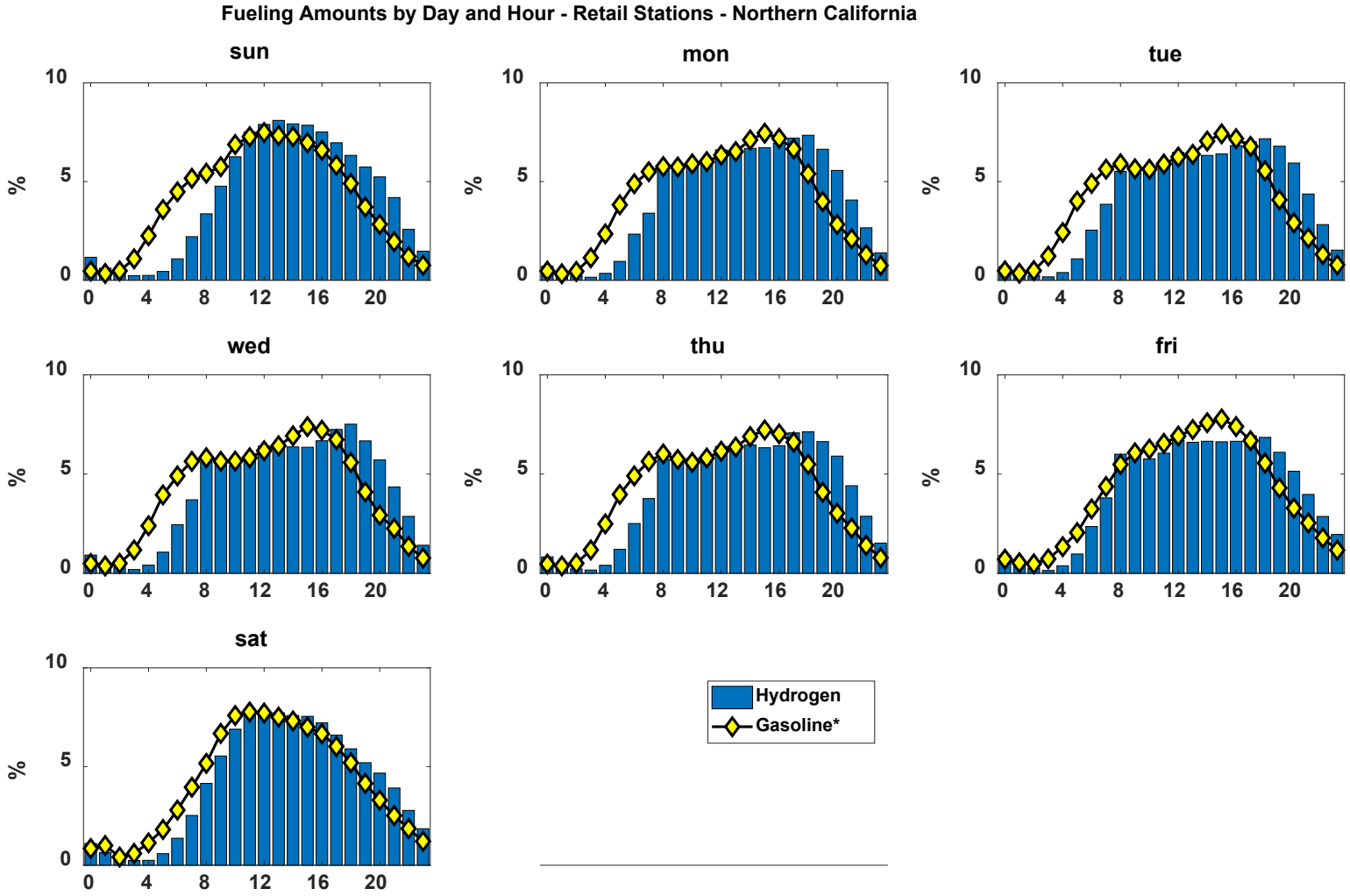
CDP-INFR-88a Connector/Destination Stations Fueling Profile by Day and Hour



*Chevron gasoline profile "Hydrogen Delivery Infrastructure Options Analysis", T. Chen, 2008.

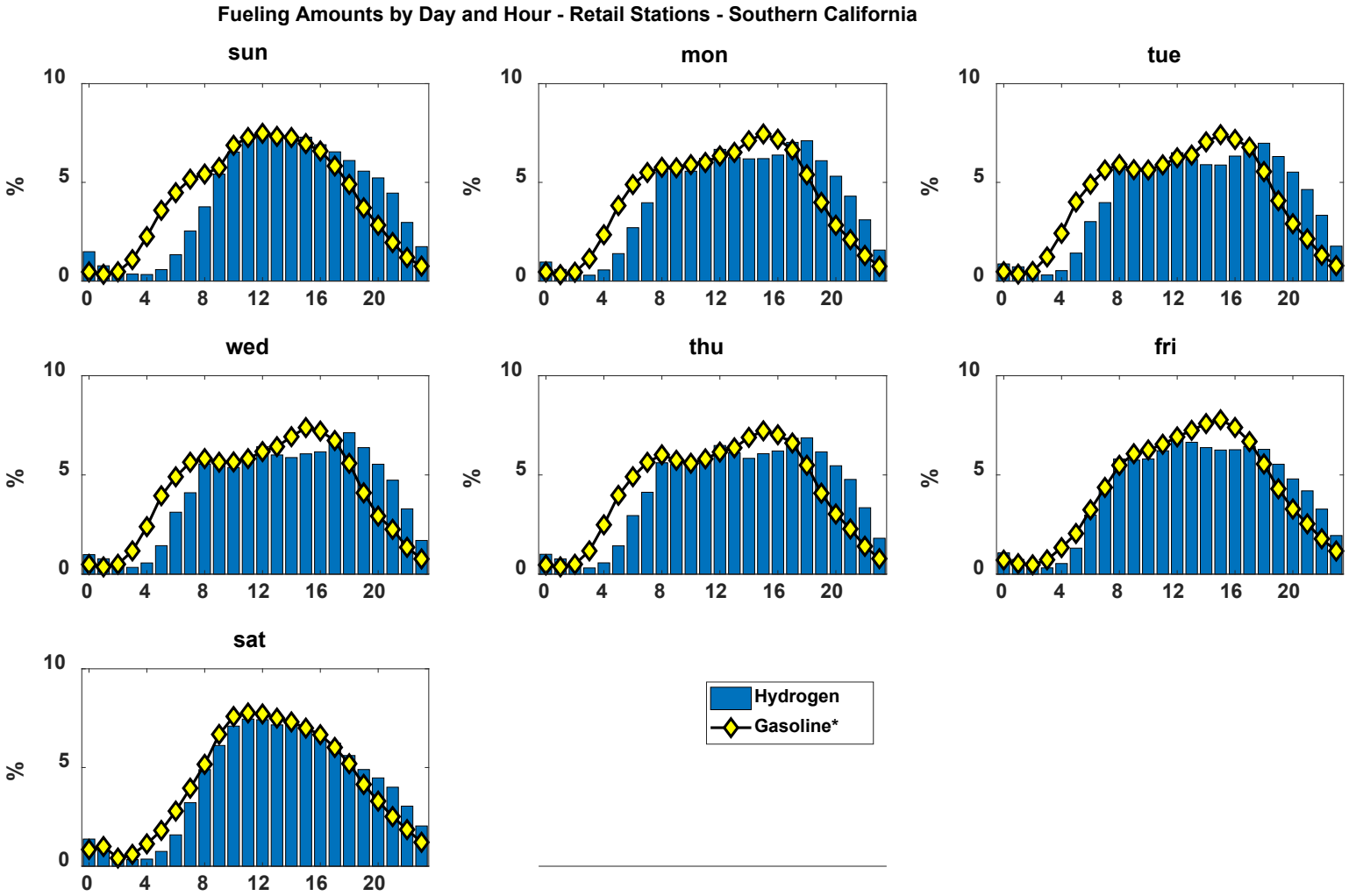
CDP-INFR-88b Northern California
Fueling Profile by Day and Hour



NREL cdpRETAIL_infr_88b
Created: Jan-24-23 5:04 PM | Data Range: 2014Q3-2022Q2

*Chevron gasoline profile "Hydrogen Delivery Infrastructure Options Analysis", T. Chen, 2008.

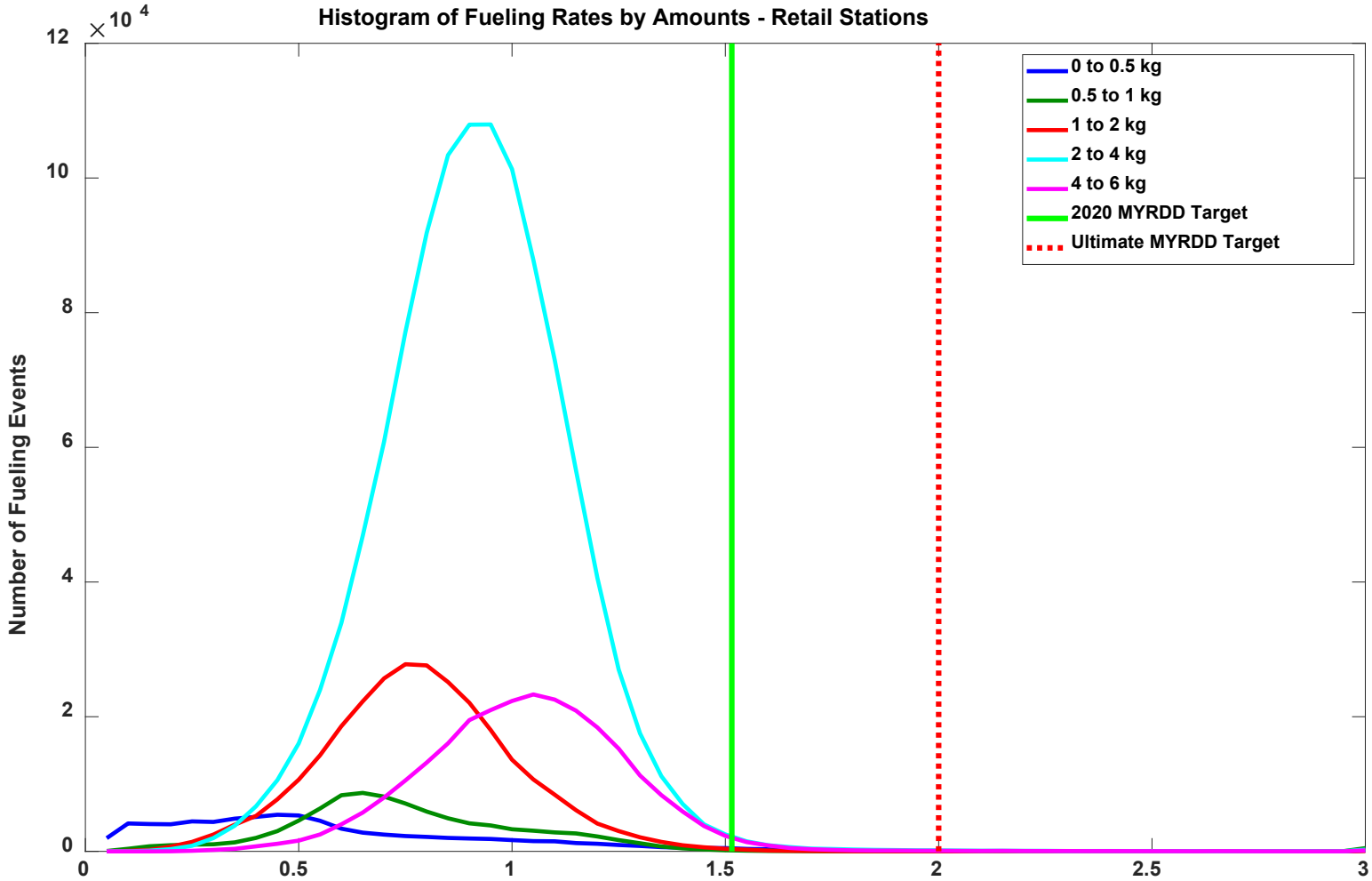
CDP-INFR-88c Southern California
Fueling Profile by Day and Hour



NREL cdpRETAIL_infr_88c
Created: Jan-24-23 5:04 PM | Data Range: 2014Q3-2022Q2

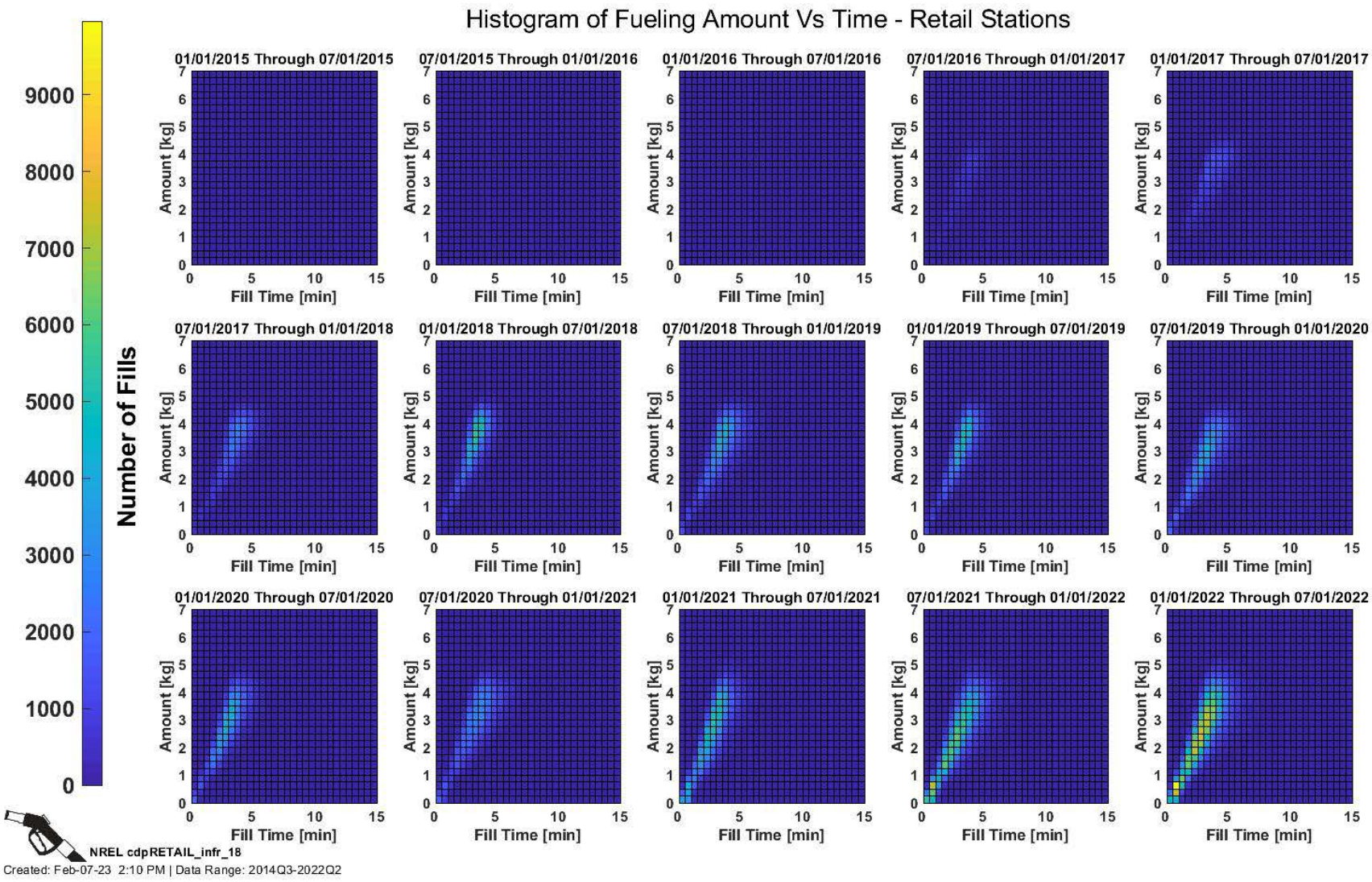
*Chevron gasoline profile "Hydrogen Delivery Infrastructure Options Analysis", T. Chen, 2008.

