Next Generation Hydrogen Station Composite Data Products: All Stations (Retail and Non-Retail Combined)

Data through Quarter 4 of 2017

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May 2018
Hydrogen Station Project Partners

- Air Liquide
- Air Products
- California Air Resources Board
- California Energy Commission
- California State University Los Angeles
- FirstElement Fuel
- Gas Technology Institute
- Linde
- H2 Frontier
- Proton OnSite
- Shell
- IPHE and HySUT
Analysis Categories

- Deploy
- Performance
- Cost
- Utilization
- Reliability
- Safety
- Energy
- Quality
Deployment
CDP-INFR-11
Hydrogen Stations by Type

Hydrogen Station Type

- Delivered
- On-Site
- Other Projects

Number of Stations

- Delivered Pipeline
- Liquid Delivery
- Compressed Delivery
- Onsite SMR
- Onsite Electrolysis
- Mobile Fueler
- Trailers

Legend:
- Retired
- Future
- Open

Created: May-04-18 11:52 AM | Data Range: 2014Q3-2017Q4
Hydrogen Station Timeline

Duration [days]
Safety
Safety (and Maintenance) Learnings
From Safety Reports Template

- Alarms not communicated
- Breakaway leak
- Check compressor oil filter
- Check integrity of delivered equipment
- Compressor leaking at startup normal?
- Does isolated leak need to shut down station?
- Electrical glitch
- Estop activated after hearing escaping gas-nitrogen
- Estop activated when nozzle stuck on car
- Estop activated without cause
- Estop flooded prevented restart
- False Alarm - No Fire
- Fill and leak check together caused shutdown - false leak alarm
- Filter to catch scrap from material processing
- Forgot to turn back on after maintenance
- Freezing and thawing caused moisture in communication connector
- Frozen cooling block - defrost
- HTO sensor fault
- Heat trace short caused false fire alarm
- Heavy rain triggered fire alarm
- Hose vent failure - nozzle stuck on car
- Loose wire intermittent problems
- Loud popping could be relief valve
- Mass balance alarm bug
- Mass balance alarm caused by high ambient temperature
- Power Issue - 3 Phase
- Predict service life better
- Proper installation prevents leaks
- Rain on sensor causing alarm
- Regular inspection of compressor valves
- Regular leak checks
- Regular station inspection
- Reset
- Spider web obscuring sensor
- Thermocouple failure shutdown station
- Vibration from normal activity shutdown dispenser
- Vibration isolation
An Incident is an event that results in:
- a lost time accident and/or injury to personnel
- damage/unplanned downtime for project equipment, facilities or property
- impact to the public or environment
- any hydrogen release that unintentionally ignites
- release of any volatile, hydrogen containing compound (including the hydrocarbons used as common fuels)

A Near Miss is:
- an event that under slightly different circumstances could have become an incident
- any hydrogen release sufficient to sustain a flame if ignited

A Minor H2 Leak is:
- an unplanned hydrogen release insufficient to sustain a flame, and does not accumulate in sufficient quantity to ignite
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- an unplanned hydrogen release insufficient to sustain a flame, and does not accumulate in sufficient quantity to ignite
CDP-INFR-48
Mean Fills per Hydrogen Leak

Station Average: 971 Fills per H₂ Leak.

9 of 34 stations did not report leaks.
Mean Hydrogen Dispensed per Hydrogen Leak

Station Average: 3415 kg H$_2$ Dispensed per H$_2$ Leak.

9 of 34 stations did not report leaks.
Maintenance and Reliability
Maintenance by Equipment Type

Total Events\(^1\) = 7,913
58% unscheduled

- dispenser: 35%
- compressor: 24%
- entire: 20%
- chiller: 17%
- safety: 8%
- storage: 8%
- electrical: 7%
- air: 7%

Total Hours\(^1\) = 23,907
57% unscheduled

Event Count
- multiple systems: 1015

MISC includes the following failure modes: stack, fuel, electrolyzer, purifier, feedwater, gas mgmt panel, reformer, station other, thermal management, other.

