

Appendix A

Summary of Weather Conditions at Each Campaign

This Appendix presents a summary of the weather conditions encountered on each day of each campaign. This data was sourced from the almanac history of wunderground.com for the weather station of the nearest airport to each campaign site. The name of each airport from which weather data is sourced is given for each campaign. All referenced airports with the exception of San Bernadino International and Tijuana Rodriguez International use weather stations that are a part of the Automatic Surface Observation System (ASOS) program, which is a cooperative program managed by the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the Department of Defense (DOD), which serves as the nation's primary surface weather observing network.¹ Note that the Opus instruments also continuously logged temperature, pressure, and humidity and can be used as a separate reference, but the DU instrument did not.

Weather Data for the Bakersfield Campaign – Meadows Field (October, 2021)

	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Oct 18	62	55.4	50	50	43.1	36	93	66.3	38	21	8.9	0	29.5	29.5	29.4	0
Oct 19	72	59.1	47	40	37.3	36	68	46.2	28	8	4.4	0	29.5	29.5	29.4	0.03
Oct 20	78	64.2	51	40	38	35	66	40.5	21	12	4.3	0	29.6	29.6	29.5	0
Oct 21	81	69.2	58	41	37.3	33	49	32.1	21	10	4.5	0	29.6	29.5	29.5	0
Oct 22	78	67.7	59	56	49.6	39	72	53.7	35	18	8.2	0	29.5	29.4	29.4	0
Oct 23	69	62.7	58	53	46	42	75	55.9	40	12	5.4	0	29.4	29.4	29.4	0
Oct 24	78	67.2	58	52	46	42	60	47.7	31	8	4.6	0	29.4	29.3	29.3	0
Oct 26	64	57.1	51	51	48.6	46	96	74.6	52	8	4.1	0	29.7	29.7	29.5	0.91
Oct 27	68	59.5	50	51	48.3	46	89	67.5	50	8	3.5	0	29.8	29.8	29.7	0
Oct 29	78	65.5	56	58	55.3	52	90	71.1	48	8	4	0	29.5	29.4	29.4	0

¹ National Weather Service. Automated Surface Observing System (ASOS). <https://www.weather.gov/asos/>

Weather Data for the City of Industry Campaign – Long Beach/Daugherty Field (February, 2023)

	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Feb 19	65	55.3	44	48	41	32	72	59.6	41	10	3.3	0	30	30	29.9	0
Feb 20	74	60	49	50	41.7	35	72	53.1	24	13	3.9	0	30.1	30	29.9	0
Feb 21	64	57.4	50	52	46	35	81	66.3	49	28	10.4	0	29.9	29.7	29.6	0
Feb 22	57	53.2	50	35	31.4	25	57	44	31	26	18.2	6	29.9	29.8	29.6	0
Mar 2	60	52.8	42	42	35.7	25	74	53.2	36	9	3.9	0	30.1	30	29.9	0.19
Mar 3	61	53.8	45	46	43	38	80	67.3	56	10	3	0	30	29.9	29.9	0
Mar 4	60	54.7	46	48	43.4	38	80	66.3	51	12	4.7	0	30	29.9	29.9	0

Weather Data for the El Centro Campaign – Imperial County Airport (October, 2022)

	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Oct 7	93	82.2	70	60	55.7	52	68	42.4	25	7	1.9	0	30.1	30	29.9	0
Oct 8	93	83.8	73	64	57.1	51	68	42.2	24	9	4.2	0	30.1	30	29.9	0
Oct 9	93	83	74	61	56.5	52	62	41.9	26	8	3.7	0	30.1	30	29.9	0
Oct 10	95	82.9	72	61	54	47	57	39.1	20	9	2.9	0	30	29.9	29.8	0
Oct 11	96	83	70	58	54.3	48	63	40	20	10	5.5	0	29.9	29.9	29.9	0
Oct 12	95	83.2	72	59	54.8	51	59	40	22	8	4	0	30	30	29.9	0
Oct 13	96	82.7	69	58	52.9	46	65	39	18	8	4.8	0	30	29.9	29.8	0
Oct 14	96	83.8	69	65	52	45	60	36.1	17	14	6.2	0	29.8	29.8	29.7	0

Weather Data for the Fresno Campaign – Fresno Yosemite Airport (June, 2021)

	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Jun 7	84	72	62	45	39.8	31	52	33.5	16	17	9.1	5	29.5	29.4	29.4	0
Jun 8	78	66.9	56	40	36.9	31	53	35.3	19	20	11.6	7	29.7	29.6	29.5	0
Jun 9	77	66	55	40	37	32	55	36.2	21	21	12.2	5	29.8	29.7	29.7	0
Jun 10	78	66.3	53	41	34.5	25	62	34.7	15	18	12	3	29.9	29.8	29.7	0
Jun 11	84	70.8	56	41	33.3	17	51	28.9	9	15	10	6	29.7	29.7	29.6	0
Jun 12	90	76.9	62	56	47.9	39	60	38.4	18	15	8.5	0	29.6	29.6	29.5	0

Weather Data for the Oakland Campaign – Oakland Int'l Airport (March, 2022)

	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Mar 31	62	54.2	49	49	46.4	44	86	75.6	53	17	5.9	0	30.1	30	29.9	0
Apr 1	67	54.4	45	50	46.6	42	93	76.2	52	16	6.4	0	30	30	29.9	0
Apr 2	69	57.5	47	52	48.2	44	90	72.7	50	14	7	0	30.1	30	30	0
Apr 3	63	55.9	47	49	45.8	43	93	69.9	53	22	9.5	0	30.1	30	30	0
Apr 4	65	56.9	48	52	48	43	84	73	54	22	12.8	0	30.2	30.1	30.1	0
Apr 5	68	58.4	50	50	45.7	43	86	64.8	40	18	9.7	0	30.2	30.2	30.1	0
Apr 6	79	61.8	47	52	44.8	38	86	58.5	26	16	5.1	0	30.2	30.1	30.1	0

Weather Data for the Riverside Campaign – San Bernadino Int’l Airport (November, 2022)

	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Nov 13	66	49.8	40	39	29.8	19	71	50.8	17	22	3.9	0	28.9	28.8	28.7	0
Nov 14	70	50.7	40	33	28.7	21	67	46.5	16	8	2.5	0	28.9	28.9	28.8	0
Nov 15	72	51.5	40	30	24	14	63	39.1	14	14	3.9	0	29	28.9	28.8	0
Nov 16	72	55.6	46	24	12.9	1	38	20.6	9	26	6.8	0	29.1	29	29	0
Nov 17	73	50.1	39	24	18.7	12	46	31.9	10	9	3.1	0	29	28.9	28.8	0
Nov 18	73	51.4	39	25	21	12	54	34.2	11	12	2.6	0	28.8	28.8	28.7	0
Nov 19	68	57	43	20	14.1	9	39	20.1	11	24	10.3	0	28.9	28.9	28.8	0

Weather Data for the San Ysidro Campaign – Tijuana Rodriguez Int’l Airport (April, 2023)

	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Apr 2	64	54.4	46	54	50.2	46	100	86.9	59	12	4	0	29.6	29.6	29.5	0
Apr 3	57	53	50	50	45.4	37	94	76.7	58	86	12.9	3	29.5	29.5	29.4	0
Apr 4	59	51	43	41	31.4	21	76	49	31	20	7.8	0	29.6	29.6	29.5	0
Apr 5	63	52.2	43	48	41.7	36	94	70.8	42	14	6.3	0	29.6	29.6	29.6	0
Apr 6	70	56.6	43	46	38.1	25	100	57.9	18	20	5.3	0	29.6	29.5	29.5	0
Apr 7	64	55.8	48	52	45.5	37	100	70.4	37	15	5.8	0	29.6	29.5	29.5	0
Apr 8	68	55.9	45	55	51.3	45	100	86.4	56	16	5.6	0	29.6	29.6	29.5	0