CDP-INFR-17
Fueling Rates by Amount Filled

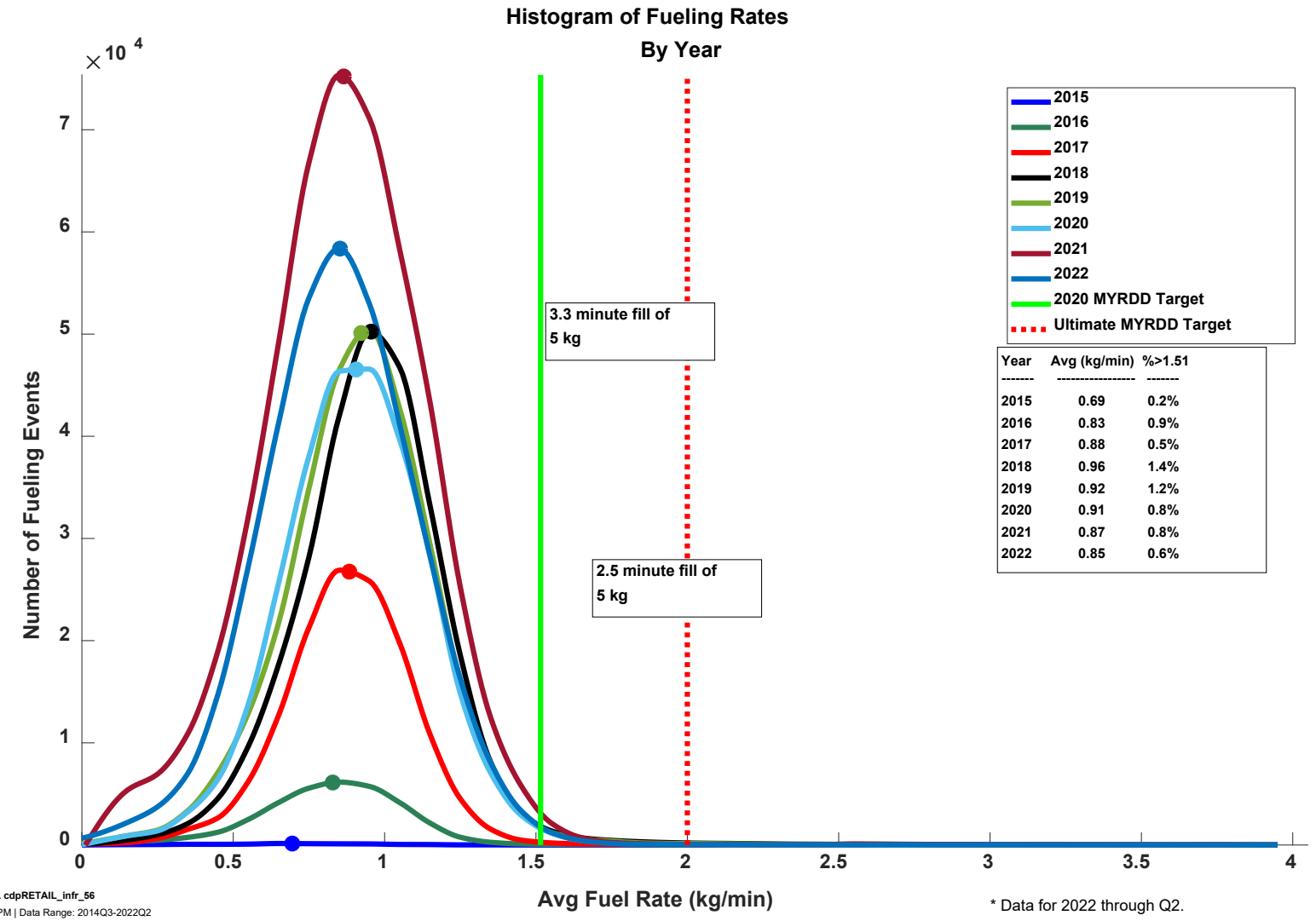


NREL cdpRETAIL_infr_17
Created: Feb-07-23 12:12 PM | Data Range: 2014Q3-2022Q2

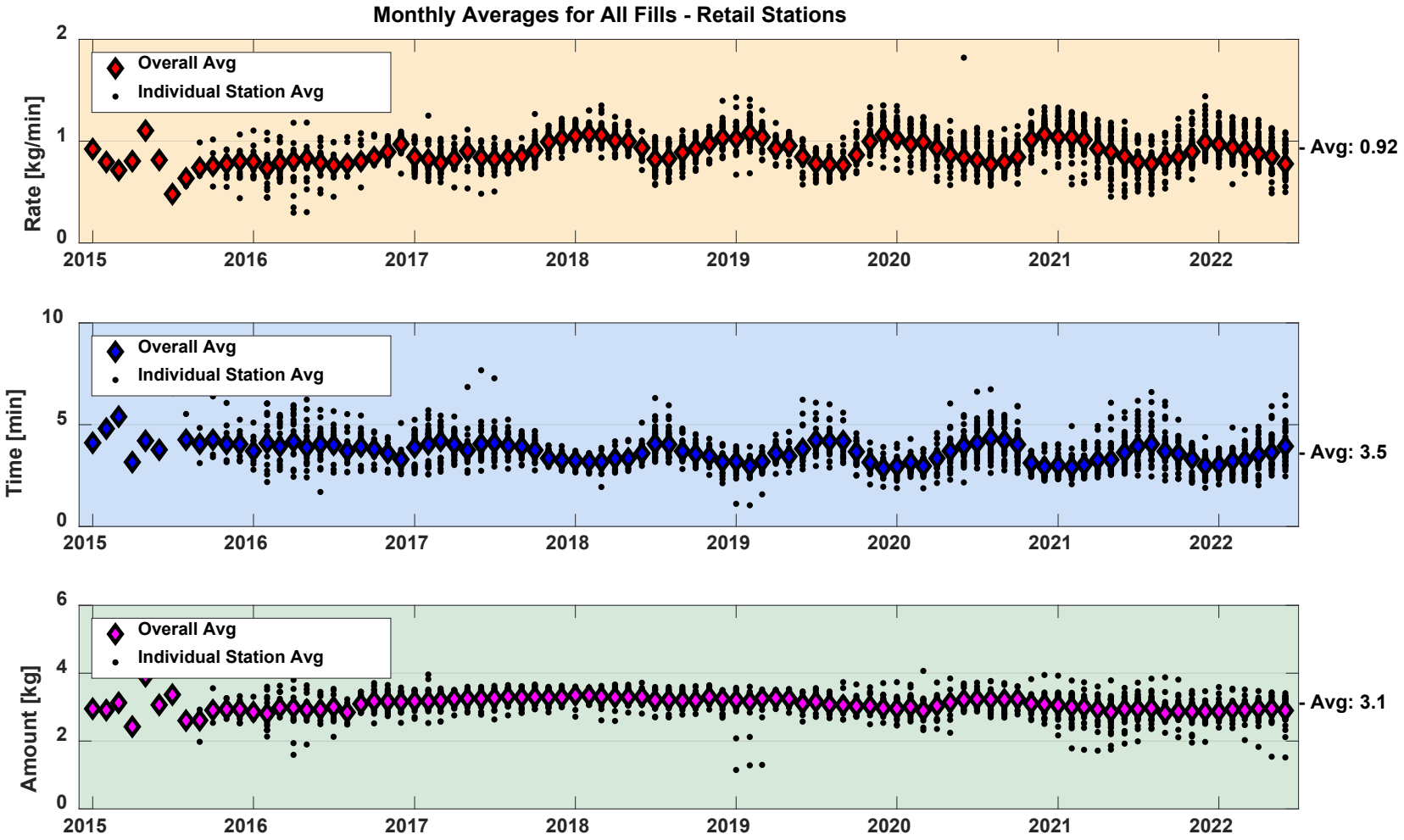
CDP-INFR-18
Fueling Amount vs. Time to Fill



CDP-INFR-56
Fueling Rates by Year

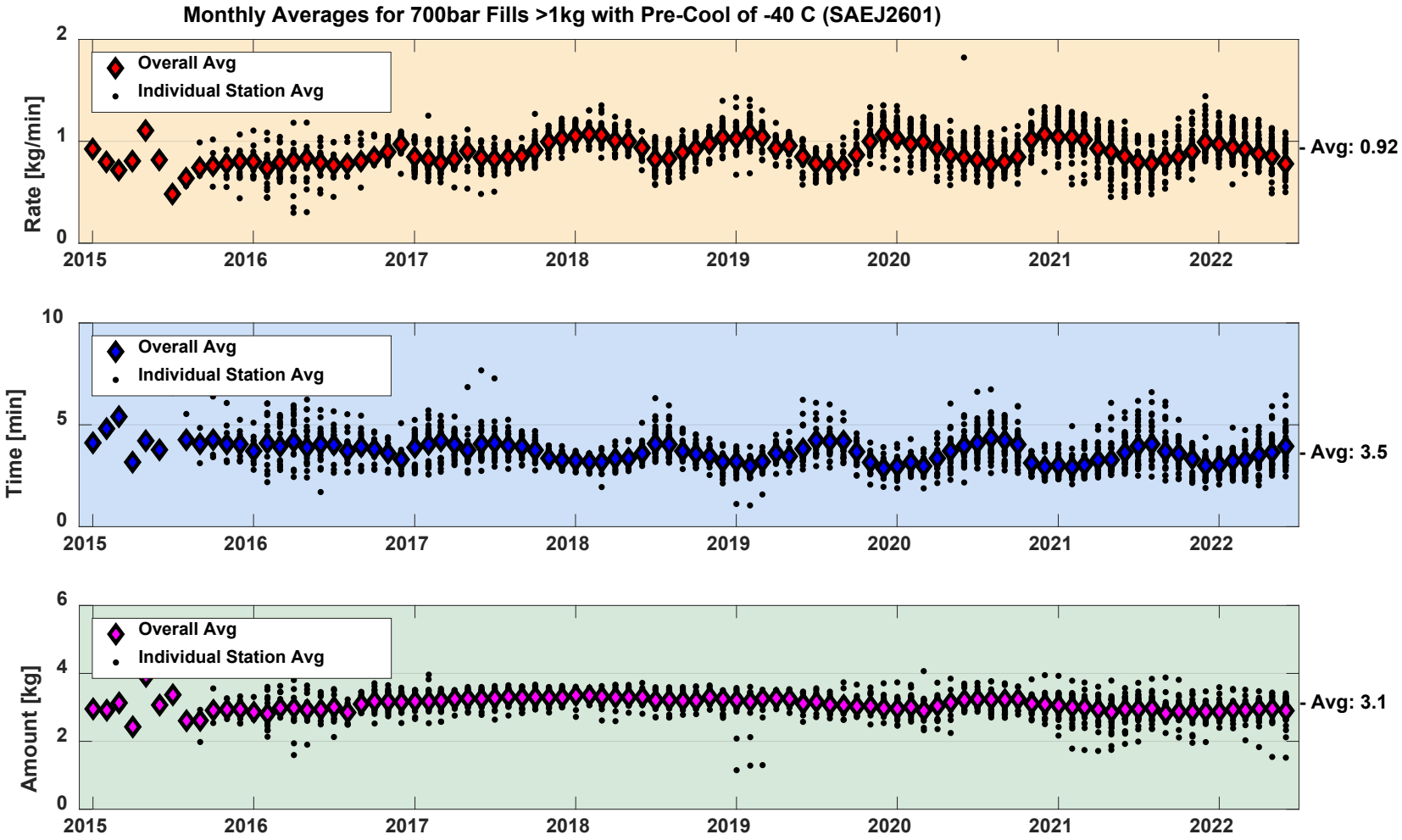


CDP-INFR-55
Monthly Averages: All Fills



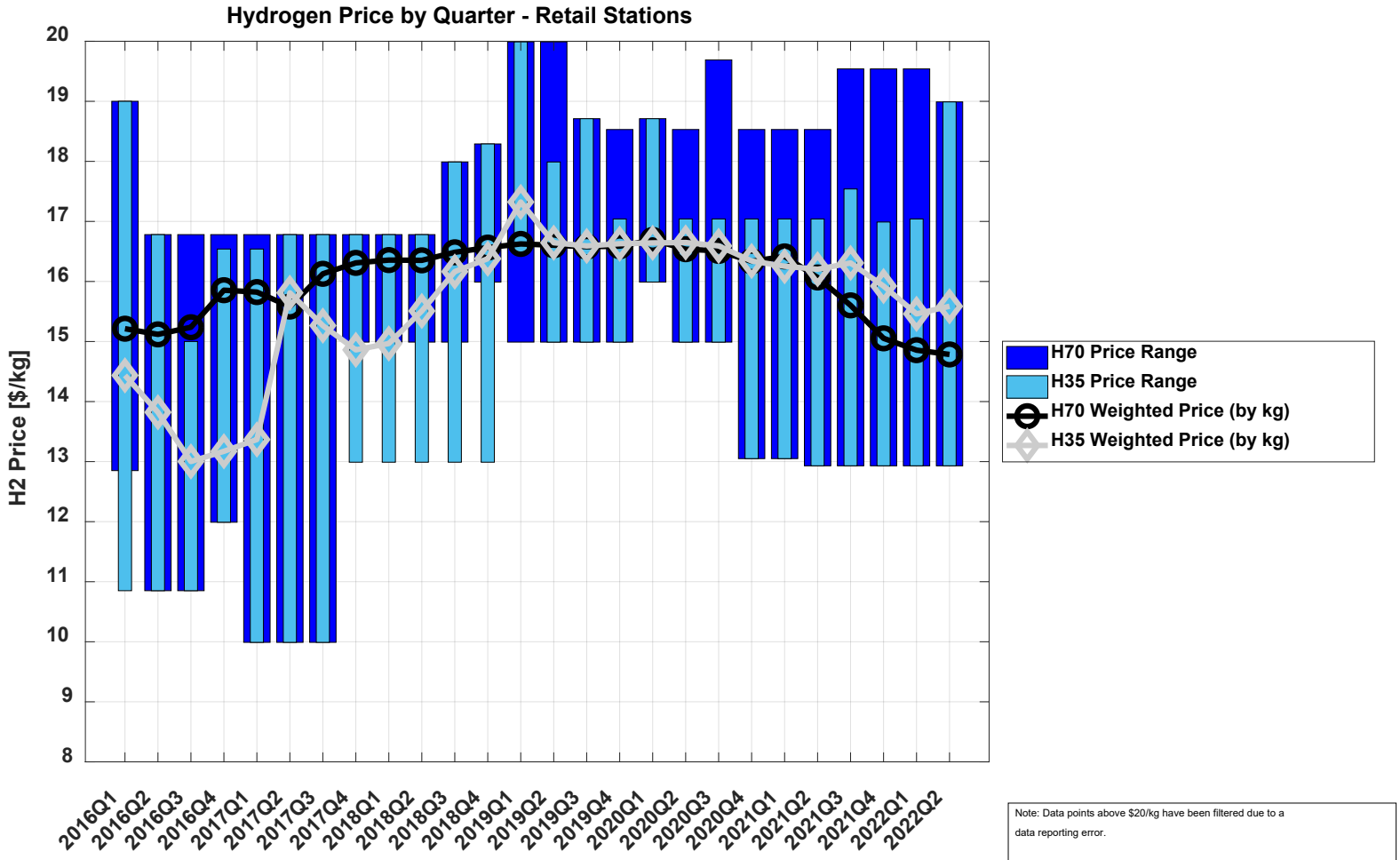
NREL cdpRETAIL_infr_55
Created: Jan-25-23 3:39 AM | Data Range: 2014Q3-2022Q2