\(^1\) Total includes classified events (plotted) and unclassified events.
CDP-INFR-22
Maintenance Labor Hours per Event

73% of repairs require less than the mean of 4.3 hours of labor.
Median labor hours: 2.9
CDP-INFR-23
Equipment Category Repair Time

![Equipment Category Repair Time Chart]

- 75th Percentile
- Mean
- Median
- 25th Percentile

NREL cdp_inf_23
Created: May-05-16 12:38 AM | Data Range: 2011Q1-2017Q4
Failure Modes for Top Equipment Categories

**Total Event Count**
- **SAFETY**: 9%
- **ENTIRE**: 18%
- **COMPRESSOR**: 21%
- **DISPENSER**: 33%

**Total Labor Hours**
- **SAFETY**: 6%
- **ENTIRE**: 20%
- **COMPRESSOR**: 25%
- **DISPENSER**: 28%

**Legend**
- COMMUNICATION ERROR
- FAILED PART
- NA
- OUT OF CALIBRATION
- UNDETERMINED
- MISC
- SCHEDULED (PREV MAINT, UPGRADES)

*MISC includes the following failure modes: animal damage, collision, communication error, contamination, corrosive maintenance, debris, design flaw, electrical breaker, end of life, environmental factors, fluid temp, freezing, installation error, inspect trouble alarm or report, level low, loose electrical, loose mechanical, lost signal, maintenance error, manufacturing defect, material deform/degrade/fatigue, moisture, na, operator error, operator protocol, out of calibration, over-temperature, power outage/quality, pressure loss, software bug, stress outside design limit, light, vandalism, vibration, preventative maintenance, other*

*Percentage of total events or hours.
Compressor Monthly Maintenance

Overall Averages
13 hours per station per month.
422 kg dispensed per maintenance hour.

Overall Averages
3 events per station per month.
901 kg dispensed per maintenance event.

*Trendlines connect continuous months 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.*
Maintenance Labor Hours by Quarter

Overall Average:
107 hours per station per quarter.

Stars represent individual station maintenance hours in a given quarter.
Overall Average: $12,670 per station per quarter.
Mean Fills Between Failures

- Median Site
- Lowest Site

- AIR
- CHILLER
- COMPRESSOR
- DISPENSER
- ELECTRICAL
- ELECTROLYZER
- ENTIRE
- FEEDWATER
- GAS MGMT PANEL
- REFORMER
- SAFETY
- STATION OTHER
- STORAGE
- SUMMARY
- THERMAL MANAGEMENT
CDP-INFR-50
Reliability Growth by Fills

2. % change in instantaneous mean Fills between failures
CDP-INFR-51
Mean Amount Dispensed Between Failures

Mean $H_2$ Dispensed Between Failures (kg)

- Median Site
- Lowest Site

Legend:
- Median Site
- Lowest Site

Bar Chart:
- Mean $H_2$ Dispensed Between Failures (kg)
- Categories: Air, Chiller, Compressor, Dispenser, Electrical, Electrolyzer, Entire, Feedwater, Gas Mgmt Panel, Reformer, Safety, Station Other, Storage, Summary, Thermal Management

Created: May-04-18 8:29 PM | Data Range: 2/11/01-2/17/04
CDP-INFR-52
Reliability Growth by Amount Dispensed

Overall Site Reliability Growth By $H_2$ Dispensed (kg)

Instantaneous MTBF improved for 19 of 34 sites for the last 20% of events.

Sites sorted by Increasing Age $H_2$ Dispensed (kg)

2. % change in instantaneous mean $H_2$ Dispensed (kg) between failures
Historical Failure Rate (bathtub curve) by Fills

\[ \rho = \lambda \, \beta \, \text{Fills}^{(\beta-1)} \]

\[ \lambda = 1.118 \]

\[ \beta = 0.652 \]

15 Mean Fills per Failure at 1000 Fills
Historical Failure Rate (bathtub curve) by kg $H_2$ Dispensed

$\rho = \lambda \beta \text{ kg } H_2 \text{ Dispensed}^{(\beta-1)}$

$\lambda = 0.795$

$\beta = 0.659$

35 Mean kg $H_2$ Dispensed per Failure

at 5000 kg $H_2$ Dispensed
Mean Fills per H₂ Leak Over Time

Average for all stations reporting:
274 Fills per H₂ Leak.
9 of 34 stations did not report leaks.
Mean Hydrogen Dispensed per Leak Over Time

Average for all stations reporting: 848 kg H₂ Dispensed per H₂ Leak. 9 of 34 stations did not report leaks.
Maintenance Causes and Effects
Subsystem: SAFETY
Component: ENTIRE