Weather Data for the Stockton Campaign – Stockton Metro Airport (June, 2021)

	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Jun 13	87	72.7	59	59	56.7	52	93	61.3	31	18	10.4	6	29.9	29.9	29.8	0
Jun 14	84	70.9	61	60	55.1	44	93	61	31	22	11.2	7	30	29.9	29.9	0
Jun 15	87	71.6	56	52	44.6	27	78	44.9	12	16	11.9	7	30.1	30	29.9	0
Jun 16	95	78.2	60	52	45.1	35	75	37.6	13	14	9.4	0	29.9	29.9	29.8	0
Jun 17	104	82.4	58	54	48	40	72	36.4	11	14	6.8	0	29.8	29.7	29.6	0
Jun 18	107	86.3	64	54	48.5	40	70	32.2	10	13	7.1	0	29.7	29.6	29.6	0
Jun 19	101	83.1	66	54	48.5	42	63	33.1	13	13	7.9	5	29.7	29.6	29.6	0

Weather Data for the West LA Campaign – Los Angeles Int'l Airport (October, 2021)

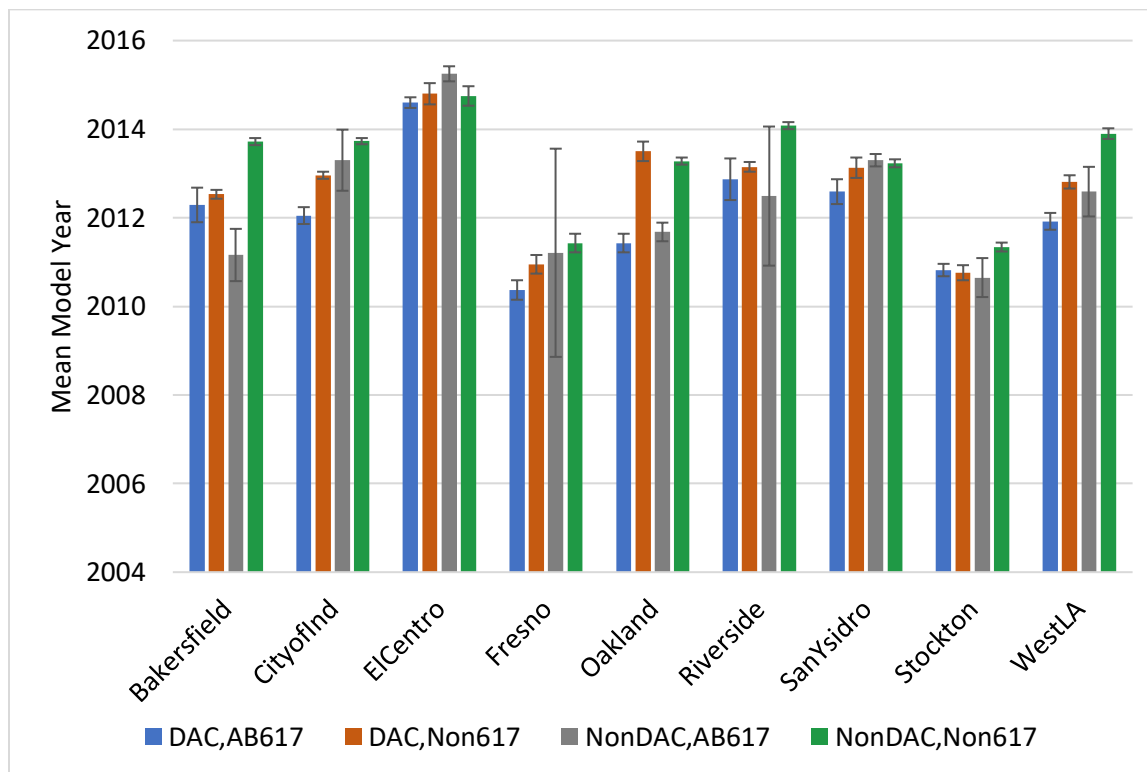
	Temperature (°F)			Dew Point (°F)			Humidity (%)			Wind Speed (mph)			Pressure (in)			Precip (in)
Date	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Total
Oct 26	66	60	53	53	51	47	94	73.5	52	16	6.6	0	30	29.9	29.9	0.39
Oct 27	76	65.3	54	52	48.1	42	77	55.7	30	12	4.8	0	30	30	29.9	0
Oct 28	84	70.9	61	53	49	44	72	48	25	13	5.3	0	29.9	29.9	29.8	0
Oct 29	78	67.4	60	61	54.2	47	100	65.3	38	13	5.8	0	29.8	29.8	29.7	0
Oct 30	67	61.3	59	67	45.5	24	100	65	22	12	5.7	0	29.9	29.8	29.8	0
Oct 31	64	61.1	56	62	56.7	53	100	85.8	70	10	5.9	0	29.9	29.9	29.8	0
Nov 1	64	59.5	53	57	54.9	51	97	85.1	72	15	7.7	0	30	30	29.9	0

Appendix B

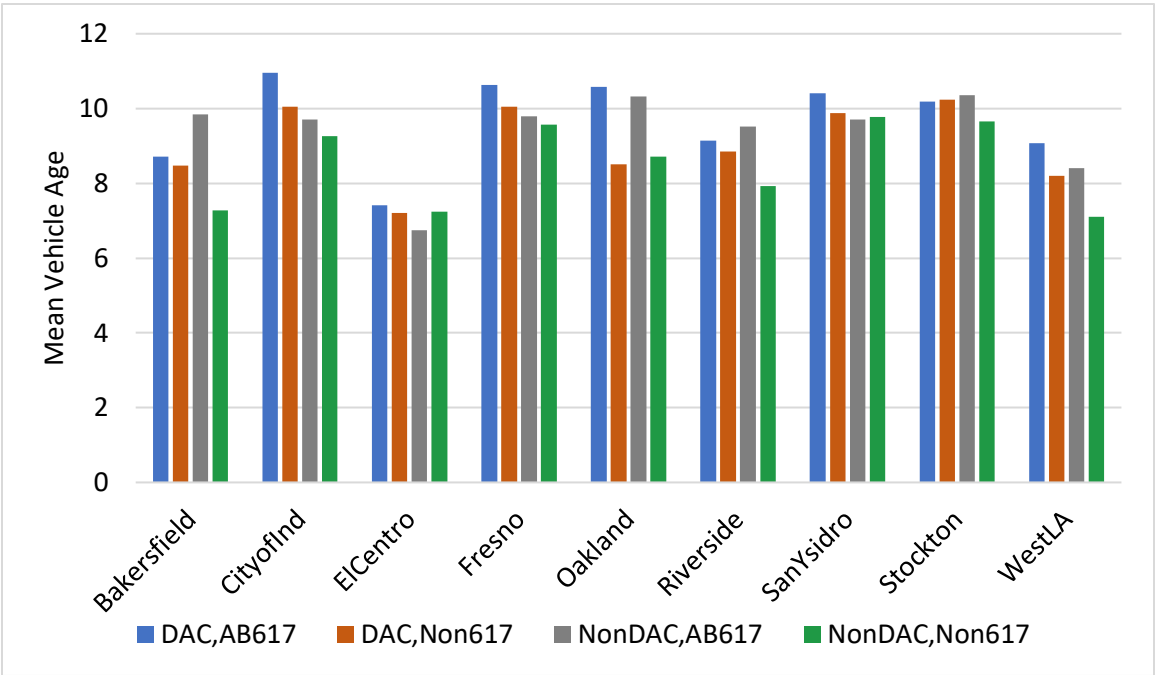
Model Year Details by DAC/AB617 Category for Each Campaign

This appendix presents LDV model year data observed at each campaign by each combination of SB535 DAC and AB617 status. The first two graphs present the average model year and average vehicle age by campaign for each DAC/AB617 combination, respectively. Subsequent graphs present the model year distribution for each campaign. For some campaigns, there were very few observations within the NonDAC, AB617 group. In model years where only 1 or 2 observations are present, points are left off the graph for readability.