CDP-INFR-57
Monthly Averages: 700 bar Fills >1 kg with Pre-Cool of -40°C



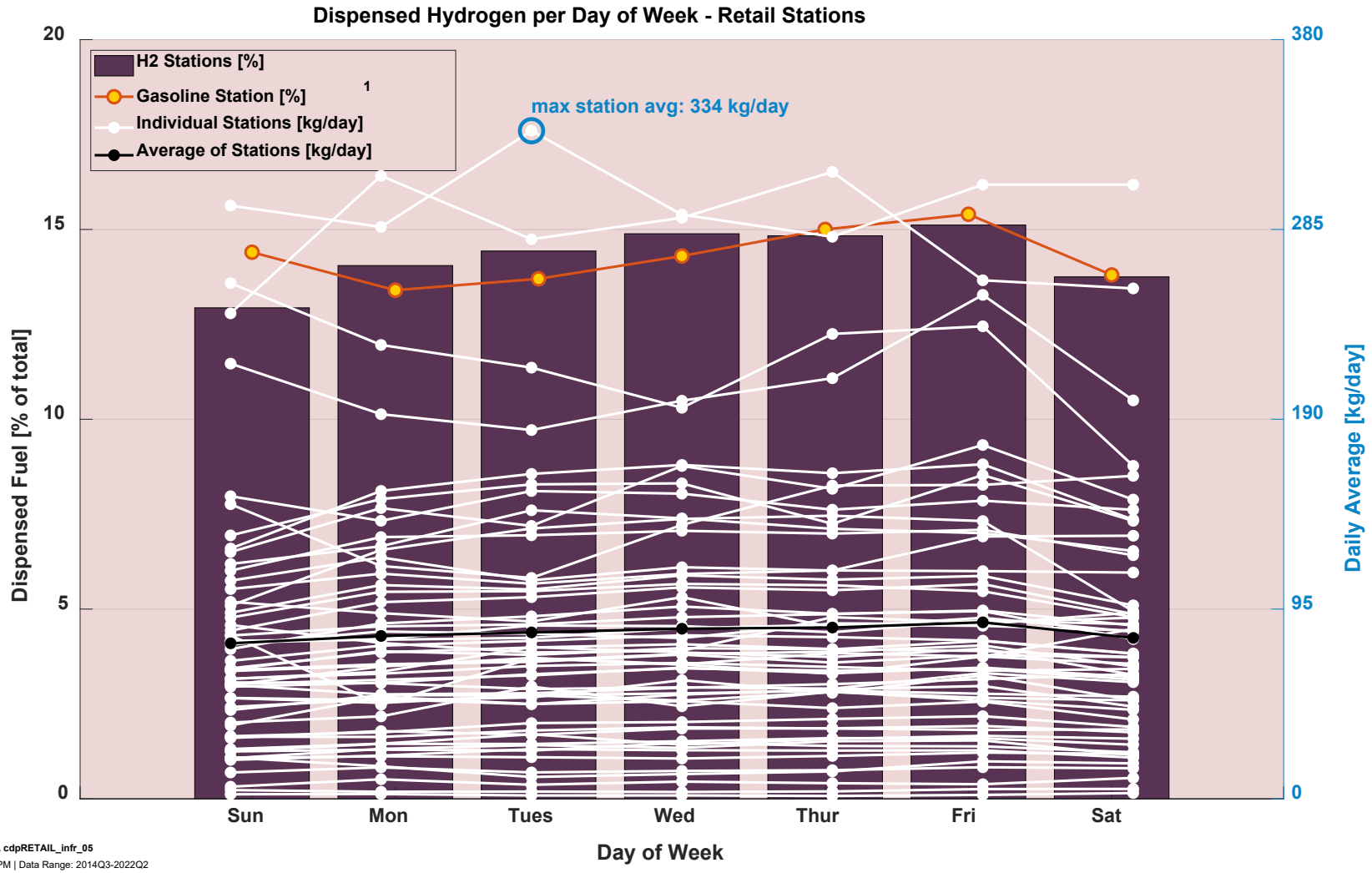
Cost

CDP-INFR-89
Hydrogen Price by Quarter



Utilization

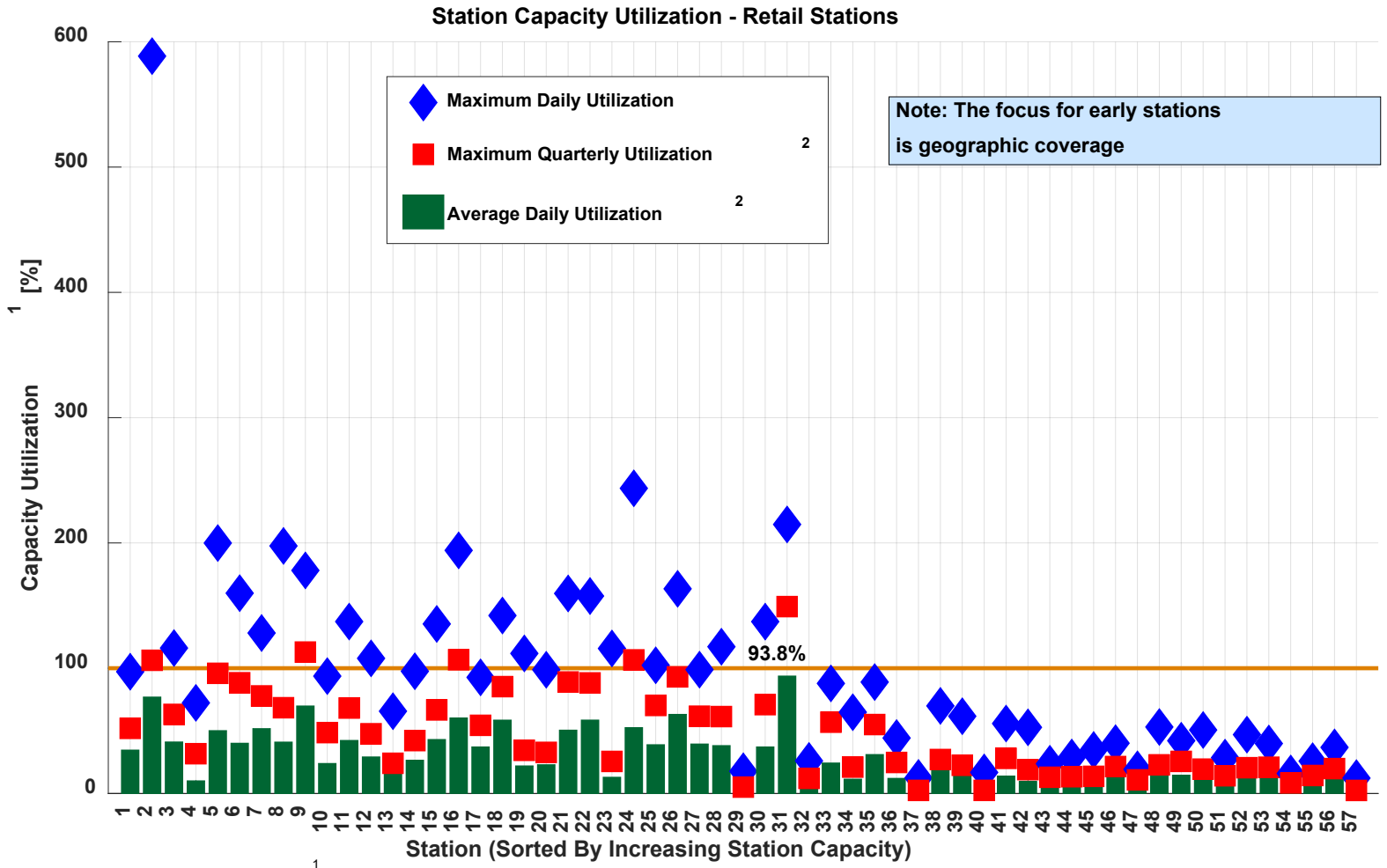
CDP-INFR-05
Dispensed Hydrogen per Day of Week



NREL cdpRETAIL_infr_05
Created: Mar-07-23 4:06 PM | Data Range: 2014Q3-2022Q2

1. Chevron weekly demand profile "Hydrogen Delivery Infrastructure Options Analysis", T. Chen.

CDP-INFR-06
Station Capacity Utilization

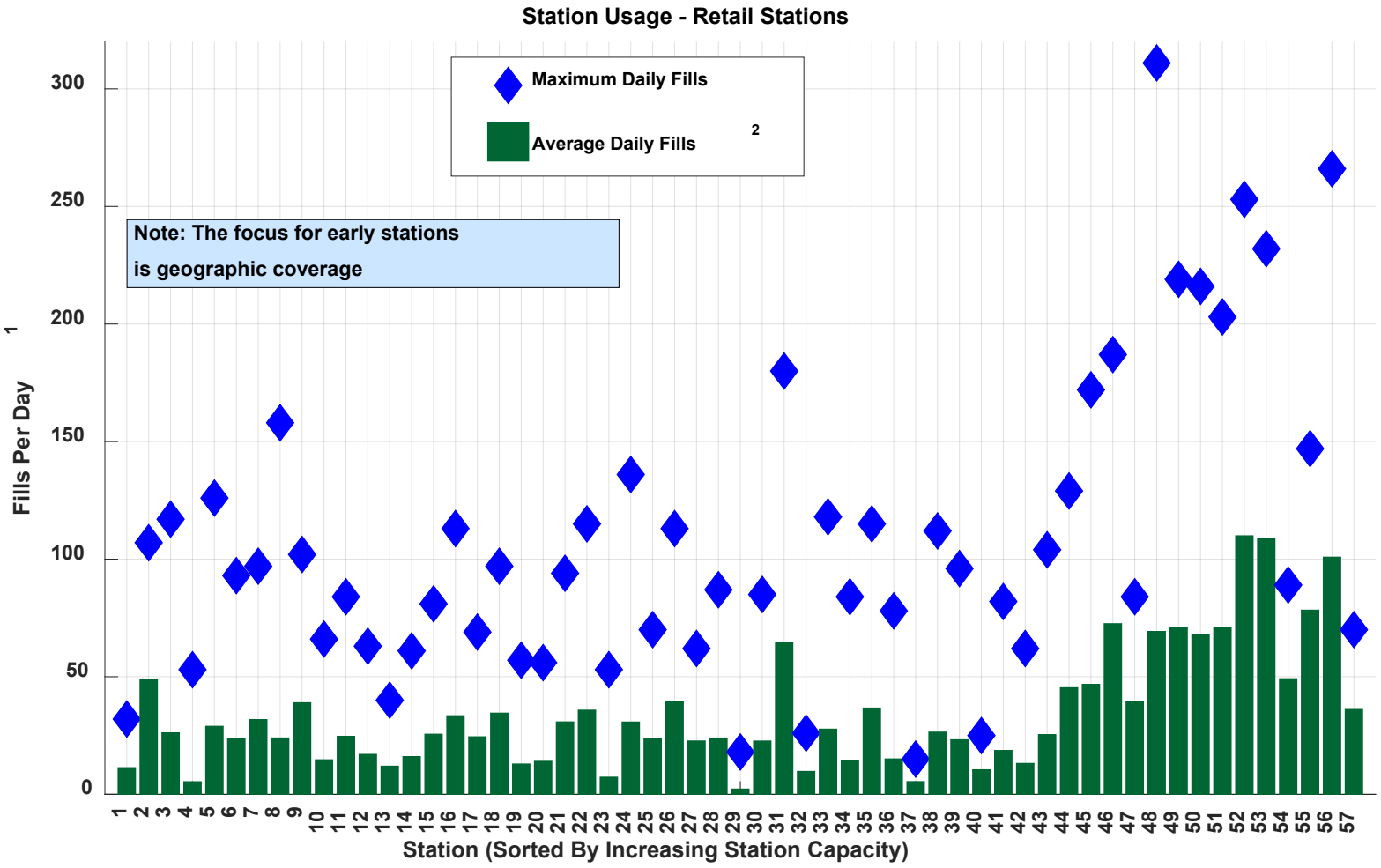


NREL cdpRETAIL_infr_06
Created: Jan-24-23 11:59 PM | Data Range: 2014Q3-2022Q2

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

[2] Maximum quarterly utilization considers all days; average daily utilization considers only days when at least one filling occ urred