Preventative Maintenance accounted for 92% of all events. Suppressed in the plot to show detail for other causes.
Maintenance Causes and Effects

Subsystem: SAFETY
Component: SENSOR

Preventative Maintenance accounted for 53% of all events. Suppressed in the plot to show detail for other causes.
Maintenance Causes and Effects

Subsystem: SAFETY
Component: SOFTWARE

Causes

Effects

Preventative Maintenance accounted for 71% of all events.
Suppressed in the plot to show detail for other causes.
Maintenance Causes and Effects

Subsystem: DISPENSER
Component: ENTIRE

Causes

Effects

Preventative Maintenance accounted for 27% of all events. Suppressed in the plot to show detail for other causes.
Maintenance Causes and Effects

Subsystem: DISPENSER
Component: FITTING

- Preventative Maintenance accounted for 0% of all events. Suppressed in the plot to show detail for other causes.

 Causes

- MATERIAL DEFORM/DEGRADE/FATIGUE
- TIGHT
- UNDETERMINED
- LOOSE MECHANICAL
- ENVIRONMENTAL FACTORS
- UNDETERMINED

 Effects
Maintenance Causes and Effects

Subsystem: DISPENSER
Component: NOZZLE

Preventative Maintenance accounted for 4% of all events. Suppressed in the plot to show detail for other causes.
Maintenance Causes and Effects
Subsystem: COMRESSOR
Component: ENTIRE

Preventative Maintenance accounted for 45% of all events. Suppressed in the plot to show detail for other causes.
Maintenance Causes and Effects

Subsystem: COMPRESSOR
Component: VALVE

Causes

Effects
Maintenance Causes and Effects
Subsystem: COMPRESSOR
Component: SEAL

Preventative Maintenance accounted for 6% of all events. Suppressed in the plot to show detail for other causes.
Performance
CDP-INFR-01
Hydrogen Dispensed by Quarter

Hydrogen Dispensed By Quarter

Cumulative Hydrogen Dispensed = 642,865 kg

By Year

- 2017: 440,361 kg
- 2016: 109,341 kg
- 2015: 27,431 kg
- 2014: 19,738 kg
- 2013: 16,335 kg
- 2012: 17,433 kg
- 2011: 18,055 kg
- 2010: 2,260 kg
- 2009: 1,910 kg

H2 Dispensed [1,000 kg]

Note: Colors represent individual stations
CDP-INFR-58
Hydrogen Fills by Quarter

Hydrogen Fills By Quarter

Cumulative Fuelings = 221,677

By Year

2017: 146,174 kg
2016: 39,347 kg
2015: 9,873 kg
2014: 6,845 kg
2013: 6,383 kg
2012: 7,164 kg
2011: 3,539 kg
2010: 1,233 kg
2009: 1,119 kg

Note: Colors represent individual stations
Hydrogen Dispensed by Region

Cumulative Hydrogen Dispensed
Northern California = 167,286 kg
Southern California = 419,181 kg
Connector California = 17,383 kg
Histogram of Fueling Rates

203,210 Events
Average = 0.8 kg/min
1.2% > 1.51 kg/min
0.4% > 2 kg/min

2.5 minute fill of 5 kg
Histogram of Fueling Amounts

Average = 3.02 kg
Histogram of Time Between Fuelings

- Back-to-Back Fills
- 14% of fills are within 0-5 minutes of each other
- 65% of fills have more than 20 minutes between them
- 204723 Total Fills

Final Pressures for Fills with <5 Minutes in Between

- Previous Fill
- Next Fill

*Time is from end of fill to start of next fill.
Fueling Final Pressures

- **350 bar Fills (200 to 450 bar)**
  - Avg Final Pressure = 343 bar
  - % of Fills > 350 bar = 46%
  - Number of Fills = 12291

- **700 bar Fills (> 450 bar)**
  - Avg Final Pressure = 767 bar
  - % of Fills > 700 bar = 89%
  - Number of Fills = 167280

*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

Histogram of Fueling Rates
350 vs 700 bar Fills

Fill Type | Avg | %>1.51 | %>2 | Count
----------|-----|--------|-----|------
350 bar   | 0.70| 2.9%   | 1.0%| 13819
700 bar   | 0.84| 1.0%   | 0.6%| 190342

2.5 minute fill of 5 kg
CDP-INFR-90
Hydrogen Dispensed by Quarter and Pressure
CDP-INFR-13
Number of Fueling Events per Hour