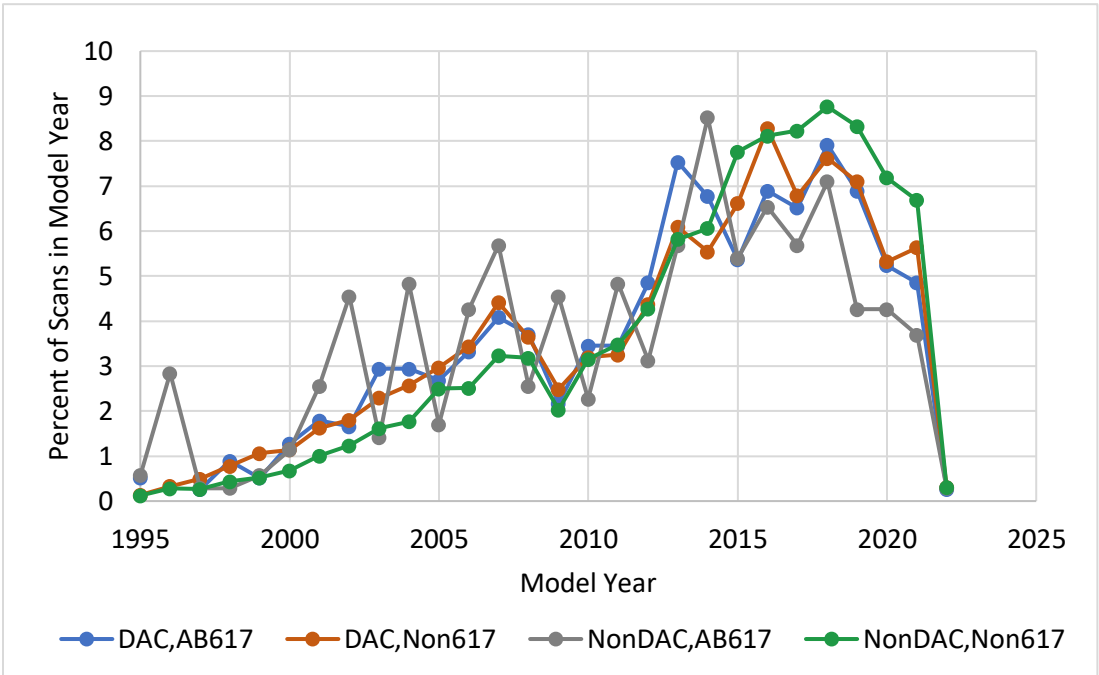
Average Model Years by Campaign



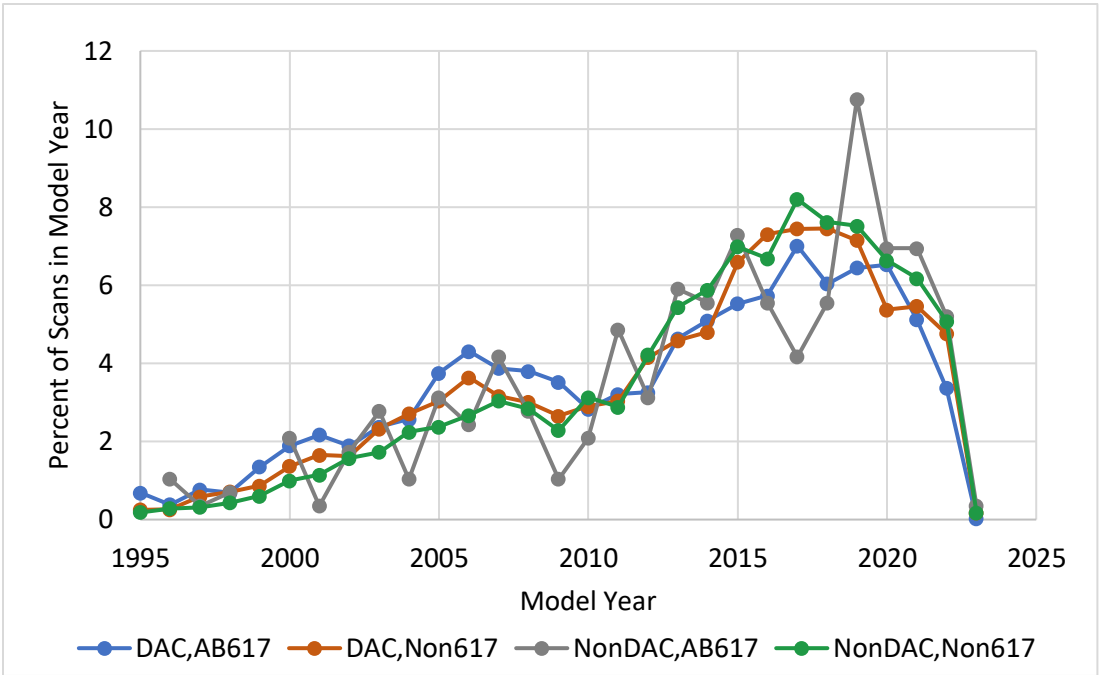
Average Vehicle Age by Campaign



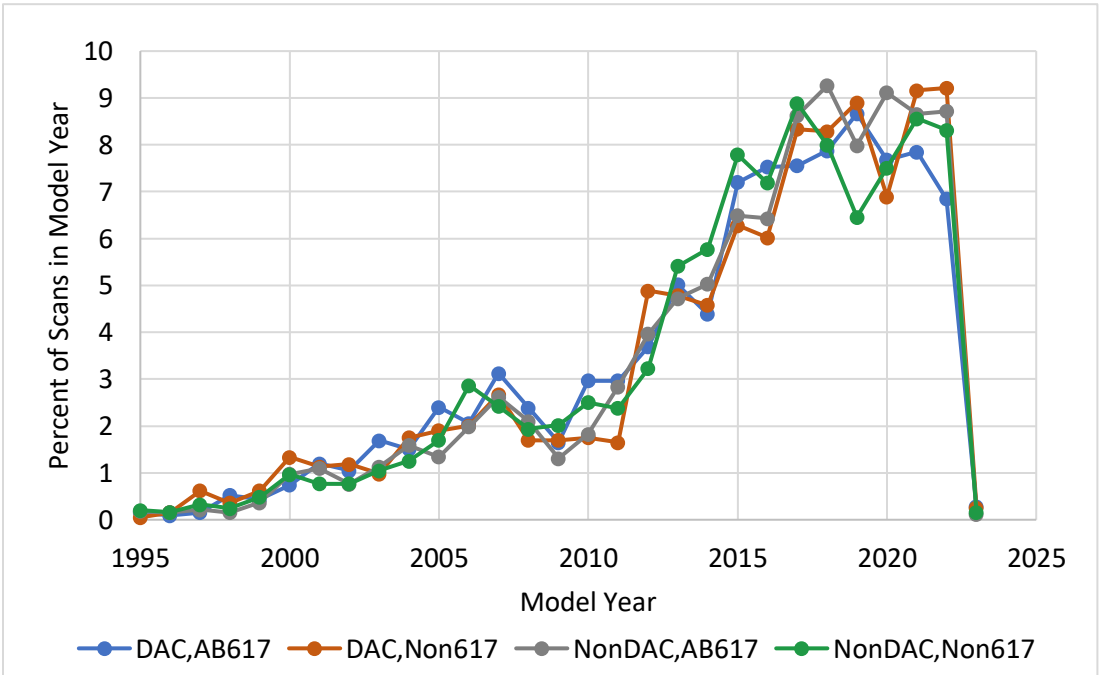
Model Year Distribution – Bakersfield



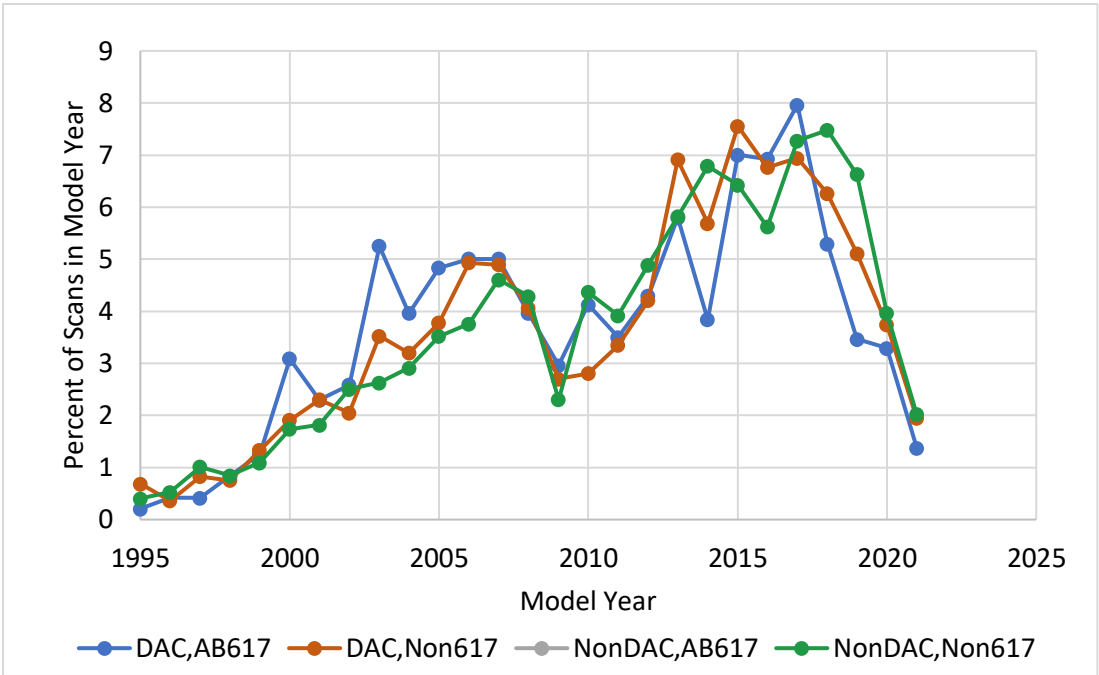
Model Year Distribution – City of Industry