CDP-INFR-07
Station Usage

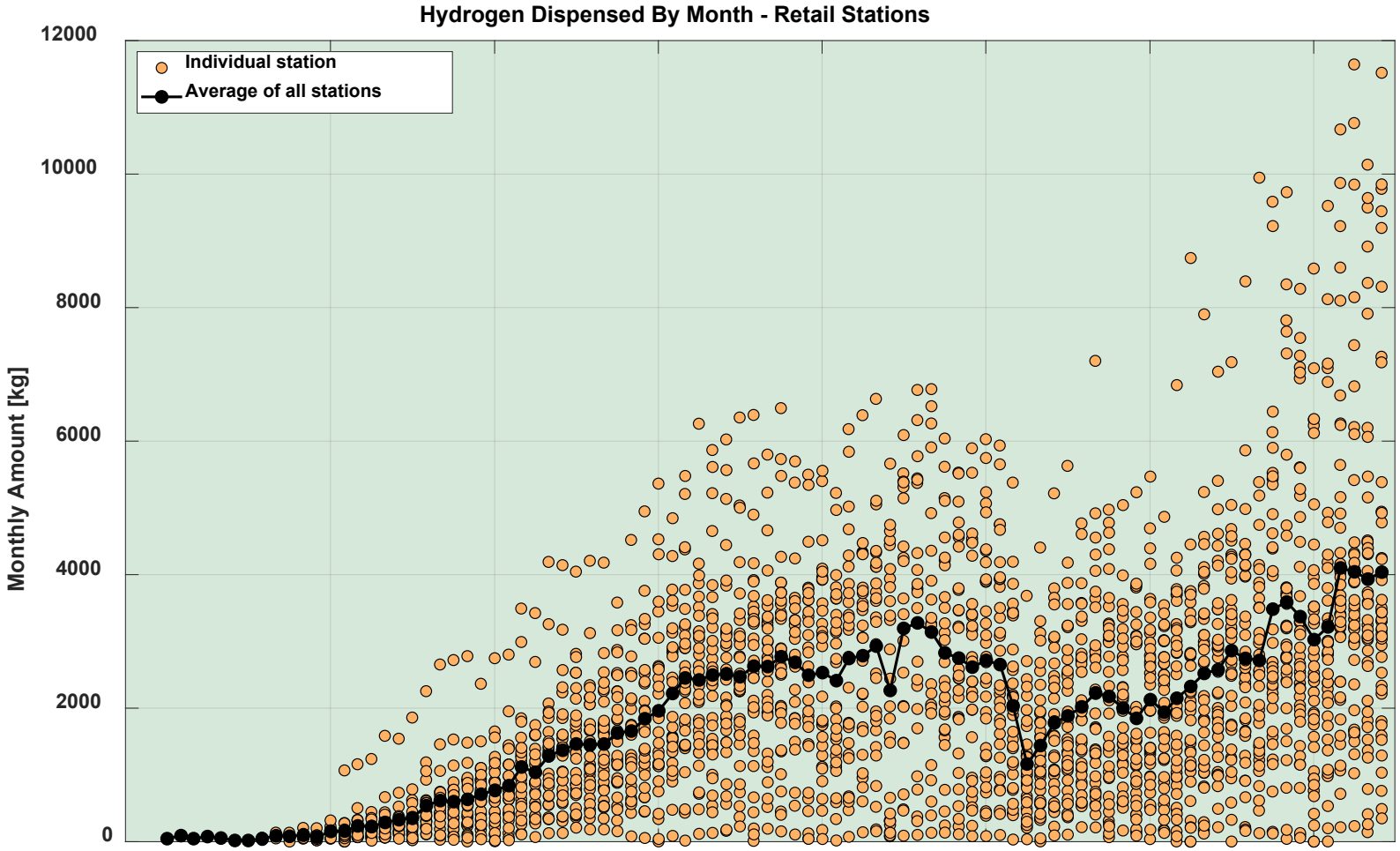


NREL cdpRETAIL_infr_07
Created: Feb-21-23 2:52 PM | Data Range: 2014Q3-2022Q2

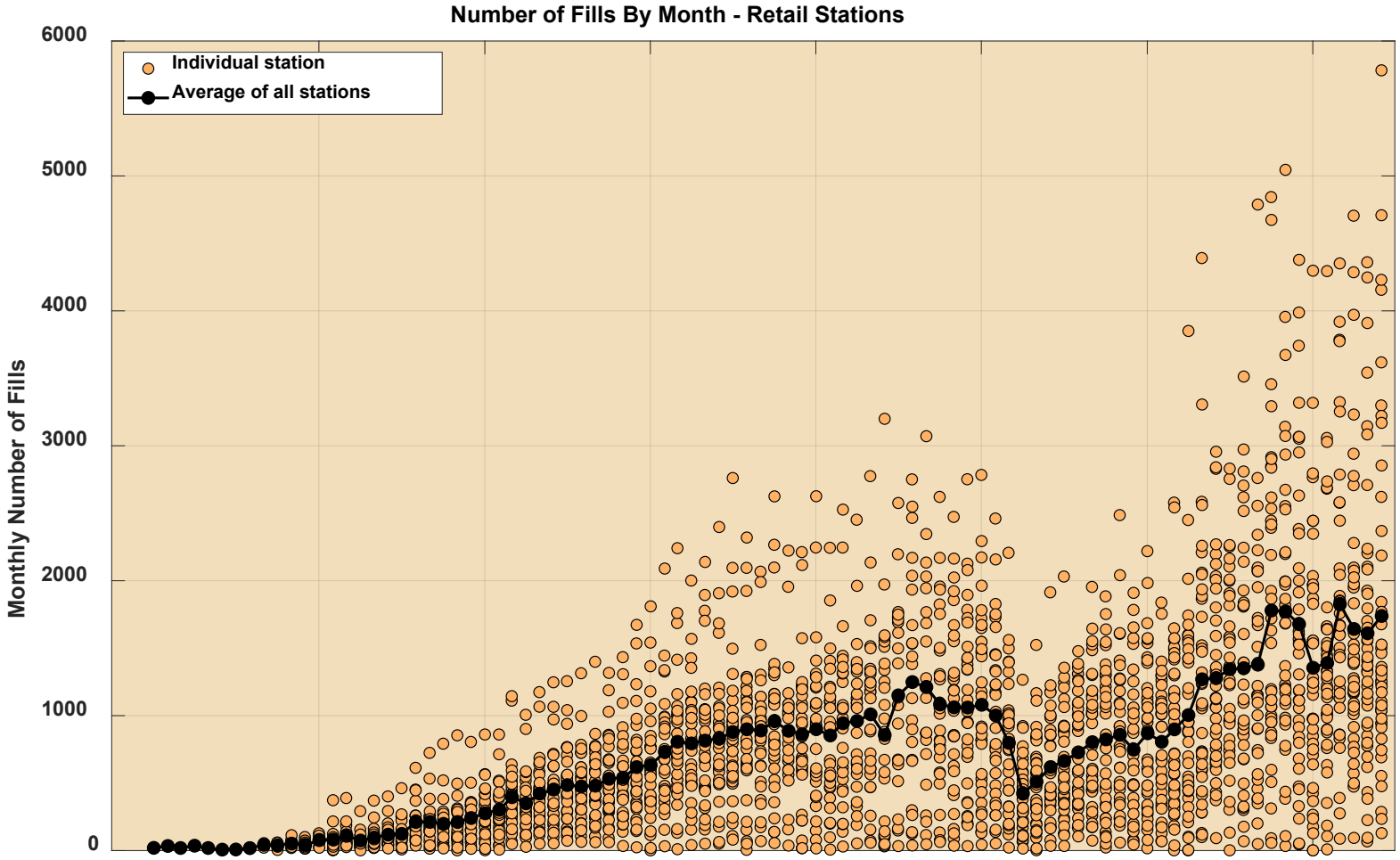
[1] Excludes hydrogen fills of < 0.5 kg

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

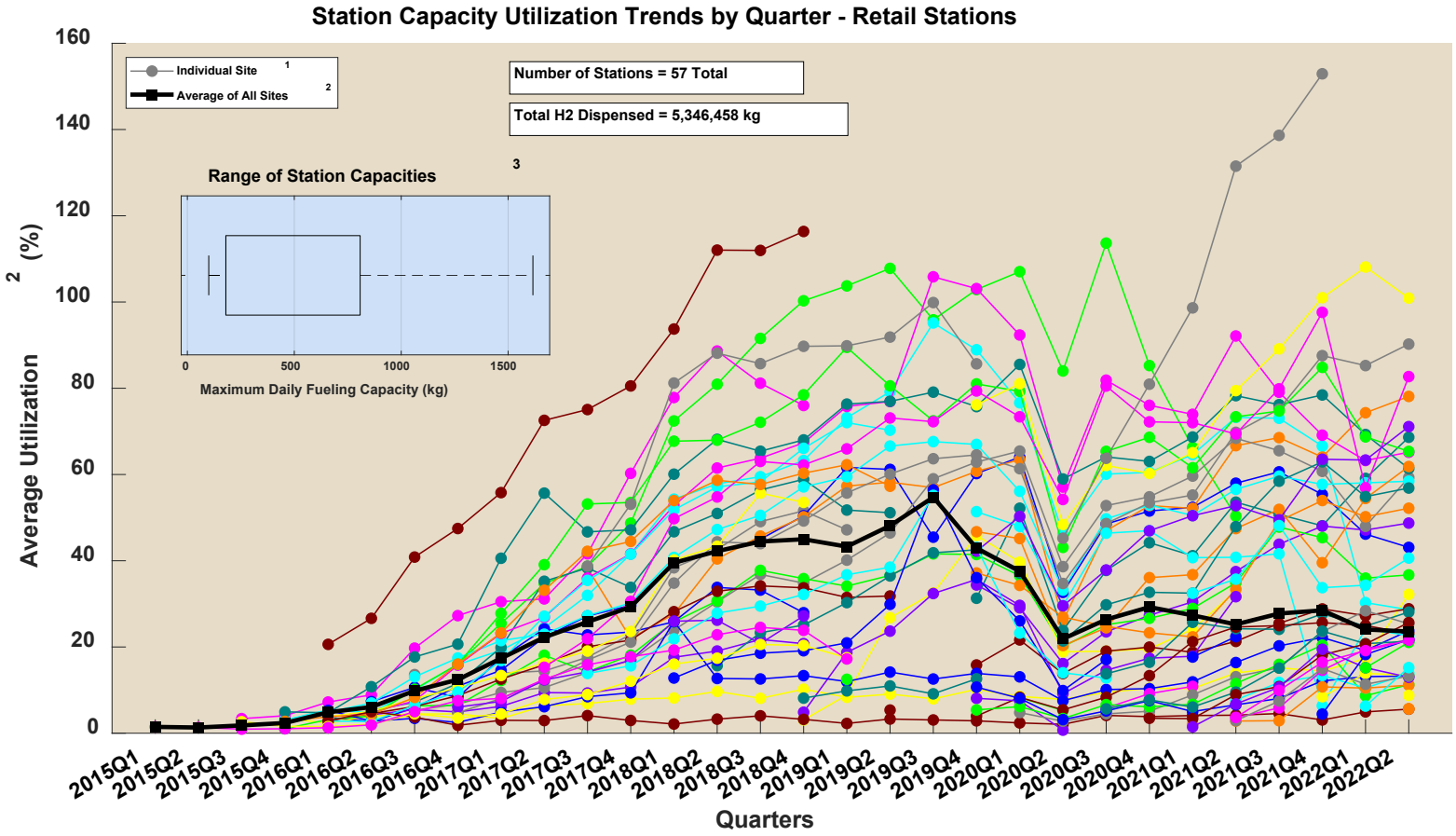
CDP-INFR-19
Hydrogen Dispensed by Month



CDP-INFR-20
Number of Fills by Month



CDP-INFR-44
Station Capacity Utilization Trends by Quarter



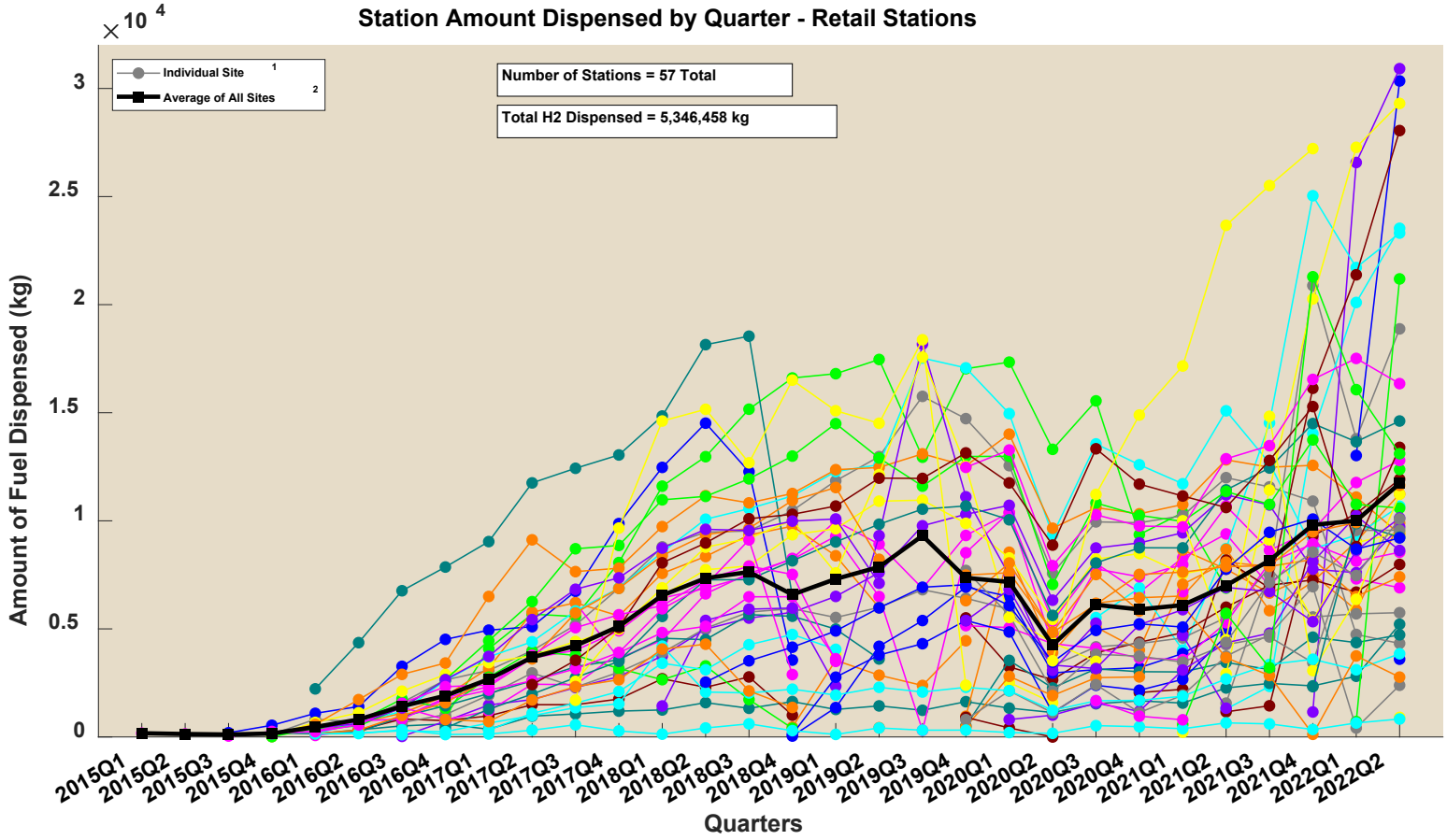
[1] Trendlines connect continuous quarters of operation for a single station. Gaps in trendlines represent quarters in which a station was offline or missing data. Each station is represented by a unique color.

[2] Average quarterly utilization only considers quarters when at least one fill occurred.

[3] Station nameplate capacity is as reported to NREL and reflects a variety of system design considerations including: system capacity, throughput, system reliability, and maintenance. Actual daily usage may exceed nameplate capacity.

NREL cdpRETAIL_infr_44
Created: Jan-25-23 7:51 AM | Data Range: 2014Q3-2022Q2

CDP-INFR-45
Station Amount Dispensed by Quarter

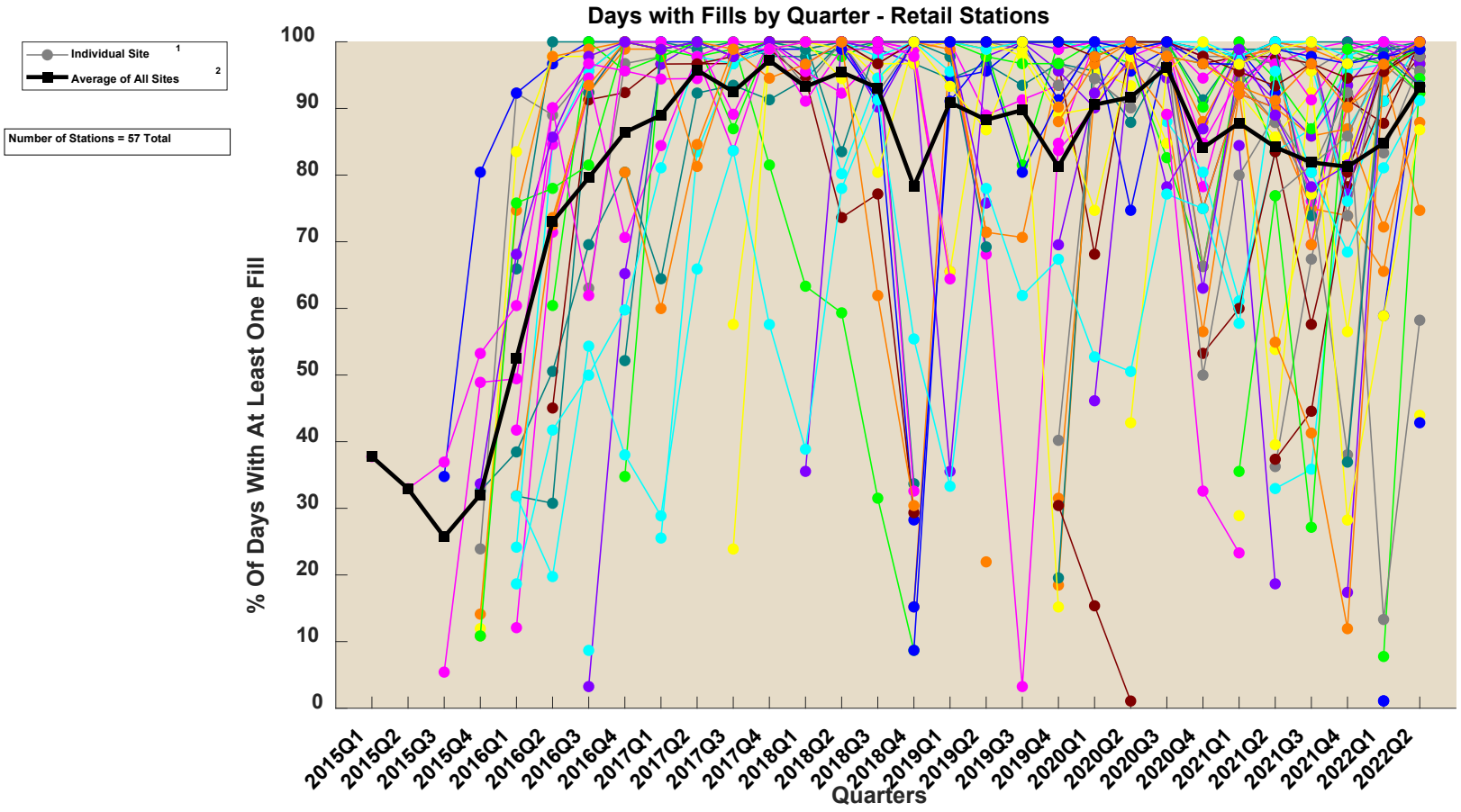


[1] Trendlines connect continuous quarters of operation for a single station. Gaps in trendlines represent quarters in which a station was offline or missing data. Each station is represented by a unique color.

[2] Average quarterly amount only considers quarters when at least one fill occurred.

NREL cdpRETAIL_infr_45
Created: Jan-25-23 6:14 AM | Data Range: 2014Q3-2022Q2

CDP-INFR-46
Days with Fills by Quarter

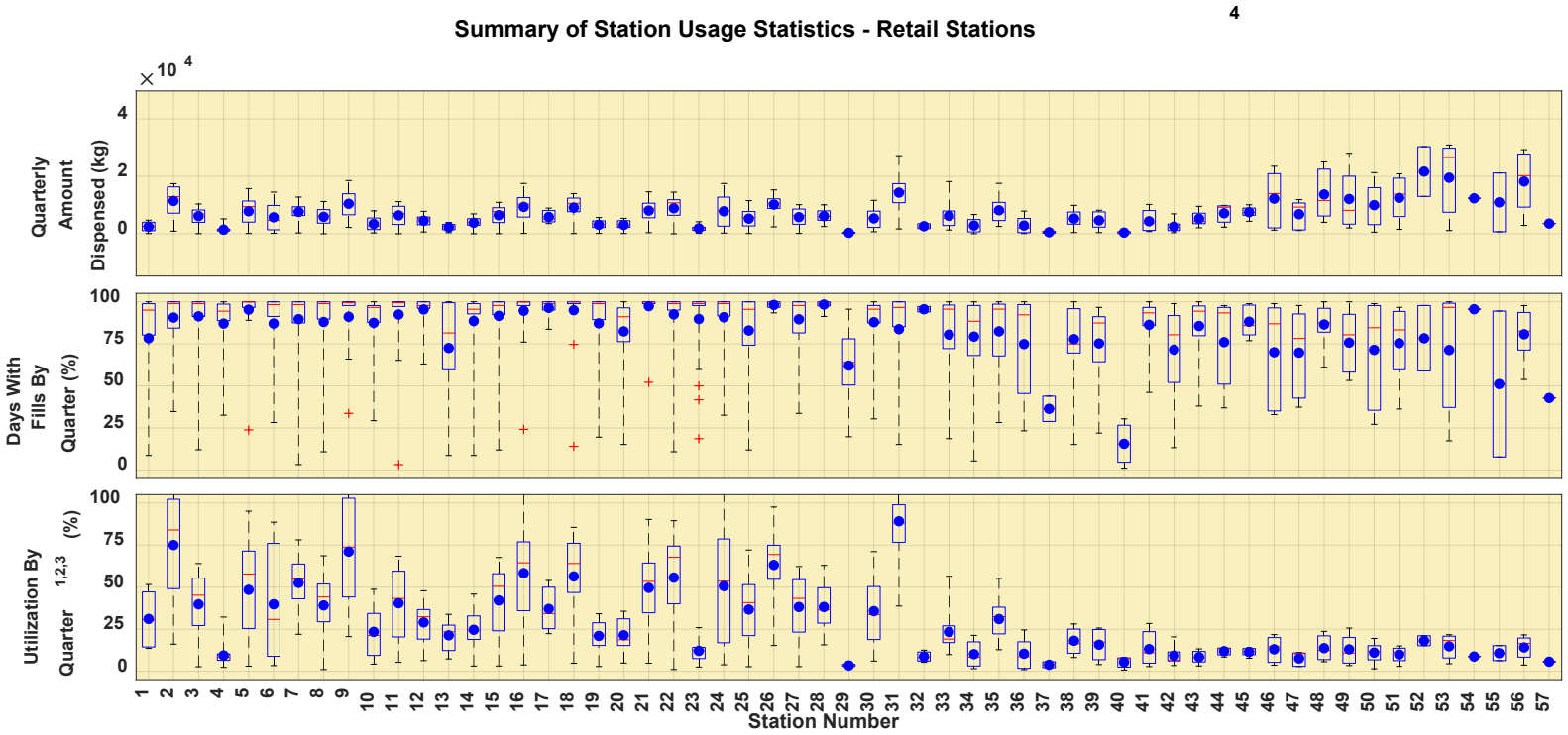


[1] Trendlines connect continuous quarters of operation for a single station. Gaps in trendlines represent quarters in which a station had no fills or was missing data. Each station is represented by a unique color.