Number of Fuelings Per Hour

Average: 2.1 per hour
Median: 2.0 per hour
Max: 32.0 per hour
Hydrogen Dispensed Per Hour

Average: 6.4 kgs per hour
Median: 5.0 kgs per hour
Max: 89.6 kgs per hour
Number of Filling Events per Time of Day

- H2 Fueling
- Gasoline Profile

Number Included: 209,383 fills

Time of Day [hours]

Fueling Amounts per Time of Day

Amount Included
638,596 kg

Total [%]
Max [kg]
Average [kg]
CDP-INFR-17
Fueling Rates by Amount Filled
CDP-INFR-18
Fueling Amount vs. Time to Fill

Histogram of Fueling Amount Vs Time

1/1/2014 Through 7/1/2014
Amount [kg]
0 1 2 3 4 5 6 7
Fill Time [min] 0 5 10 15

7/1/2014 Through 1/1/2015
Amount [kg]
0 1 2 3 4 5 6 7
Fill Time [min] 0 5 10 15

1/1/2015 Through 7/1/2015
Amount [kg]
0 1 2 3 4 5 6 7
Fill Time [min] 0 5 10 15

7/1/2015 Through 1/1/2016
Amount [kg]
0 1 2 3 4 5 6 7
Fill Time [min] 0 5 10 15

1/1/2016 Through 7/1/2016
Amount [kg]
0 1 2 3 4 5 6 7
Fill Time [min] 0 5 10 15

7/1/2016 Through 1/1/2017
Amount [kg]
0 1 2 3 4 5 6 7
Fill Time [min] 0 5 10 15

1/1/2017 Through 7/1/2017
Amount [kg]
0 1 2 3 4 5 6 7
Fill Time [min] 0 5 10 15

7/1/2017 Through 1/1/2018
Amount [kg]
0 1 2 3 4 5 6 7
Fill Time [min] 0 5 10 15

Number of Fills
0 500 1000 1500 2000 2500

Created: May-06-18 11:15 AM | Data Range: 2008Q3-2017Q4
CDP-INFR-56
Fueling Rates by Year

Histogram of Fueling Rates
By Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Avg (kg/min)</th>
<th>%&gt;1.51</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>0.66</td>
<td>4%</td>
</tr>
<tr>
<td>2012</td>
<td>0.56</td>
<td>3%</td>
</tr>
<tr>
<td>2013</td>
<td>0.54</td>
<td>3%</td>
</tr>
<tr>
<td>2014</td>
<td>0.70</td>
<td>11%</td>
</tr>
<tr>
<td>2015</td>
<td>0.61</td>
<td>6%</td>
</tr>
<tr>
<td>2016</td>
<td>0.83</td>
<td>1.4%</td>
</tr>
<tr>
<td>2017</td>
<td>0.88</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

3.3 minute fill of 5 kg
2.5 minute fill of 5 kg
CDP-INFR-29
Monthly Averages: 700 bar Fills >1 kg with Pre-Cool of -20°C

Monthly Averages for 700 bar Fills >1 kg with Pre-Cool of -20°C

- Rate [kg/min]:
  - Overall Avg
  - Individual Station Avg
  - Avg: 0.63

- Time [min]:
  - Overall Avg
  - Individual Station Avg
  - Avg: 6.2

- Amount [kg]:
  - Overall Avg
  - Individual Station Avg
  - Avg: 3
Monthly Averages for All Fills

- Overall Avg: 0.83
- Individual Station Avg

- Time [min]: Avg: 4

- Amount [kg]: Avg: 3

Created: May-15-18 6:01 PM | Data Range: 2005Q3-2017Q4
Monthly Averages: 700 bar Fills >1 kg with Pre-Cool of -40°C

Monthly Averages for 700bar Fills >1kg with Pre-Cool of -40 C (SAEJ2601)

- **Rate [kg/min]**
  - Overall Avg
  - Individual Station Avg
  - Avg: 0.88

- **Time [min]**
  - Overall Avg
  - Individual Station Avg
  - Avg: 3.8

- **Amount [kg]**
  - Overall Avg
  - Individual Station Avg
  - Avg: 3.2
Fuel Temperature at Receptacle (°C) 30 sec after start of fill