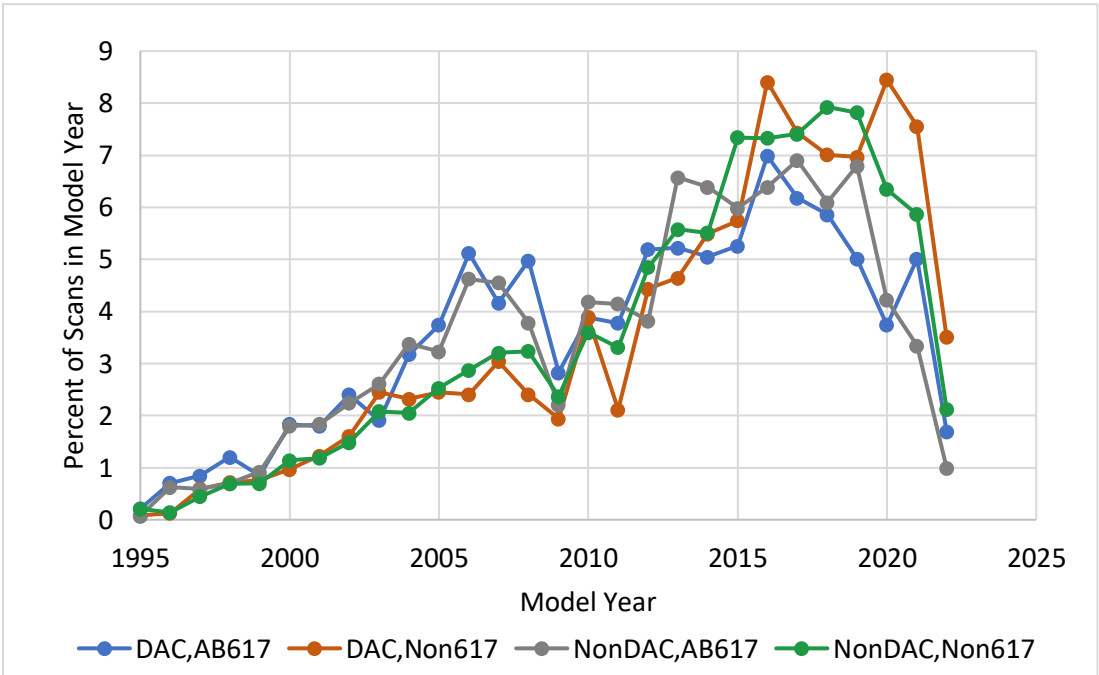
Model Year Distribution – El Centro



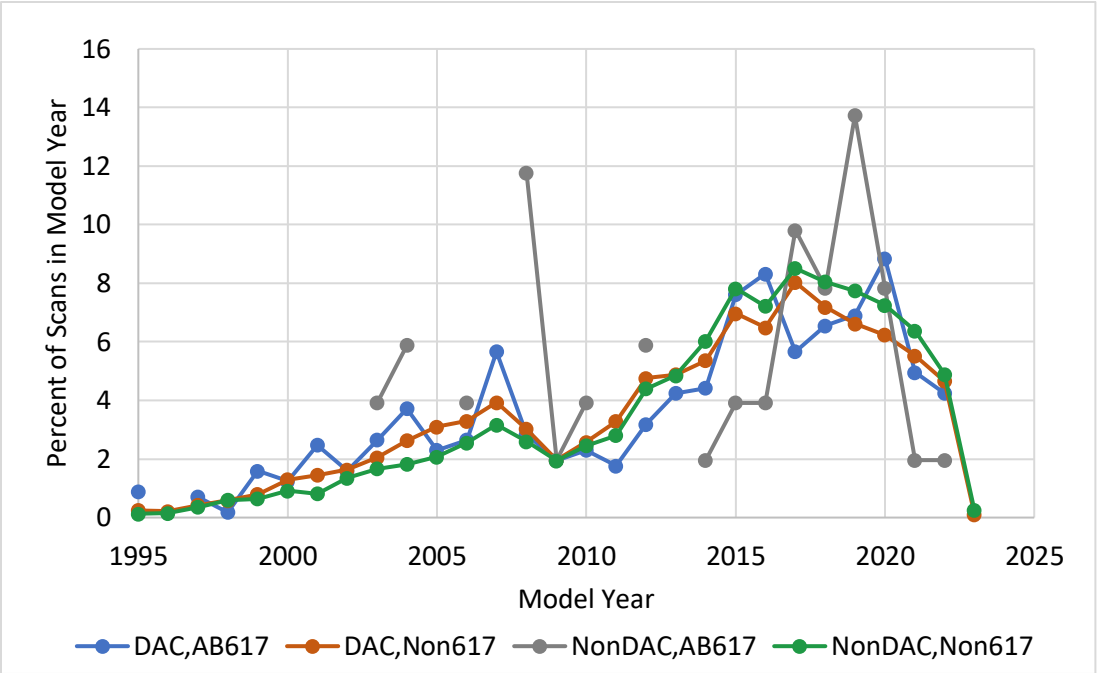
Model Year Distribution - Fresno



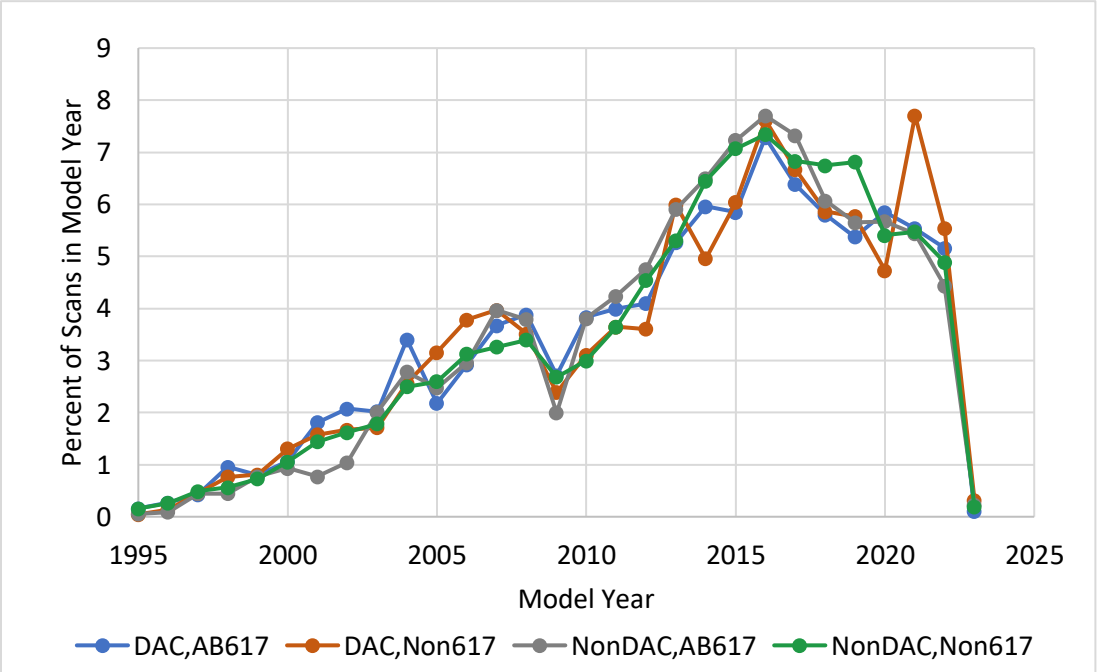
Model Year Distribution - Oakland



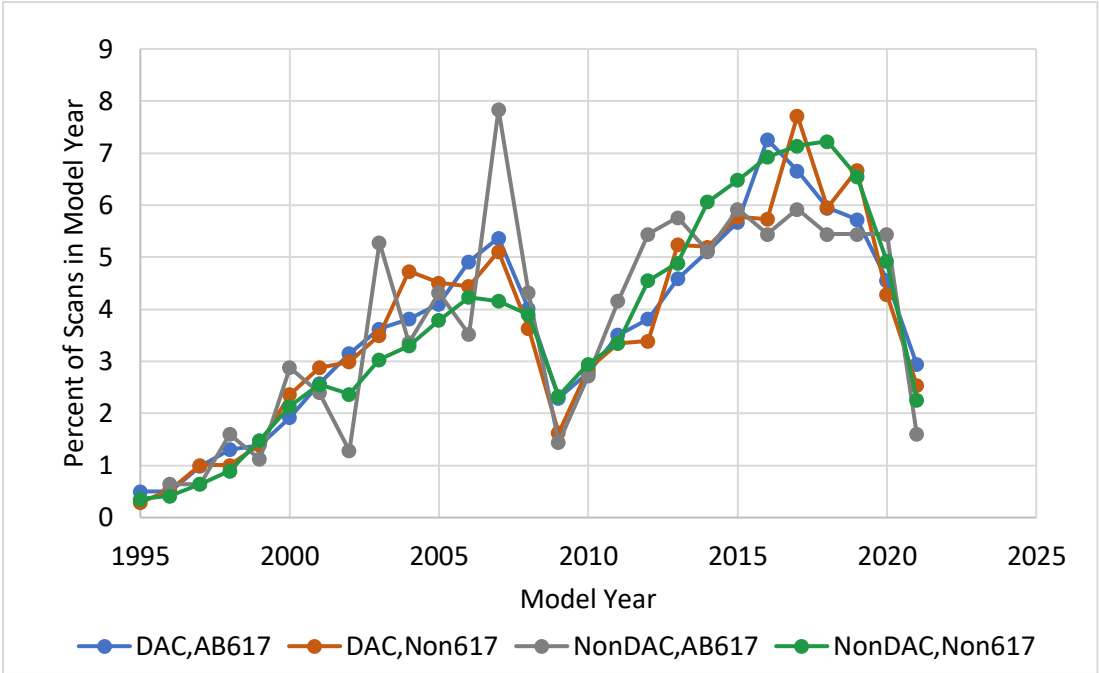
Model Year Distribution - Riverside