[2] The average percent of days with fills only considers quarters in which at least one fill occurred. Stations with no filling in a quarter are excluded from the average for that quarter. All stations with at least one fill in a quarter are given eq ual weight when calculating the average for the quarter. days

NREL cdpRETAIL_infr_46
Created: Mar-21-23 10:04 AM | Data Range: 2014Q3-2022Q2

CDP-INFR-47
Summary of Station Usage Statistics



[1] Station nameplate capacity is as reported to NREL and reflects a variety of system design considerations including: system capacity, throughput, system reliability, and maintenance. Actual daily usage may exceed nameplate capacity.

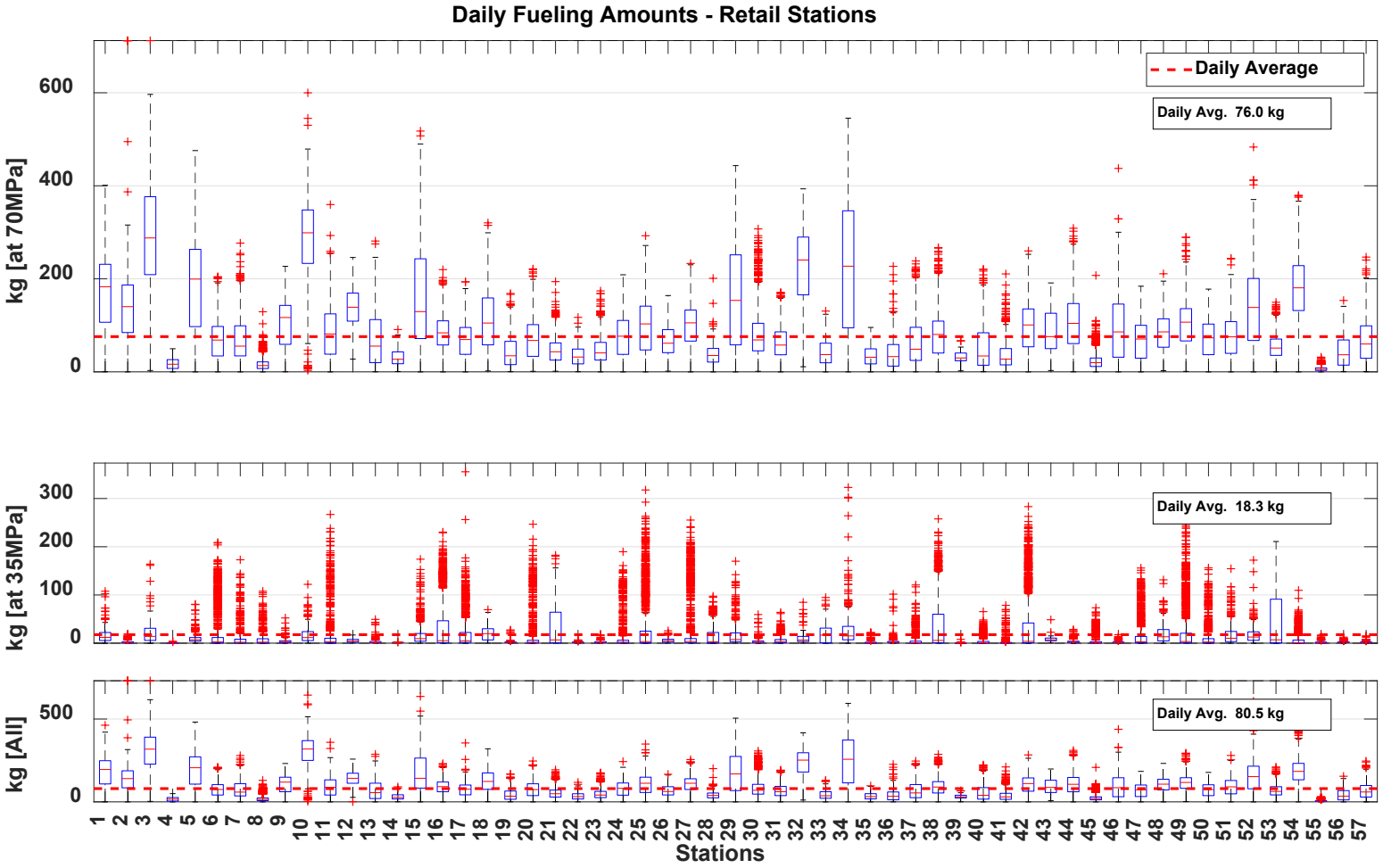
[2] Average quarterly utilization only considers days when at least one fill occured.

[3] Utilization is calculated by dividing the quarterly amount dispensed by the stations nameplate capacity.

[4] Only quarters with fills are included.

NREL cdpRETAIL_infr_47
Created: Feb-07-23 2:52 PM | Data Range: 2014Q3-2022Q2

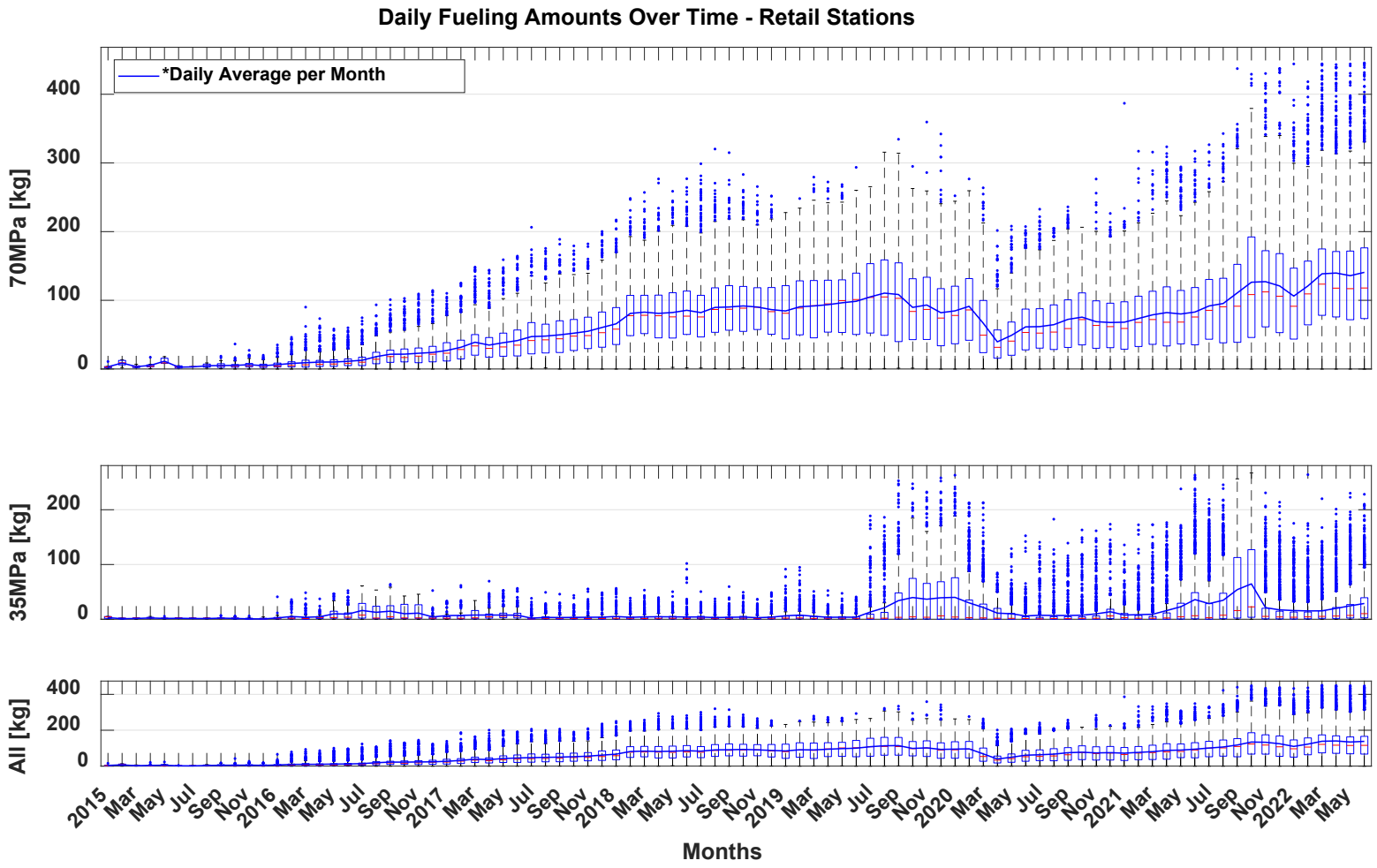
CDP-INFR-80
Daily Fueling Amounts by Station



NREL cdpRETAIL_infr_80
Created: Jan-24-23 6:29 PM | Data Range: 2014Q3-2022Q2

Note: Some outliers clipped.

CDP-INFR-82
Daily Fueling Amounts by Month

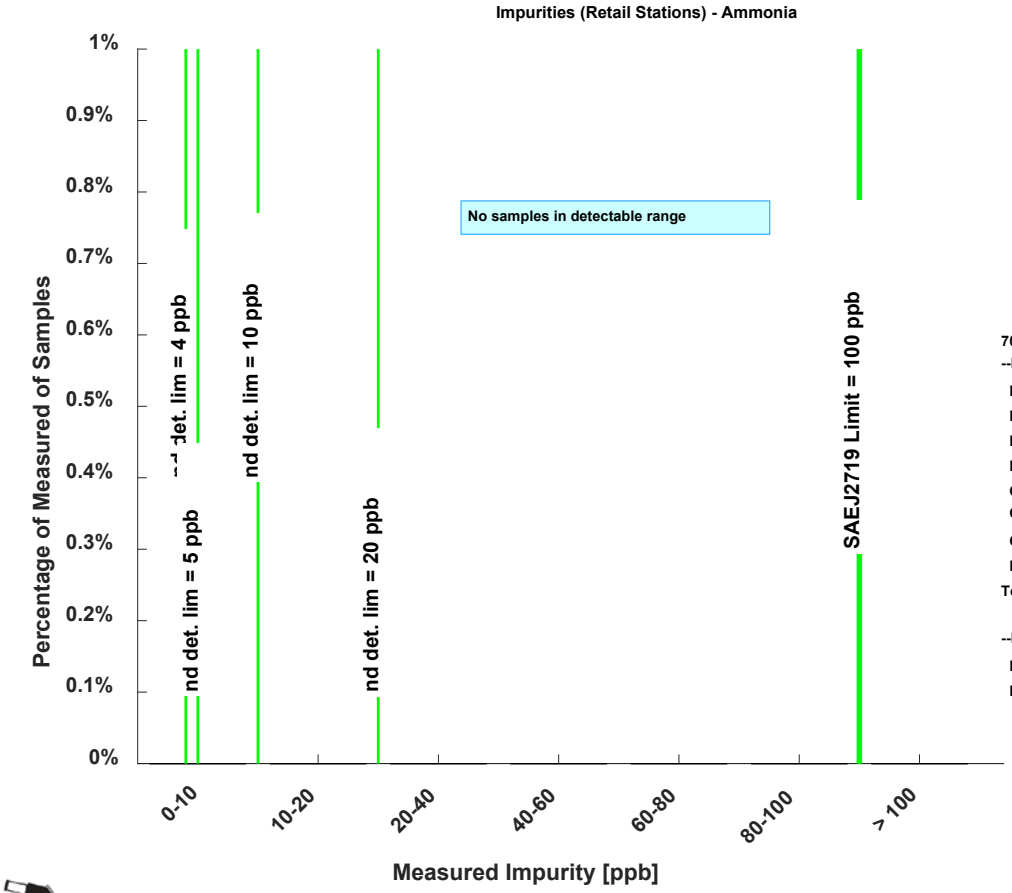


NREL cdpRETAIL_infr_82
Created: Jan-24-23 5:35 PM | Data Range: 2014Q3-2022Q2

*Daily average only includes days with fills. Outliers more than 3 standard deviations are not shown.

Hydrogen Quality

CDP-INFR-79
Impurities—Ammonia



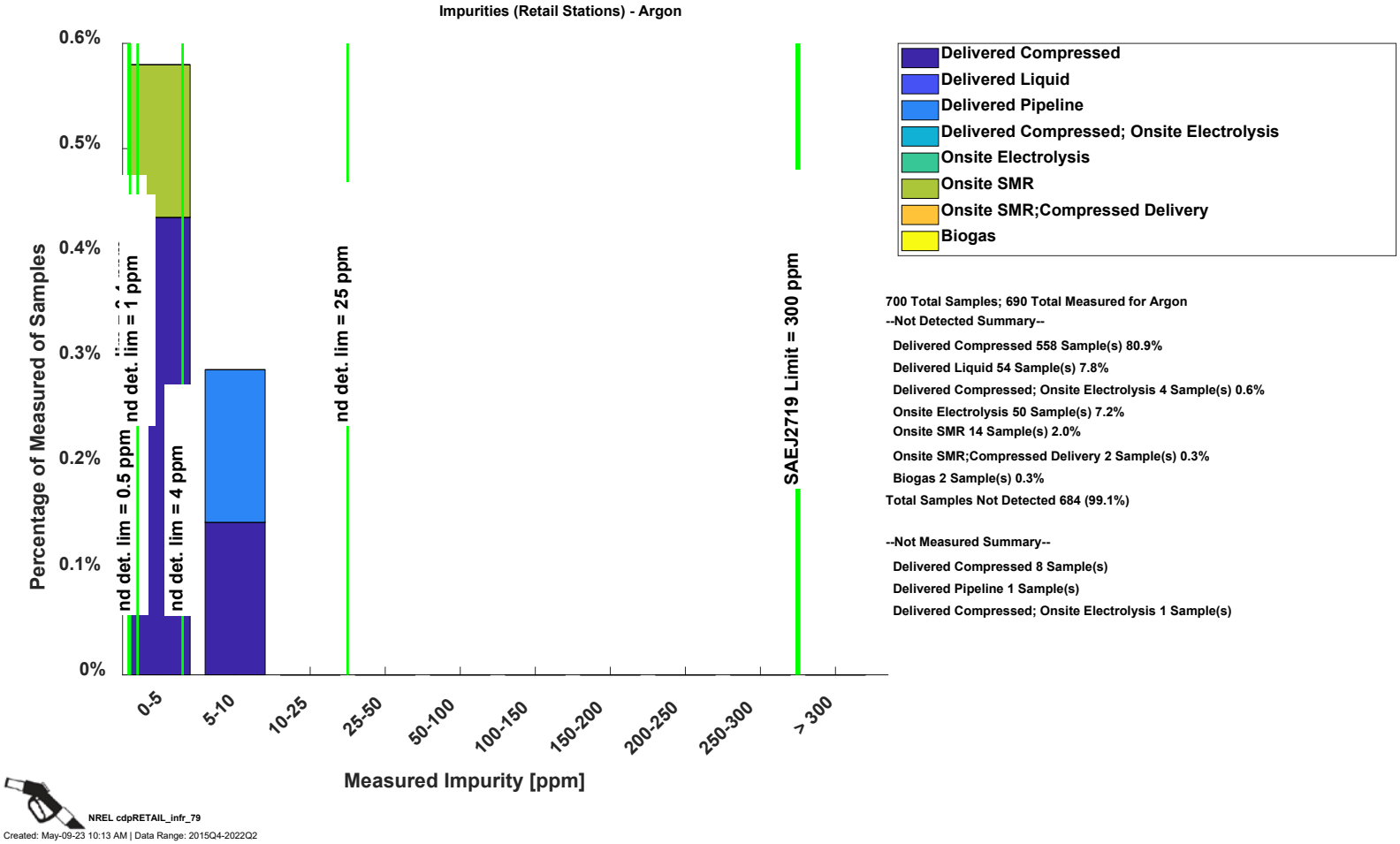
Delivered Compressed
Delivered Liquid
Delivered Pipeline
Delivered Compressed; Onsite Electrolysis
Onsite Electrolysis
Onsite SMR
Onsite SMR;Compressed Delivery
Biogas