1. SAE J2601 (2014) defines fuel delivery temperature as measured near the dispenser breakaway. See paragraph 4.21. Temperature data here are from HyStEP tests measuring fuel temperature just downstream of the receptacle. SAE J2601 requires that fuel delivery temperature reach the limits shown in blue above within 30 seconds of the start of fueling.
Cost
Compressor Operation Cost

Average = 2.29 [$/kg]

Data Points Reported

Electrical Energy Cost per kg [$/kg]
Average Station Cost by Category

Budget Amounts* (Avg Total = $2.2M), 46 Stations

- 84%
- 5%
- 4%
- 8%

*Based on budgeted data from station awards (includes cost share)
**Station includes: Hydrogen Equipment and Station Engineering, Design, Fabrication, Procurement, Site Preparation, Installation, and Construction
***Data Reporting includes quarterly reporting on performance, operation and maintenance
Station Cost*

*Based on budgeted data from station awards.
CDP-INFR-43
Station Cost by Type

Station Cost by Type*

*Based on California Energy Commission data that includes costs reported through 2016Q3.
**Cost share represents funding from sources outside CEC award.
Histogram of Monthly Maintenance Costs

- Total Quarterly Maintenance Cost
- Mean Quarterly Maintenance Cost

Frequency of Quarterly Cost vs. Total Quarterly Cost [$1,000s]

- Costs range from $0 to $30,000s
- Frequency peaks around $13,000s
Overall Average: $25 per kg.

*Each color represents a unique station. 3 data points excluded that were over $1000/kg.
Utilization
Dispensed Hydrogen per Day of Week

max station avg: 111 kg/day

Station Capacity Utilization

- Maximum Daily Utilization
- Maximum Quarterly Utilization
- Average Daily Utilization

Note: The focus for early stations is geographic coverage.

1 Station 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.

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

Maximum Daily Fills
Average Daily Fills

Note: The focus for early stations is geographic coverage

Fills Per Day

Station (Sorted By Increasing Station Capacity)

Station Usage

1 Excludes hydrogen fills of < 0.5 kg
2 Average daily fills considers only days when at least one fill occurred
CDP-INFR-20
Number of Fills by Month

Number of Fills By Month

- Individual station
- Average of all stations
CDP-INFR-74
Hydrogen Dispensed by Station Type

Hydrogen Dispensed By Station Type

- Individual station - Retail
- Individual station - Non-Retail
- Average of retail stations
- Average of non-retail stations

Monthly Amount [kg]

Years: 2009 to 2018
Station Capacity Utilization Trends by Quarter

Number of Stations = 38 Total
Total H2 Dispensed = 638,930 kg

Range of Station Capacities

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.
CDP-INFR-45
Station Amount Dispensed by Quarter

Station Amount Dispensed by Quarter

Number of Stations = 38 Total
Total H2 Dispensed = 638,930 kg

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.
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 days in a quarter are excluded from the average for that quarter. All stations with at least one fill in a quarter are given equal weight when calculating the average for the quarter.
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 occurred.
3. Utilization is calculated by dividing the quarterly amount dispensed by the stations nameplate capacity.
4. Only quarters with fills are included.
CDP-INFR-80
Daily Fueling Amounts by Station

Daily Fueling Amounts

kg [at 70MPa]

kg [at 35MPa]

kg [All]

Daily Avg. 28.1 kg

Daily Avg. 5.8 kg

Daily Avg. 26.9 kg

Stations

Created: May-04-16 4:56 PM | Data Range: 2005Q3-2017Q4
Daily Fueling Amounts by Month

Daily Fueling Amounts Over Time

- 70MPa [kg]
  - Daily Average per Month

- 35MPa [kg]

- All [kg]

*Daily average only includes days with fills.
Hydrogen Quality
68 of 86 samples (79%) met the SAE J2719 guidelines. Consecutive samples may be for a single issue.

Values are in micromole/mole, except for particulate size (Psize) in micrometer. Only values that exceed SAE J2719 guideline are shown in text. Left edge of text box aligns with date.
CDP-INFR-79
Impurities—Ammonia
CDP-INFR-79
Impurities—Argon
CDP-INFR-79
Impurities—Carbon Dioxide

17 Total Samples
--- Not Detected Summary ---
Delivered Compressed 7 Sample(s)
Onsite Electrolysis 4 Sample(s)
Onsite SMR 3 Sample(s)
--- Not Measured Summary ---
Onsite Electrolysis 1 Sample(s)
Delivered Compressed; Onsite Electrolysis 1 Sample(s)
Onsite SMR 1 Sample(s)
CDP-INFR-79
Impurities—Carbon Monoxide
Impurities—Formic Acid

[Bar chart showing the number of samples at different impurity levels and the limits for different delivery methods.]