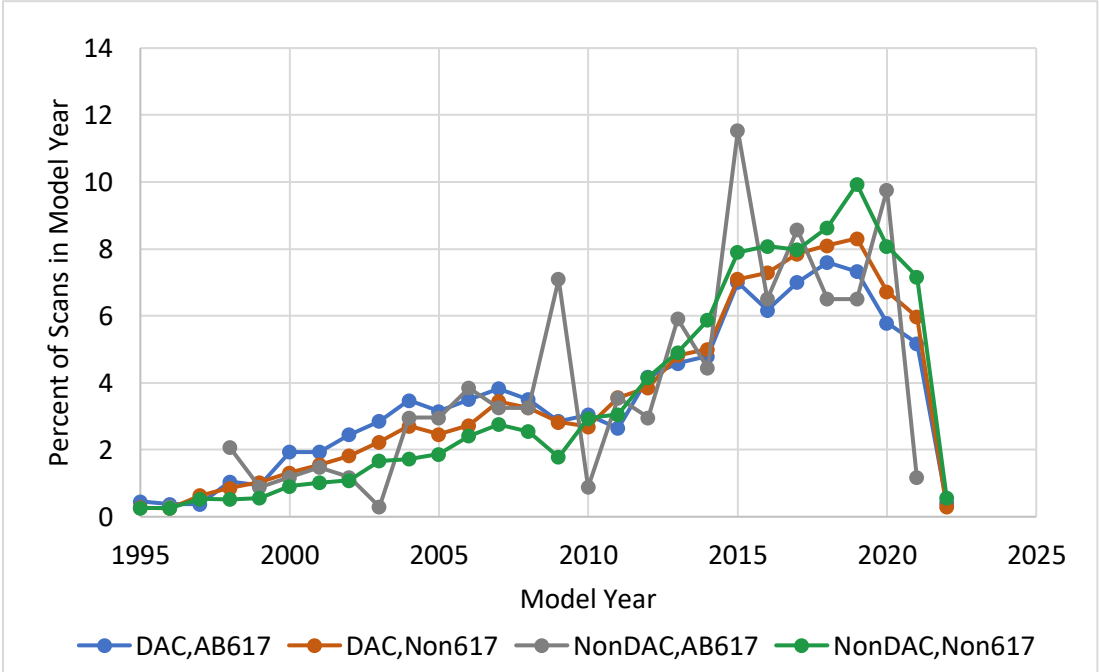
Model Year Distribution – San Ysidro



Model Year Distribution - Stockton



Model Year Distribution - West LA

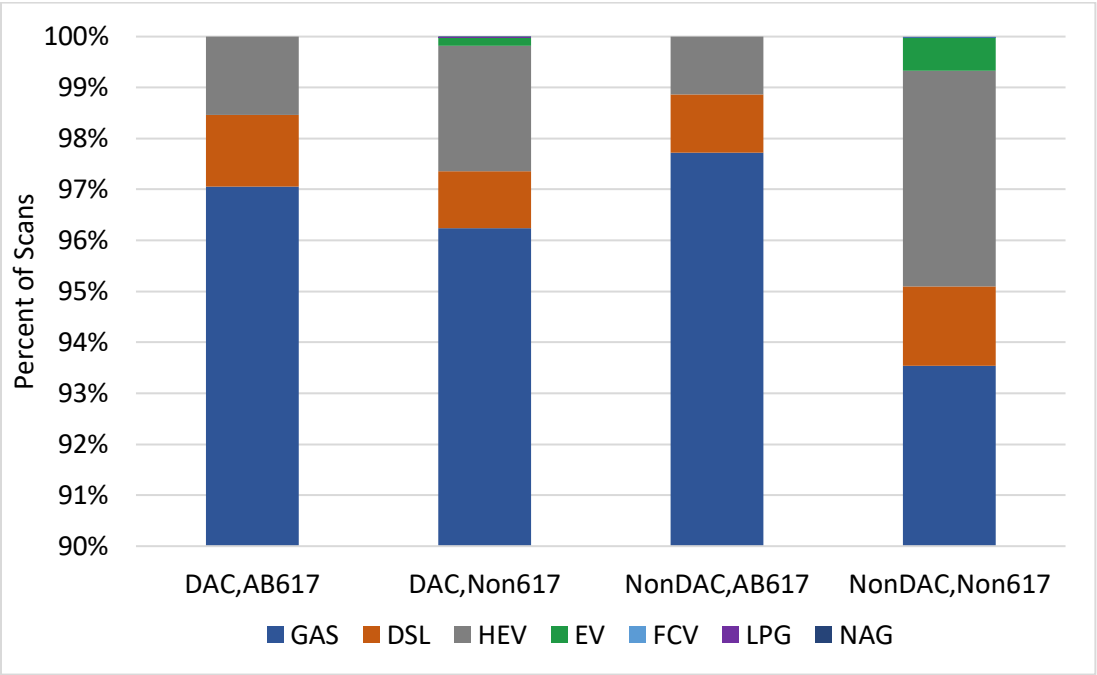


Appendix C

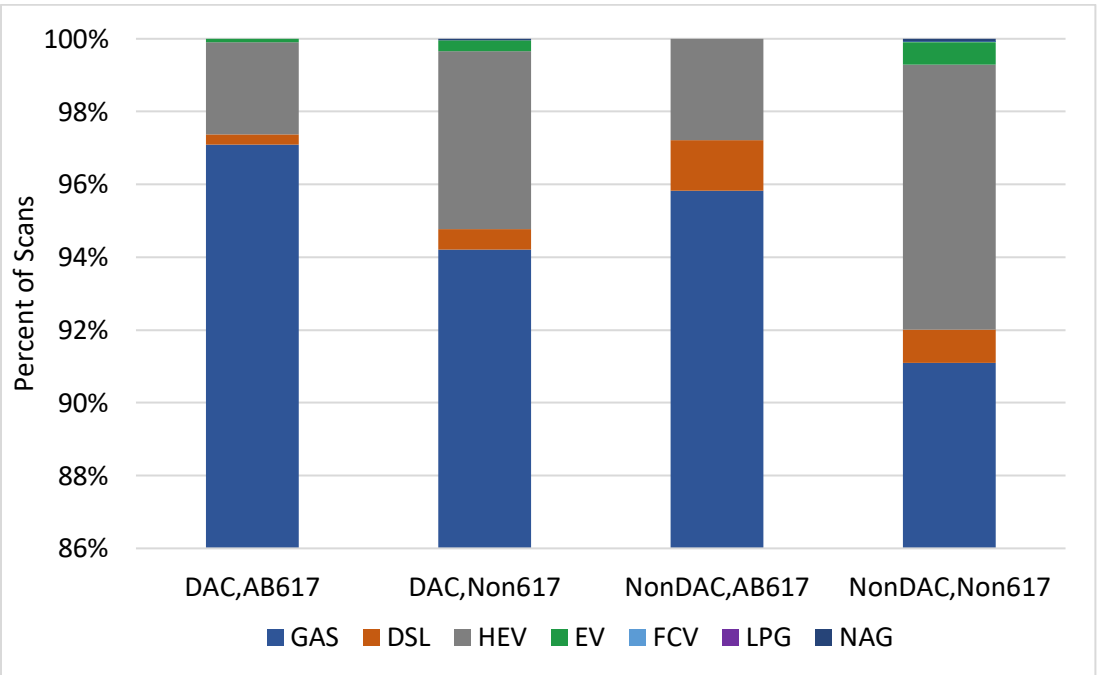
Fuel Type Distributions by DAC/AB617 Status for Each Campaign