700 Total Samples; 692 Total Measured for Ammonia
--Not Detected Summary--
Delivered Compressed 564 Sample(s) 81.5%
Delivered Liquid 54 Sample(s) 7.8%
Delivered Pipeline 2 Sample(s) 0.3%
Delivered Compressed; Onsite Electrolysis 3 Sample(s) 0.4%
Onsite Electrolysis 50 Sample(s) 7.2%
Onsite SMR 15 Sample(s) 2.2%
Onsite SMR;Compressed Delivery 2 Sample(s) 0.3%
Biogas 2 Sample(s) 0.3%
Total Samples Not Detected 692 (100.0%)

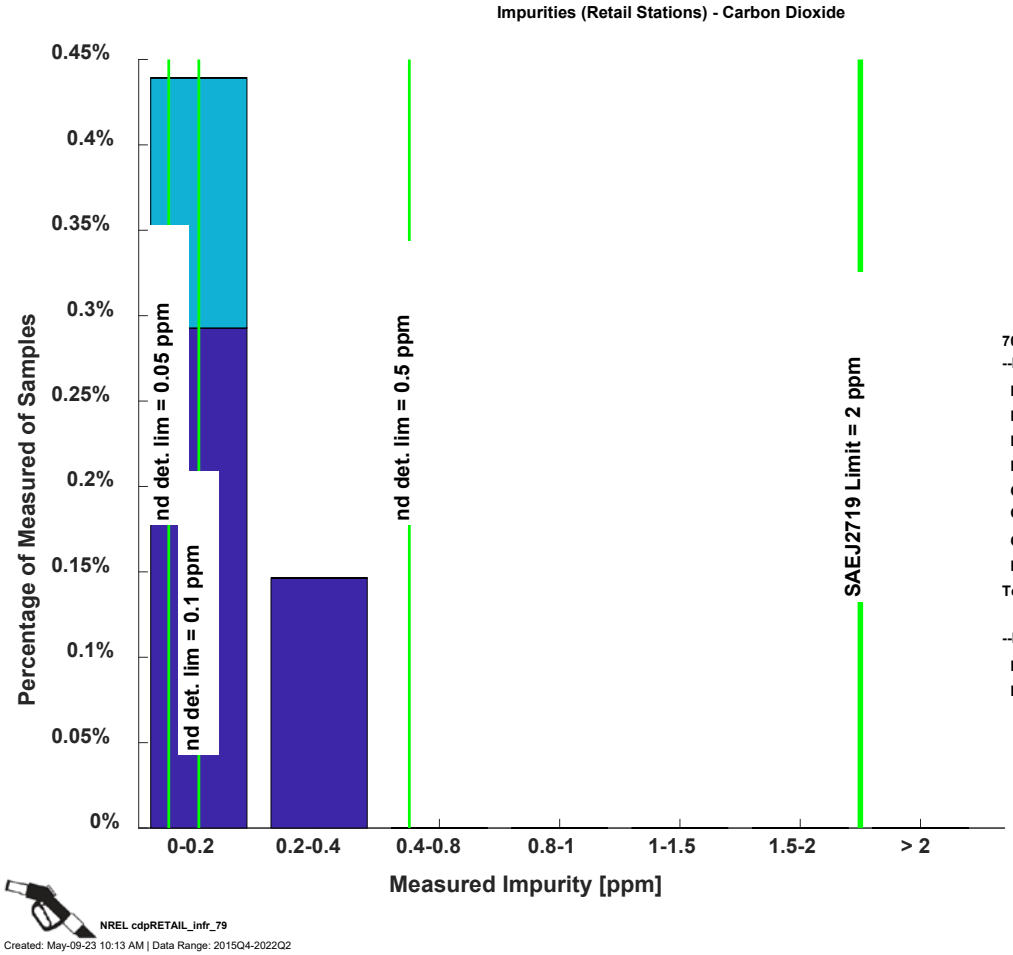
--Not Measured Summary--
Delivered Compressed 6 Sample(s)
Delivered Compressed; Onsite Electrolysis 2 Sample(s)

NREL cdpRETAIL_infr_79
Created: May-09-23 10:14 AM | Data Range: 2015Q4-2022Q2

CDP-INFR-79
Impurities—Argon



CDP-INFR-79
Impurities—Carbon Dioxide

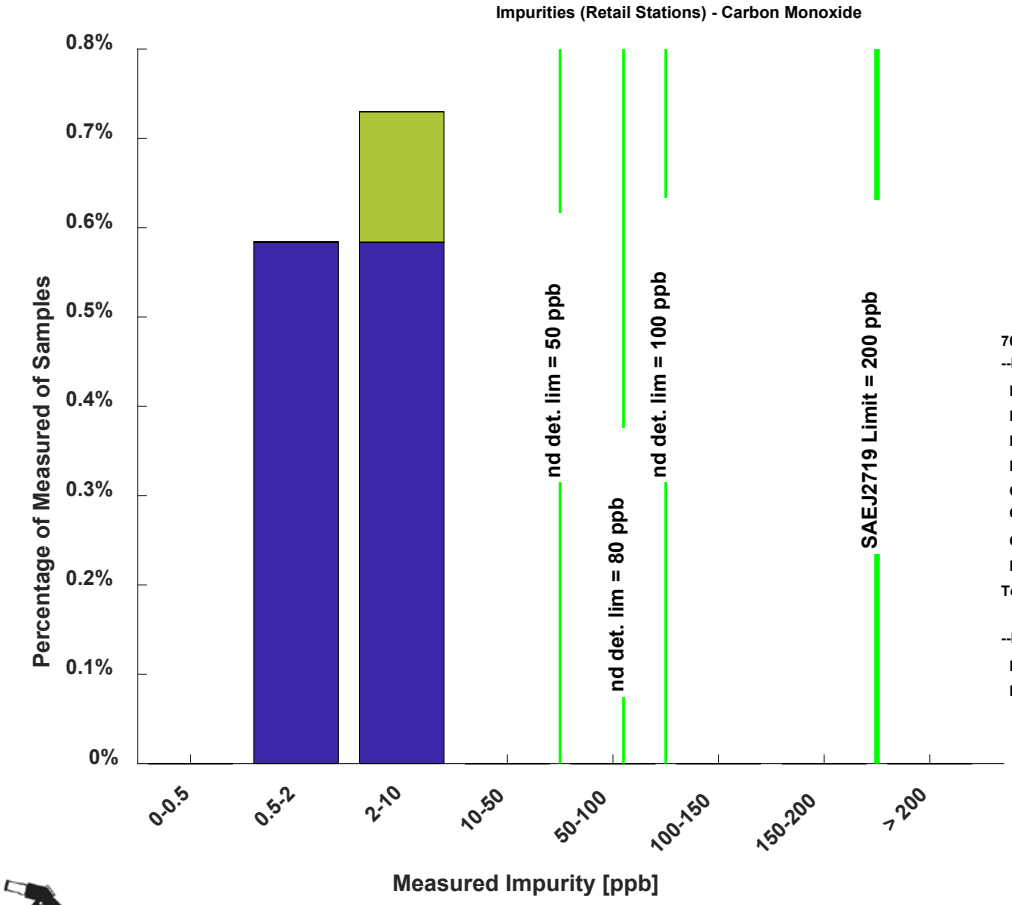


Delivered Compressed
Delivered Liquid
Delivered Pipeline
Delivered Compressed; Onsite Electrolysis
Onsite Electrolysis
Onsite SMR
Onsite SMR;Compressed Delivery
Biogas

700 Total Samples; 683 Total Measured for Carbon Dioxide
--Not Detected Summary--
Delivered Compressed 551 Sample(s) 80.7%
Delivered Liquid 54 Sample(s) 7.9%
Delivered Pipeline 2 Sample(s) 0.3%
Delivered Compressed; Onsite Electrolysis 3 Sample(s) 0.4%
Onsite Electrolysis 50 Sample(s) 7.3%
Onsite SMR 15 Sample(s) 2.2%
Onsite SMR;Compressed Delivery 2 Sample(s) 0.3%
Biogas 2 Sample(s) 0.3%
Total Samples Not Detected 679 (99.4%)

--Not Measured Summary--
Delivered Compressed 16 Sample(s)
Delivered Compressed; Onsite Electrolysis 1 Sample(s)

CDP-INFR-79
Impurities—Carbon Monoxide

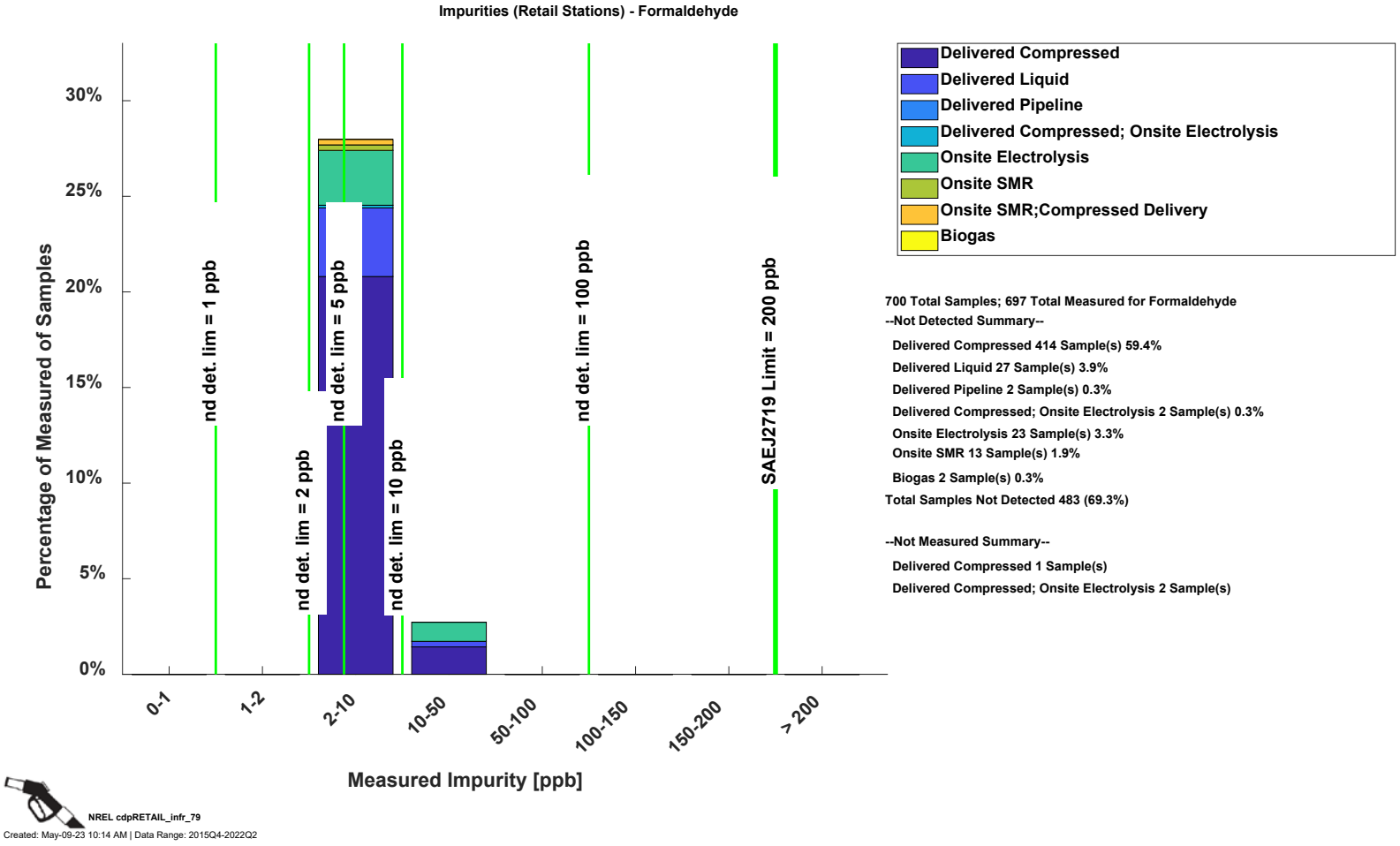


Delivered Compressed
Delivered Liquid
Delivered Pipeline
Delivered Compressed; Onsite Electrolysis
Onsite Electrolysis
Onsite SMR
Onsite SMR;Compressed Delivery
Biogas

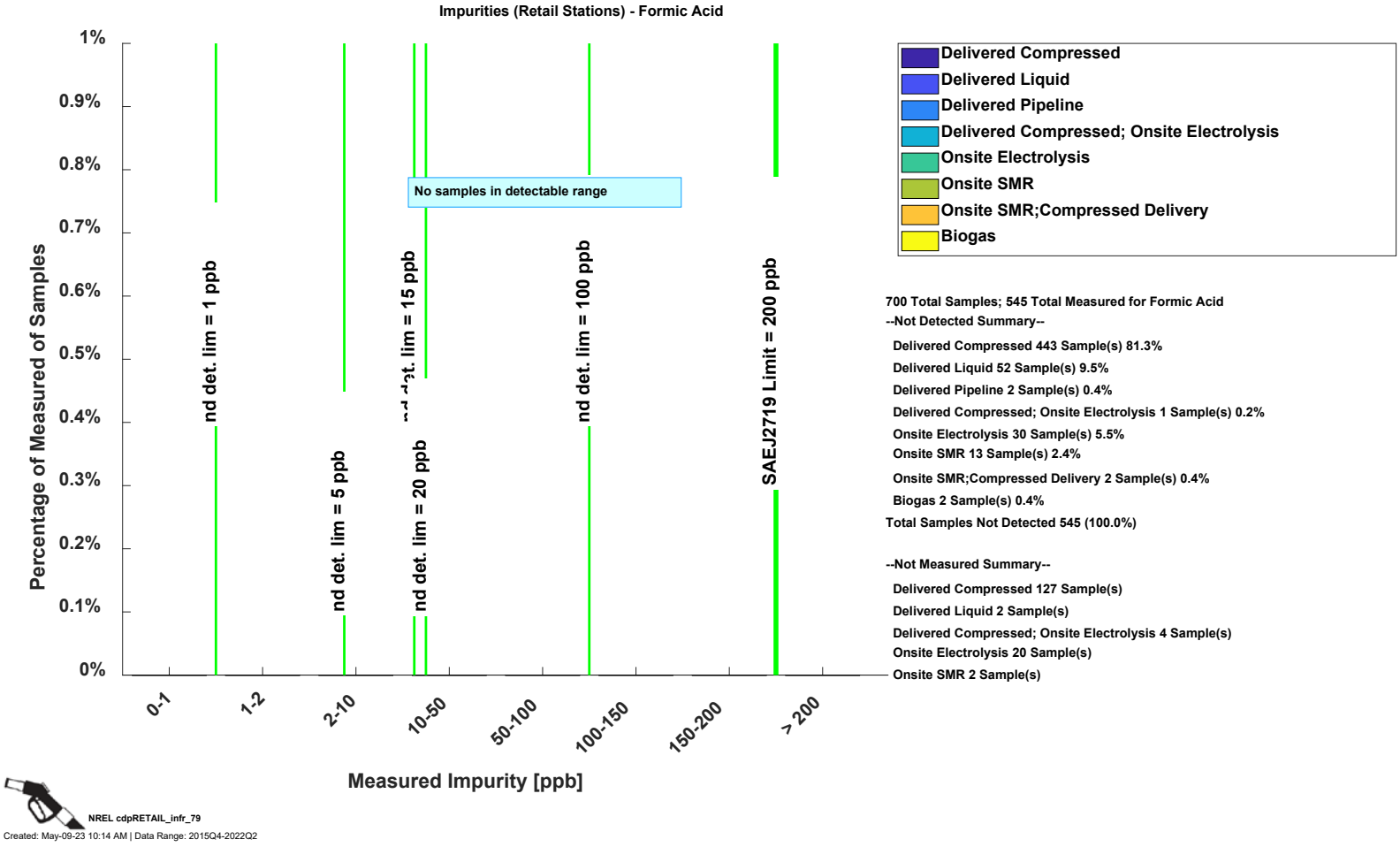
700 Total Samples; 685 Total Measured for Carbon Monoxide
--Not Detected Summary--
Delivered Compressed 549 Sample(s) 80.1%
Delivered Liquid 54 Sample(s) 7.9%
Delivered Pipeline 2 Sample(s) 0.3%
Delivered Compressed; Onsite Electrolysis 3 Sample(s) 0.4%
Onsite Electrolysis 50 Sample(s) 7.3%
Onsite SMR 14 Sample(s) 2.0%
Onsite SMR;Compressed Delivery 2 Sample(s) 0.3%
Biogas 2 Sample(s) 0.3%
Total Samples Not Detected 676 (98.7%)