- Delivered Compressed
- Delivered Liquid
- Delivered Pipeline
- Onsite Electrolysis
- Delivered Compressed; Onsite Electrolysis
- Onsite SMR

17 Total Samples
- Not Detected Summary
  - Delivered Compressed: 7 Sample(s)
  - Onsite Electrolysis: 4 Sample(s)
  - Onsite SMR: 3 Sample(s)
- Not Measured Summary
  - Onsite Electrolysis: 1 Sample(s)
  - Delivered Compressed; Onsite Electrolysis: 1 Sample(s)

SAE J2719 Limit = 200 ppb

X-axis: Measured Impurity [ppb]
Y-axis: Number of Samples
Impurities—Helium

- Delivered Compressed
- Delivered Liquid
- Delivered Pipeline
- Onsite Electrolysis
- Delivered Compressed; Onsite Electrolysis
- Onsite SMR

SAE J2719 Limit = 300 ppm
CDP-INFR-79
Impurities—Nitrogen

![Bar chart showing the distribution of nitrogen impurities in various samples.

- Delivered Compressed
- Delivered Liquid
- Delivered Pipeline
- Onsite Electrolysis
- Delivered Compressed; Onsite Electrolysis
- Onsite SMR

Impurities - Nitrogen

Number of Samples

Measured Impurity [ppm]

SAE J2719 Limit = 100 ppm

Notes for exceeding SAE J2719 Limits:
NaN

17 Total Samples
- Not Detected Summary
- Delivered Compressed 3 Sample(s)
- Delivered Compressed; Onsite Electrolysis 1 Sample(s)
- Onsite SMR 3 Sample(s)
- Not Measured Summary
- Onsite SMR 1 Sample(s)

nd det. lim = 2 ppm
nd det. lim = 4 ppm
nd det. lim = 5 ppm

Created: Oct-11-17 3:51 PM | Data Range: 2011Q1-2017Q2

NREL cdp_infr_79
CDP-INFR-79
Impurities—Particulate Concentration
CDP-INFR-79
Impurities—Total Halogenates
CDP-INFR-79
Impurities—Total Hydrocarbons

The graph shows the distribution of impurities in total hydrocarbons across different sample types:
- Delivered Compressed
- Delivered Liquid
- Delivered Pipeline
- Onsite Electrolysis
- Delivered Compressed; Onsite Electrolysis
- Onsite SMR

There are 17 total samples, with a noted detected limit of 0.1 ppm. The SAE J2719 limit is 2 ppm. Notes for exceeding SAE J2719 limits:
Ok for Total HC = 3.2 (Methane = 3.2 ok per SAE J2719)
CDP-INFR-79
Impurities—Total Sulfur

Impurities - Total Sulfur

Number of Samples

Measured Impurity [ppb]

17 Total Samples
Not Detected Summary—
Onsite Electrolysis 1 Sample(s)
Onsite SMR 1 Sample(s)
Not Measured Summary—
Onsite Electrolysis 1 Sample(s)
Delivered Compressed; Onsite Electrolysis 1 Sample(s)
Onsite SMR 1 Sample(s)

nd det. lim = 0.1 ppb
nd det. lim = 3 ppb
SAE J2719 Limit = 4 ppb
Impurities—Water

[Bar chart showing impurity levels in different categories]

Notes for exceeding SAE J2719 Limits:
Water = 22 due to maintenance (next sample ok)
Component Energy
CDP-INFR-35
Compressor Energy

Average = 3.32 [kWh/kg]
Electrolyzer Energy

Average = 62.2 [kWh/kg]

Production Energy per kg [kWh/kg]

Data Points Reported
CDP-INFR-78
Station Energy per kg Dispensed

Electricity Usage

- Compressed Delivery
- Liquid Delivery
- Onsite Electrolysis
- Onsite Electrolysis; Compressed Delivery
- Onsite SMR

Monthly Electricity Usage per kg vs Monthly Amount of Hydrogen Dispensed [kg]
CDP-INFR-83
Station Energy Cost per kg Dispensed
CDP-INFR-87
Station Electricity Cost per kWh by Utility
Thank You