This appendix presents the fuel types of the LDVs observed at each site, by each combination of SB535 DAC and AB617 status. Note that, in all cases, the gasoline bars extend from each graph's scale down to zero.

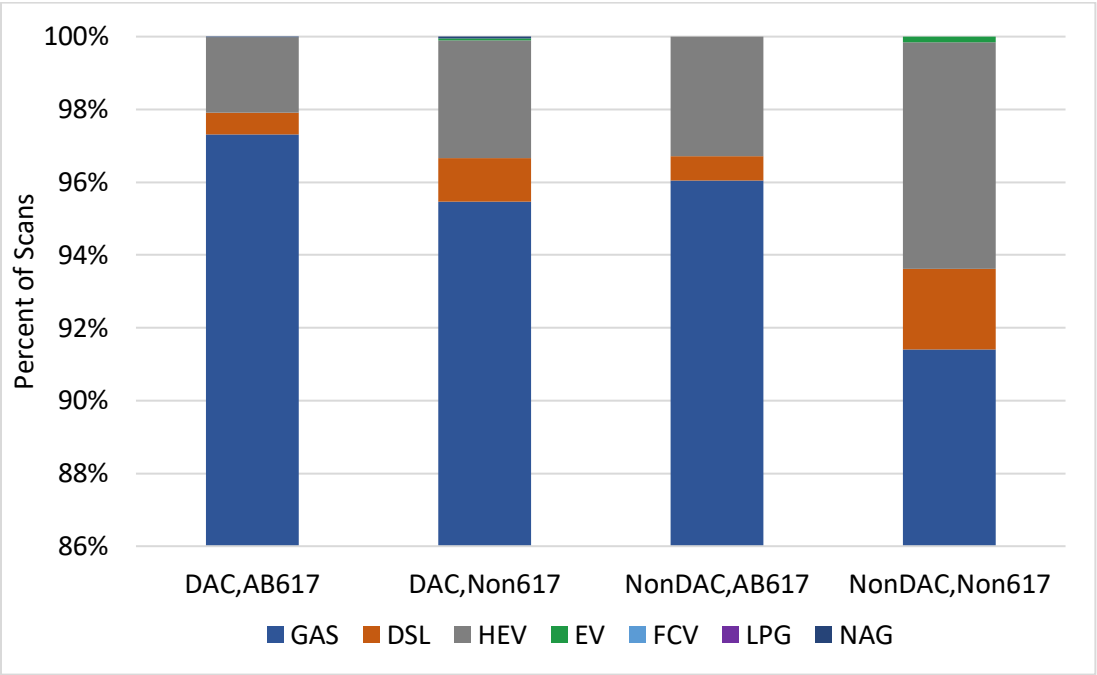
Fuel Type Prevalence by DAC/AB617 Status - Bakersfield