--Not Measured Summary--
Delivered Compressed 13 Sample(s)
Delivered Compressed; Onsite Electrolysis 2 Sample(s)

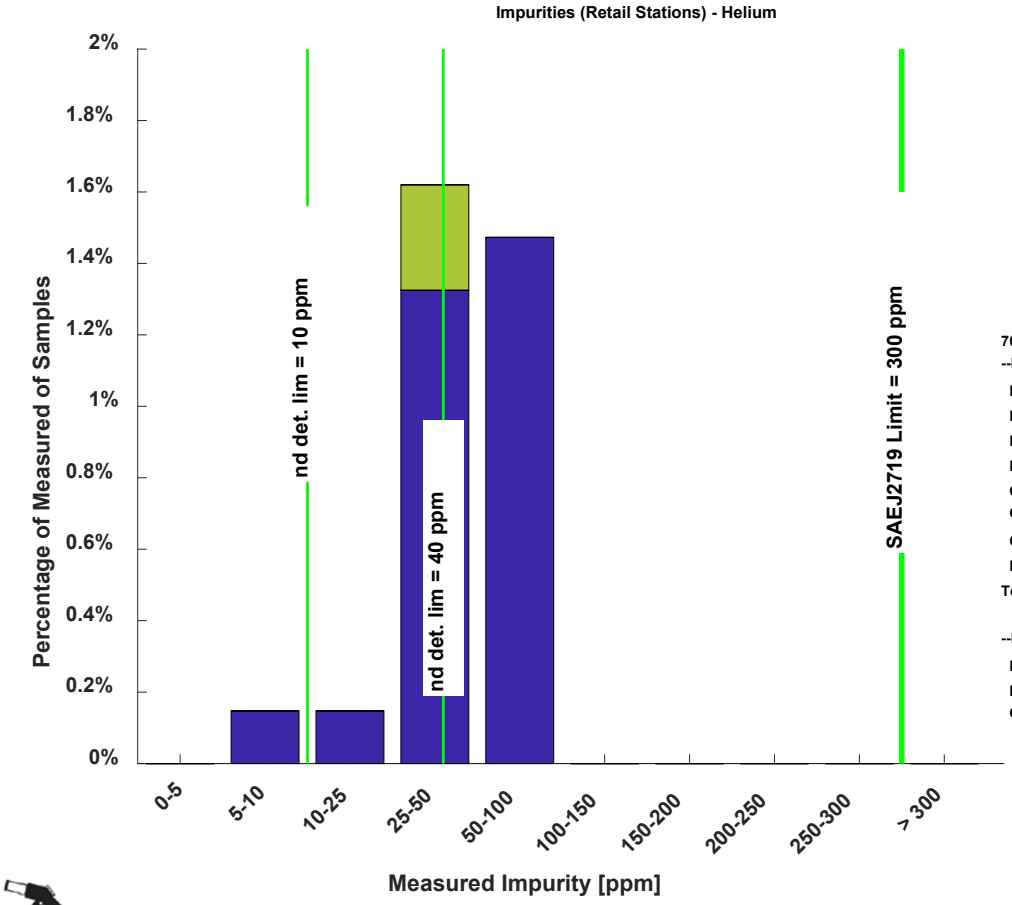
CDP-INFR-79
Impurities—Formaldehyde



CDP-INFR-79
Impurities—Formic Acid



CDP-INFR-79
Impurities—Helium

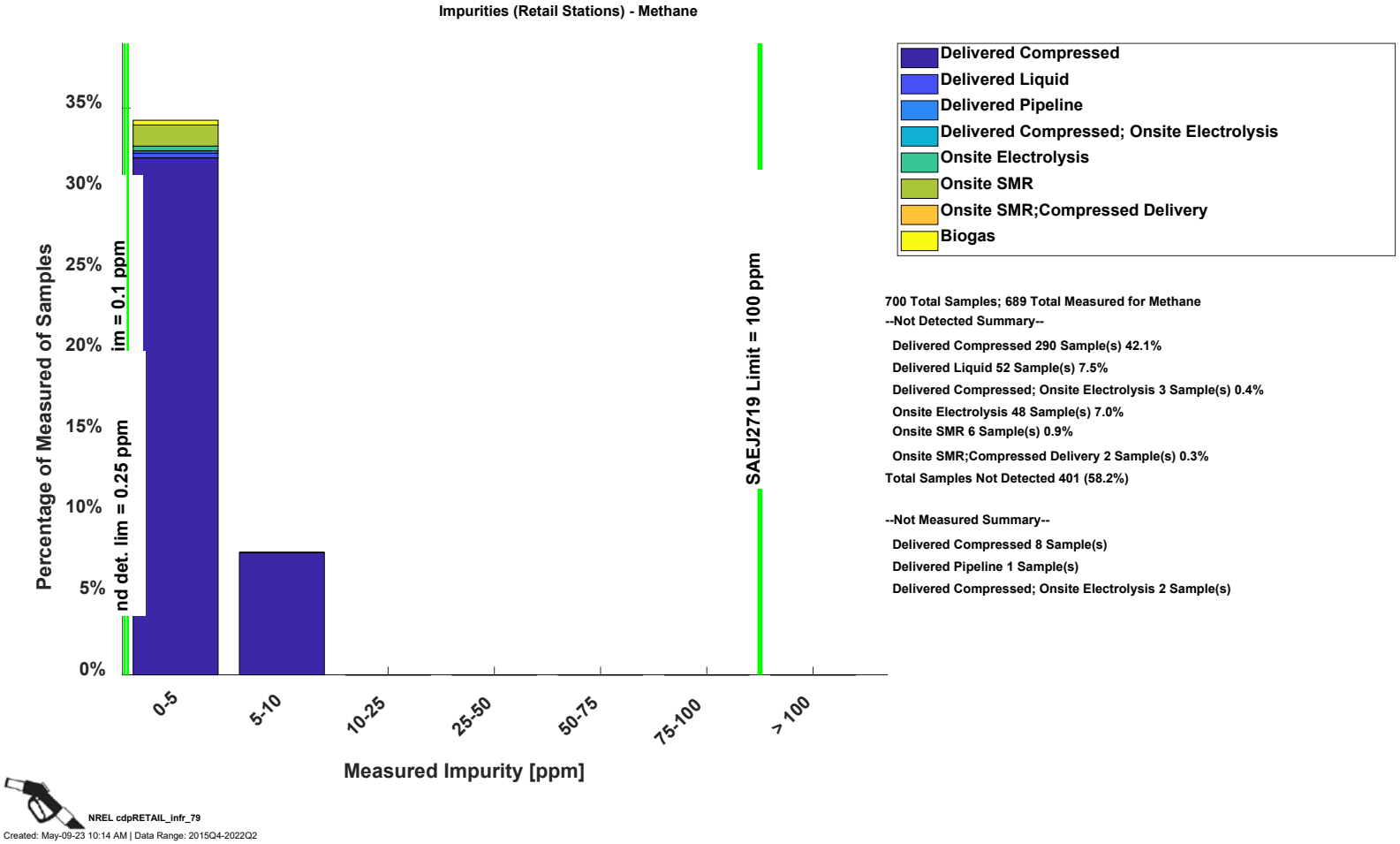


Delivered Compressed
Delivered Liquid
Delivered Pipeline
Delivered Compressed; Onsite Electrolysis
Onsite Electrolysis
Onsite SMR
Onsite SMR;Compressed Delivery
Biogas

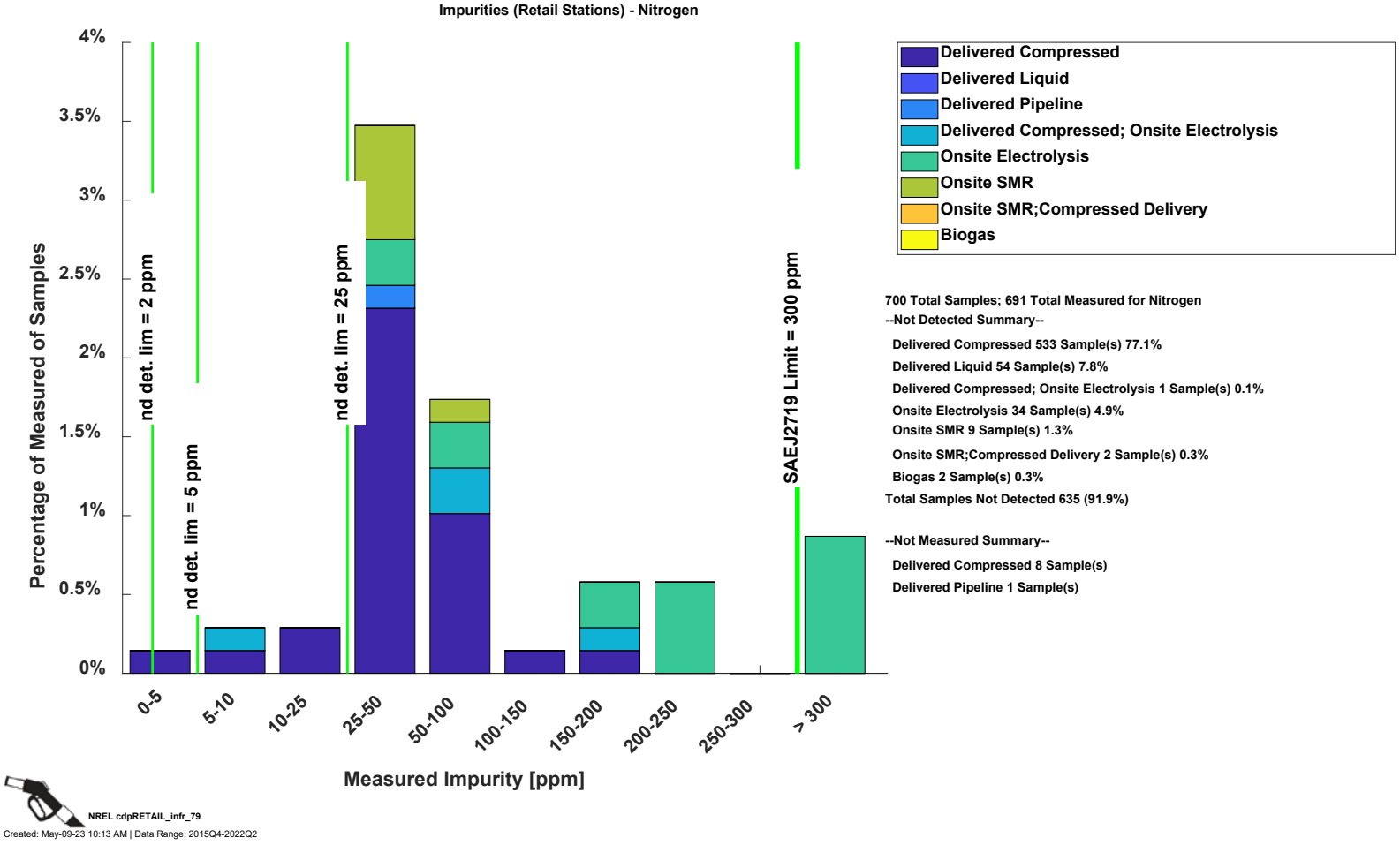
700 Total Samples; 679 Total Measured for Helium
--Not Detected Summary--
Delivered Compressed 532 Sample(s) 78.4%
Delivered Liquid 54 Sample(s) 8.0%
Delivered Pipeline 2 Sample(s) 0.3%
Delivered Compressed; Onsite Electrolysis 3 Sample(s) 0.4%
Onsite Electrolysis 48 Sample(s) 7.1%
Onsite SMR 13 Sample(s) 1.9%
Onsite SMR;Compressed Delivery 2 Sample(s) 0.3%
Biogas 2 Sample(s) 0.3%
Total Samples Not Detected 656 (96.6%)

--Not Measured Summary--
Delivered Compressed 17 Sample(s)
Delivered Compressed; Onsite Electrolysis 2 Sample(s)
Onsite Electrolysis 2 Sample(s)

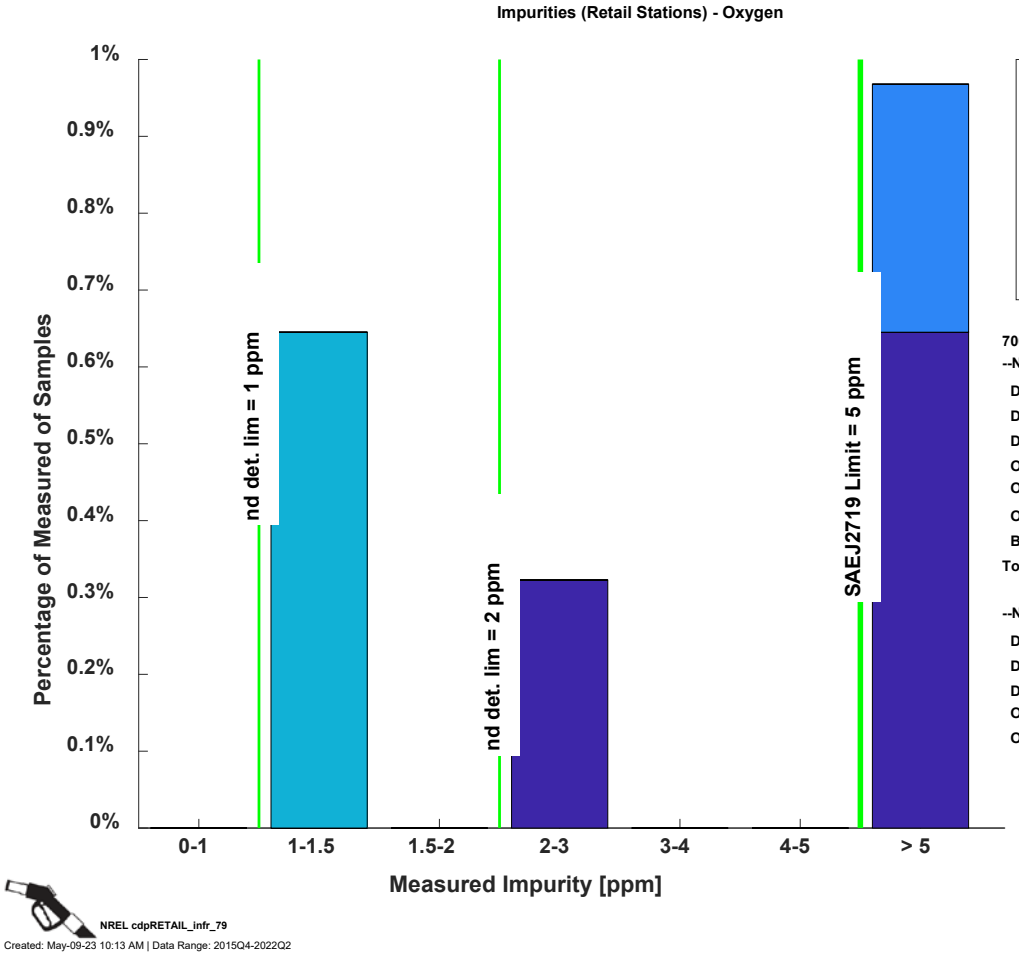
CDP-INFR-79
Impurities—Methane



CDP-INFR-79
Impurities—Nitrogen



CDP-INFR-79
Impurities—Oxygen

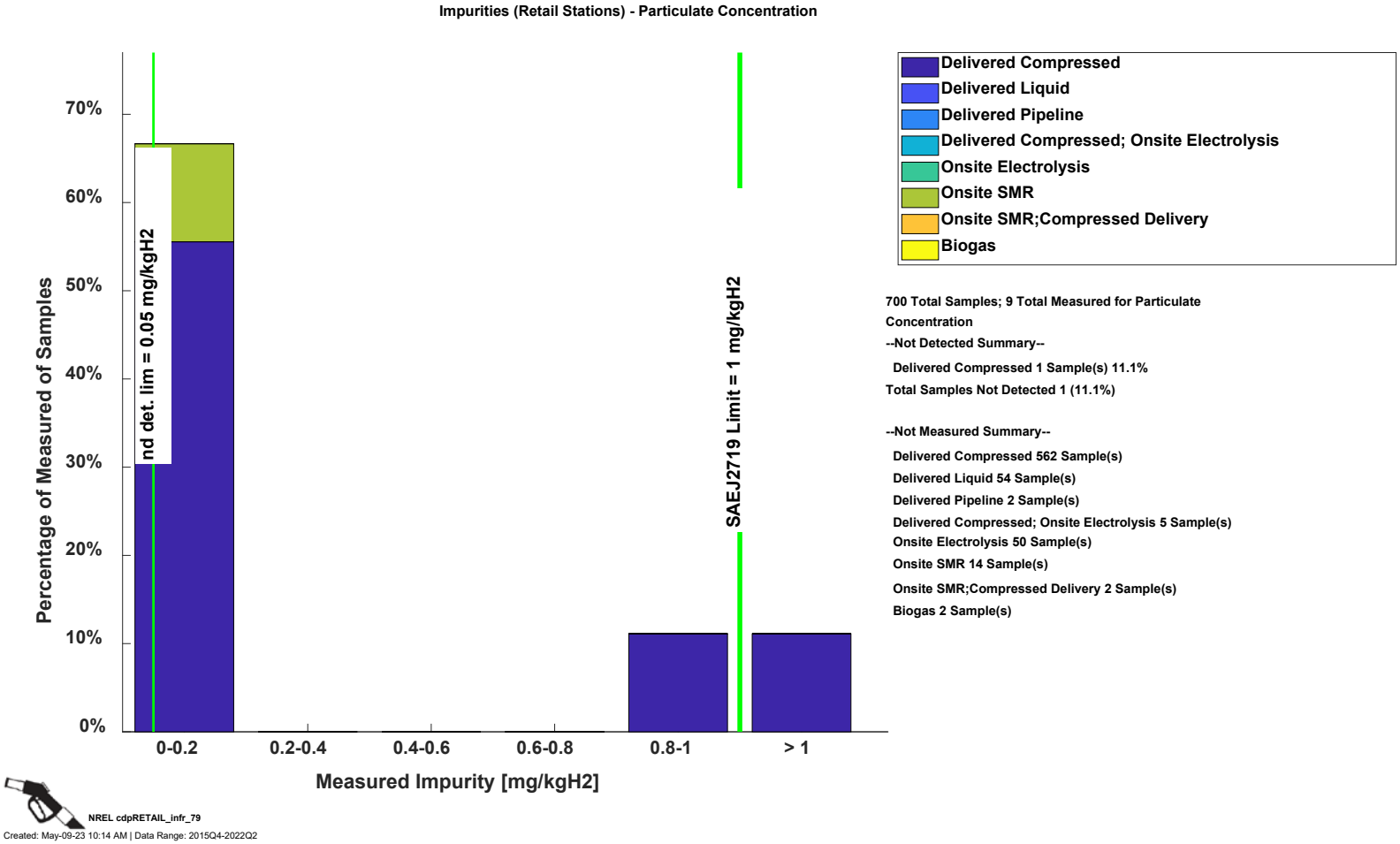


Delivered Compressed
Delivered Liquid
Delivered Pipeline
Delivered Compressed; Onsite Electrolysis
Onsite Electrolysis
Onsite SMR
Onsite SMR;Compressed Delivery
Biogas

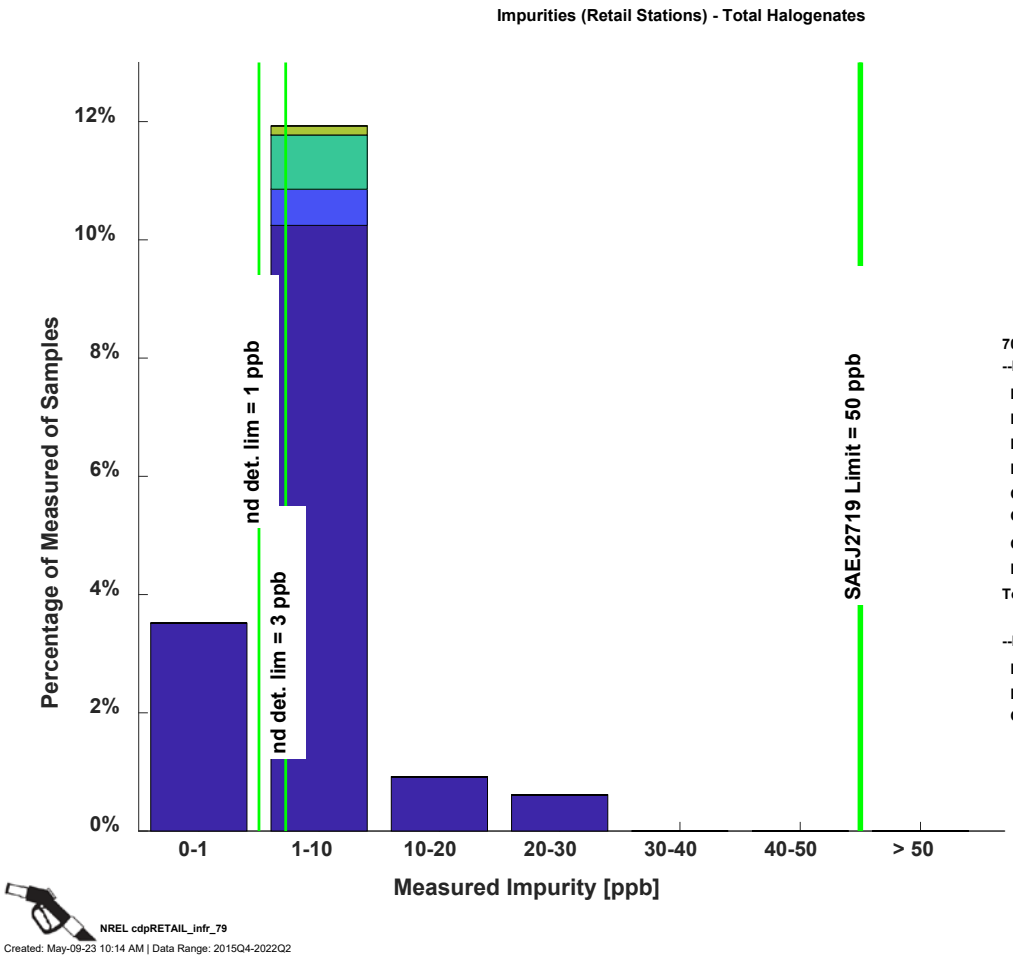
700 Total Samples; 310 Total Measured for Oxygen
--Not Detected Summary--
Delivered Compressed 242 Sample(s) 78.1%
Delivered Liquid 36 Sample(s) 11.6%
Delivered Pipeline 1 Sample(s) 0.3%
Onsite Electrolysis 14 Sample(s) 4.5%
Onsite SMR 7 Sample(s) 2.3%
Onsite SMR;Compressed Delivery 2 Sample(s) 0.6%
Biogas 2 Sample(s) 0.6%
Total Samples Not Detected 304 (98.1%)

--Not Measured Summary--
Delivered Compressed 325 Sample(s)
Delivered Liquid 18 Sample(s)
Delivered Compressed; Onsite Electrolysis 3 Sample(s)
Onsite Electrolysis 36 Sample(s)
Onsite SMR 8 Sample(s)

CDP-INFR-79
Impurities—Particulate Concentration



CDP-INFR-79
Impurities—Total Halogenates

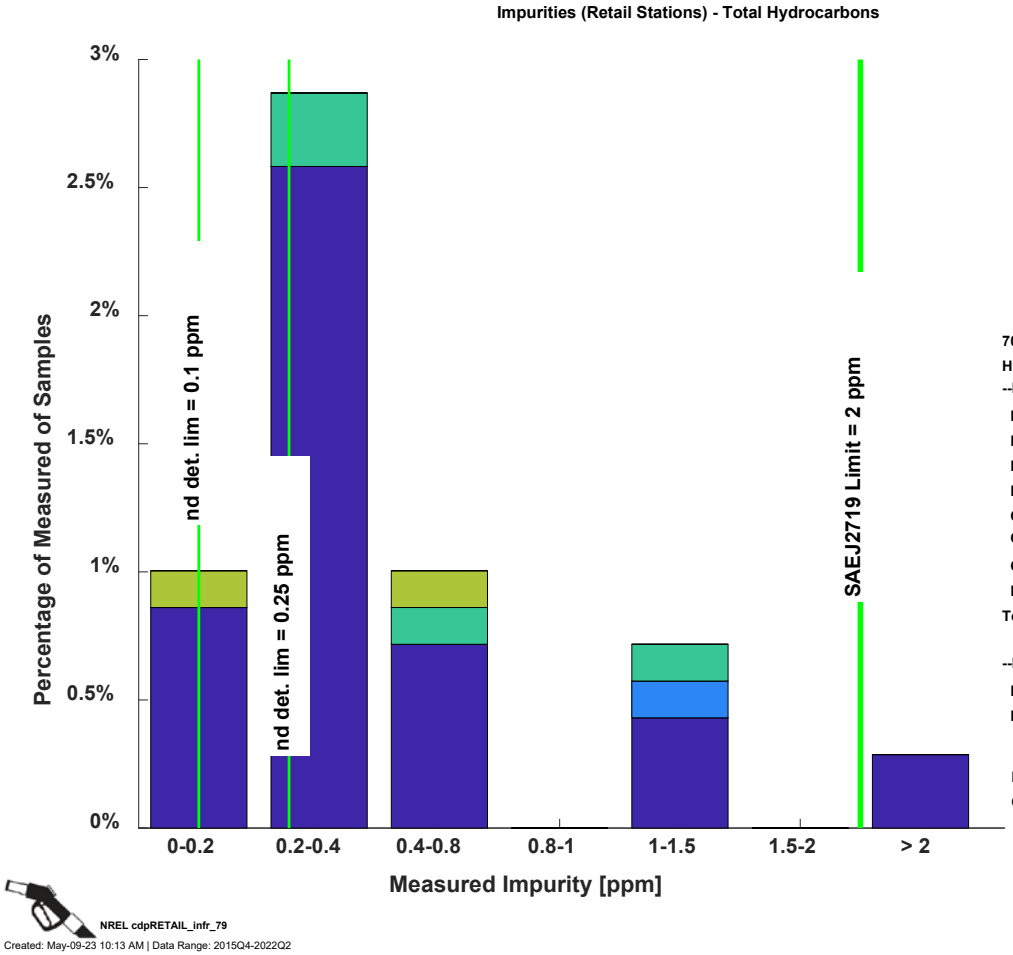


Delivered Compressed
Delivered Liquid
Delivered Pipeline
Delivered Compressed; Onsite Electrolysis
Onsite Electrolysis
Onsite SMR
Onsite SMR;Compressed Delivery
Biogas

700 Total Samples; 654 Total Measured for Total Halogenates
--Not Detected Summary--
Delivered Compressed 430 Sample(s) 68.0%
Delivered Liquid 50 Sample(s) 7.9%
Delivered Pipeline 2 Sample(s) 0.3%
Delivered Compressed; Onsite Electrolysis 3 Sample(s) 0.5%
Onsite Electrolysis 40 Sample(s) 6.3%
Onsite SMR 14 Sample(s) 2.2%
Onsite SMR;Compressed Delivery 2 Sample(s) 0.3%
Biogas 2 Sample(s) 0.3%
Total Samples Not Detected 543 (83.0%)

--Not Measured Summary--
Delivered Compressed 40 Sample(s)
Delivered Compressed; Onsite Electrolysis 2 Sample(s)
Onsite Electrolysis 4 Sample(s)

CDP-INFR-79
Impurities—Total Hydrocarbons



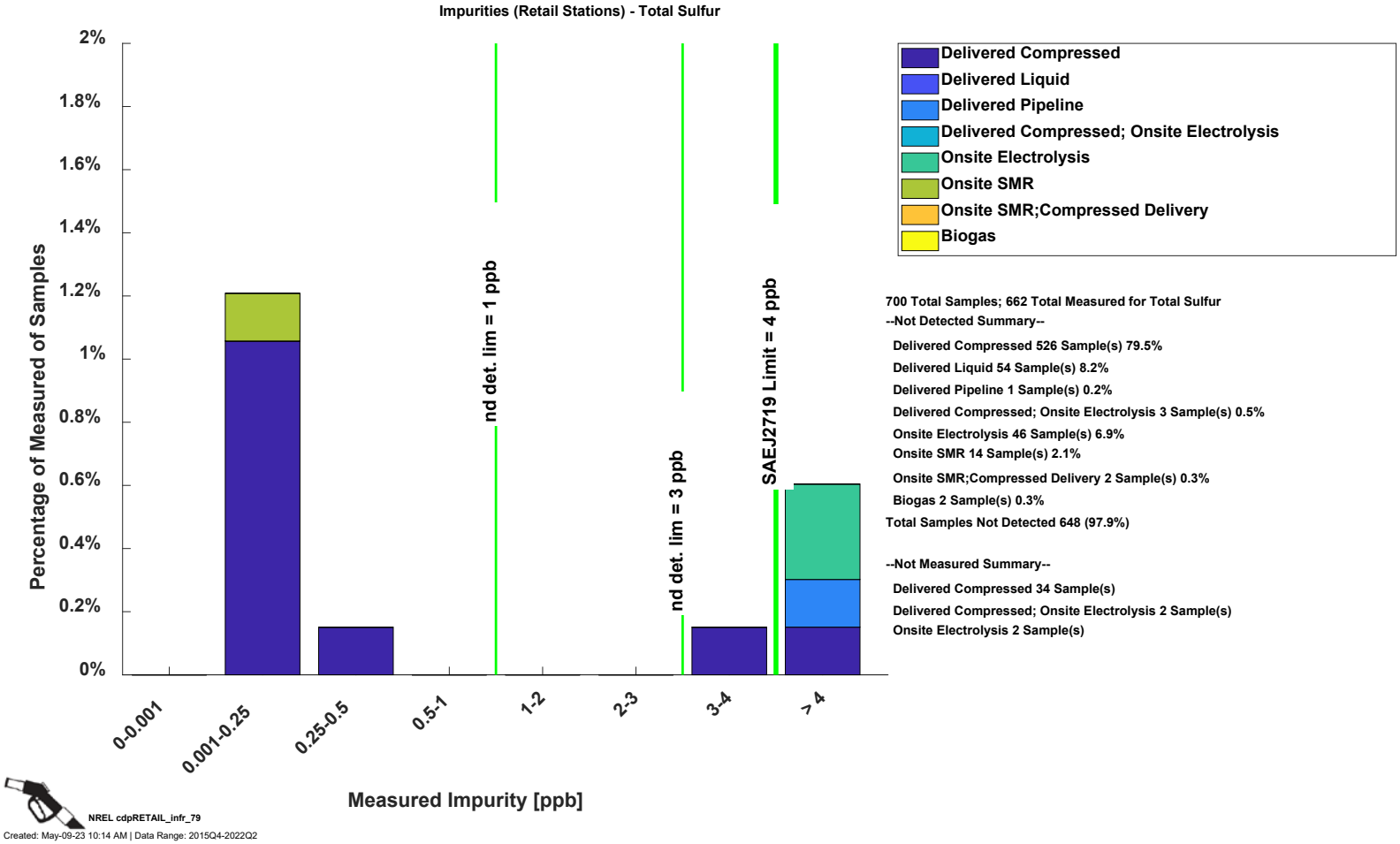
Delivered Compressed
Delivered Liquid
Delivered Pipeline
Delivered Compressed; Onsite Electrolysis
Onsite Electrolysis
Onsite SMR
Onsite SMR;Compressed Delivery
Biogas

700 Total Samples; 697 Total Measured for Total Hydrocarbons
--Not Detected Summary--
Delivered Compressed 535 Sample(s) 76.8%
Delivered Liquid 54 Sample(s) 7.7%
Delivered Pipeline 1 Sample(s) 0.1%
Delivered Compressed; Onsite Electrolysis 3 Sample(s) 0.4%
Onsite Electrolysis 46 Sample(s) 6.6%
Onsite SMR 13 Sample(s) 1.9%
Onsite SMR;Compressed Delivery 2 Sample(s) 0.3%
Biogas 2 Sample(s) 0.3%
Total Samples Not Detected 656 (94.1%)

--Not Measured Summary--
Delivered Compressed 1 Sample(s)
Delivered Compressed; Onsite Electrolysis 2 Sample(s)

Notes for exceeding SAE J2719 Limits:
Ok for Total HC = 3.2 (Methane = 3.2 ok per SAEJ2719)

CDP-INFR-79
Impurities—Total Sulfur



CDP-INFR-79
Impurities—Water