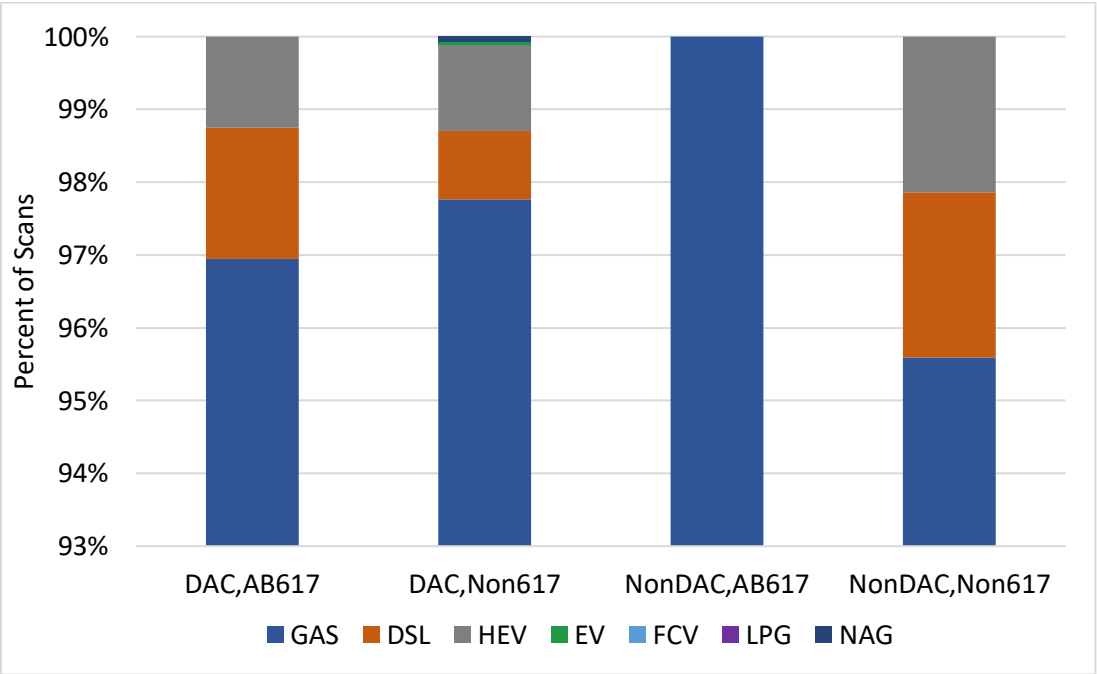
Fuel Type Prevalence by DAC/AB617 Status – City of Industry



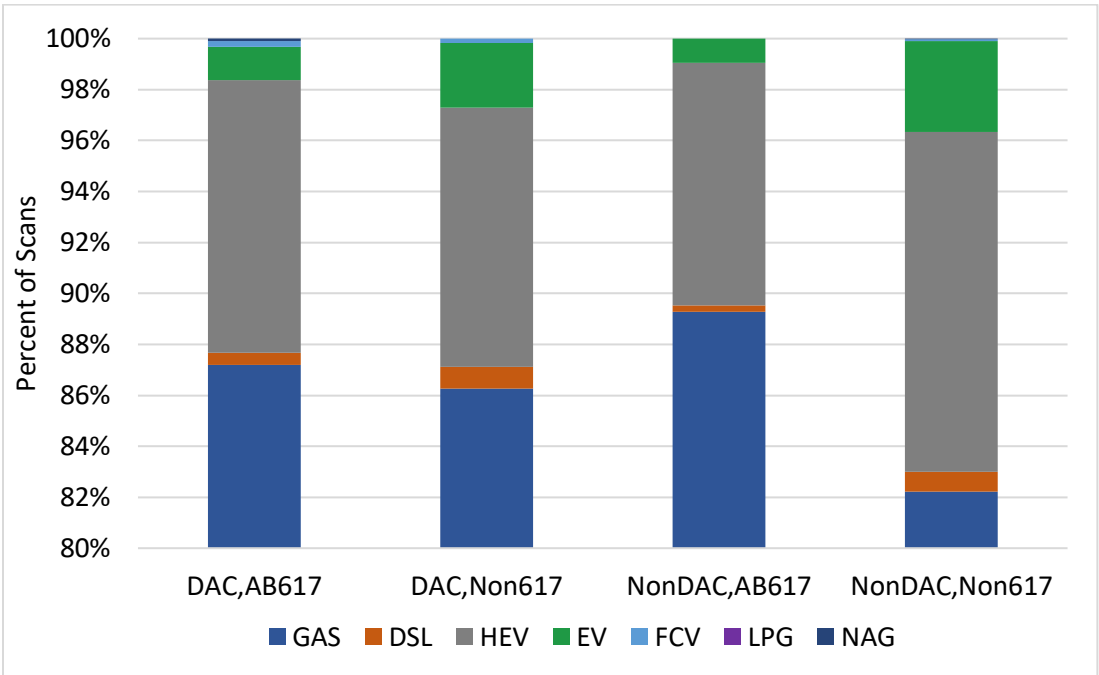
Fuel Type Prevalence by DAC/AB617 Status – El Centro



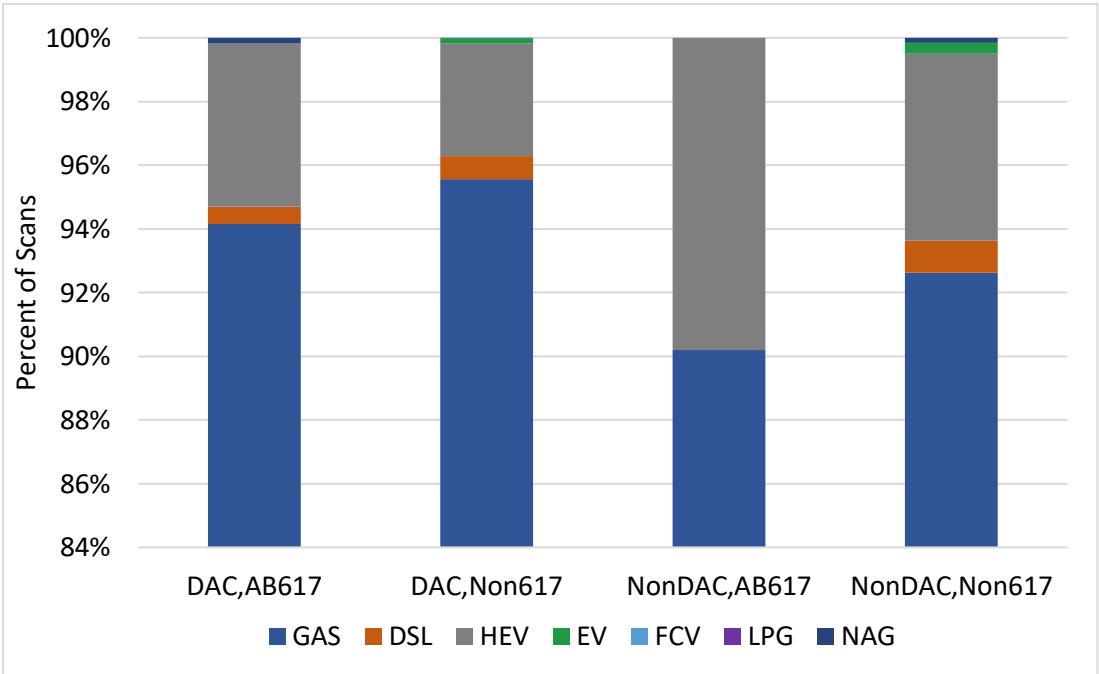
Fuel Type Prevalence by DAC/AB617 Status – Fresno (note not all EVs were included in Fresno data)



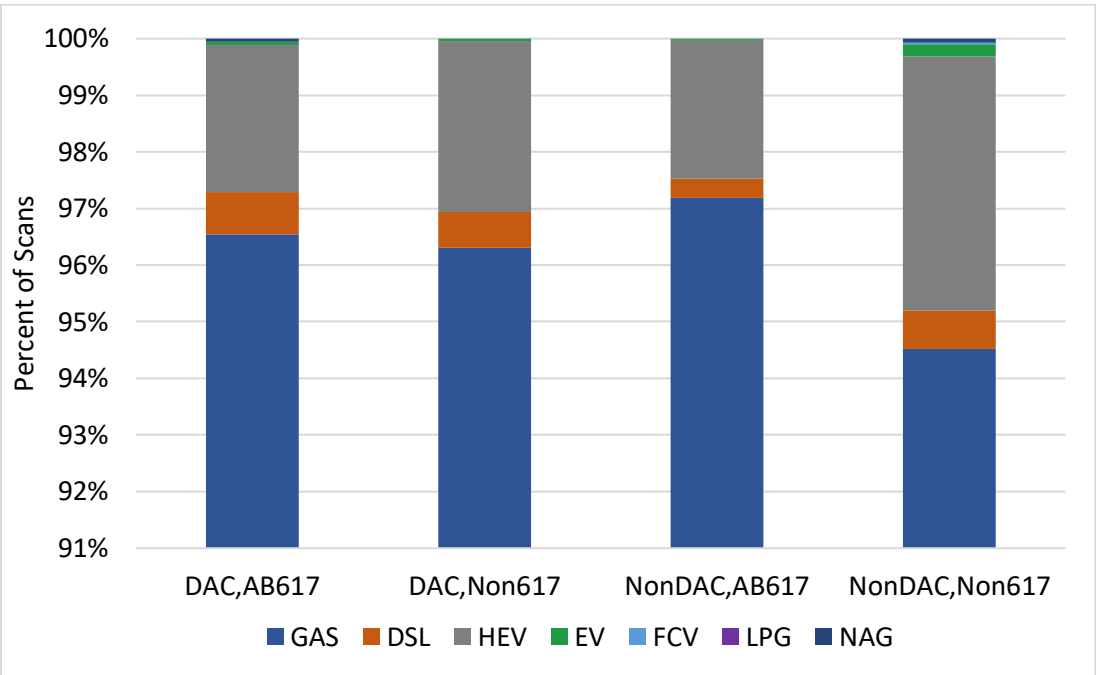
Fuel Type Prevalence by DAC/AB617 Status – Oakland



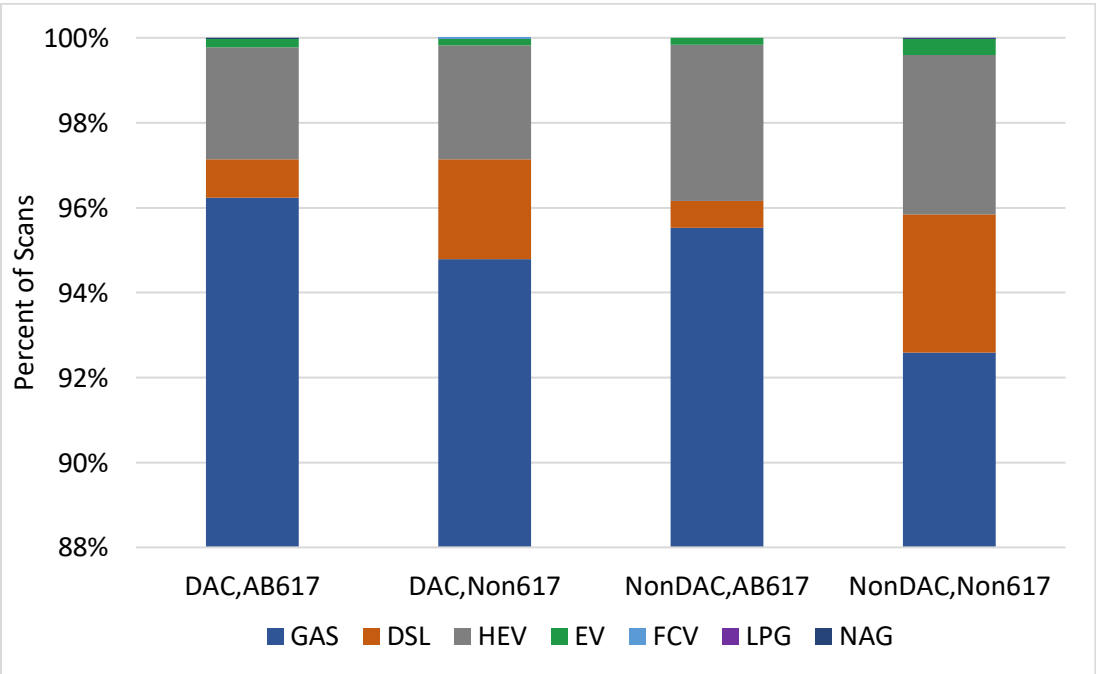
Fuel Type Prevalence by DAC/AB617 Status – Riverside



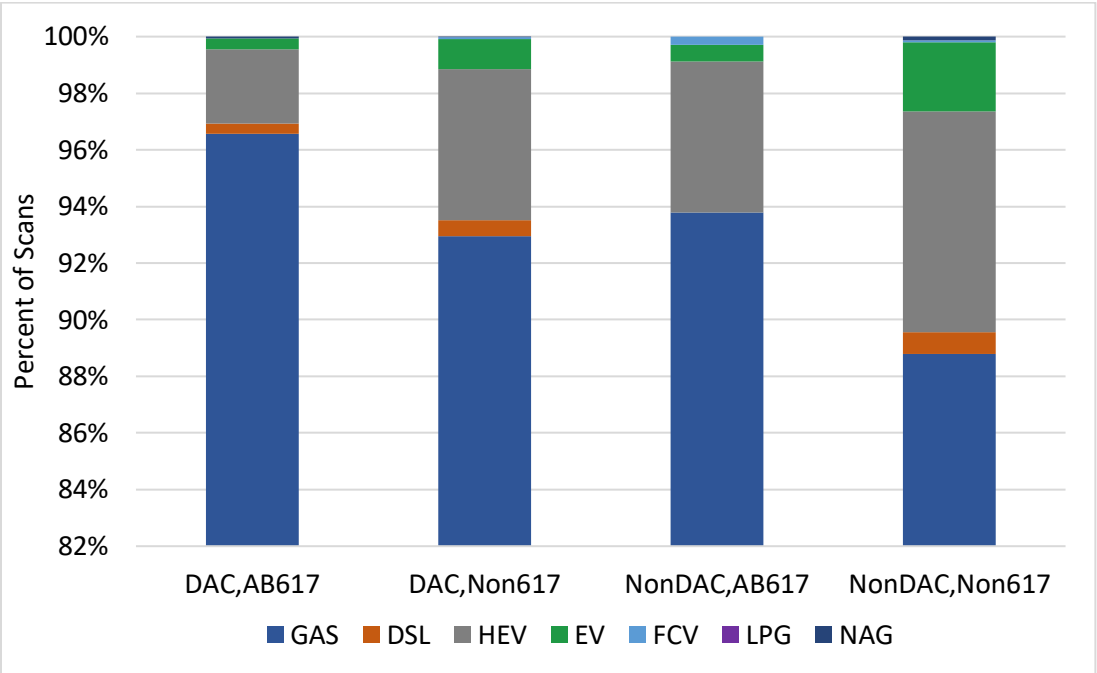
Fuel Type Prevalence by DAC/AB617 Status – San Ysidro



Fuel Type Prevalence by DAC/AB617 Status - Stockton



Fuel Type Prevalence by DAC/AB617 Status – West LA

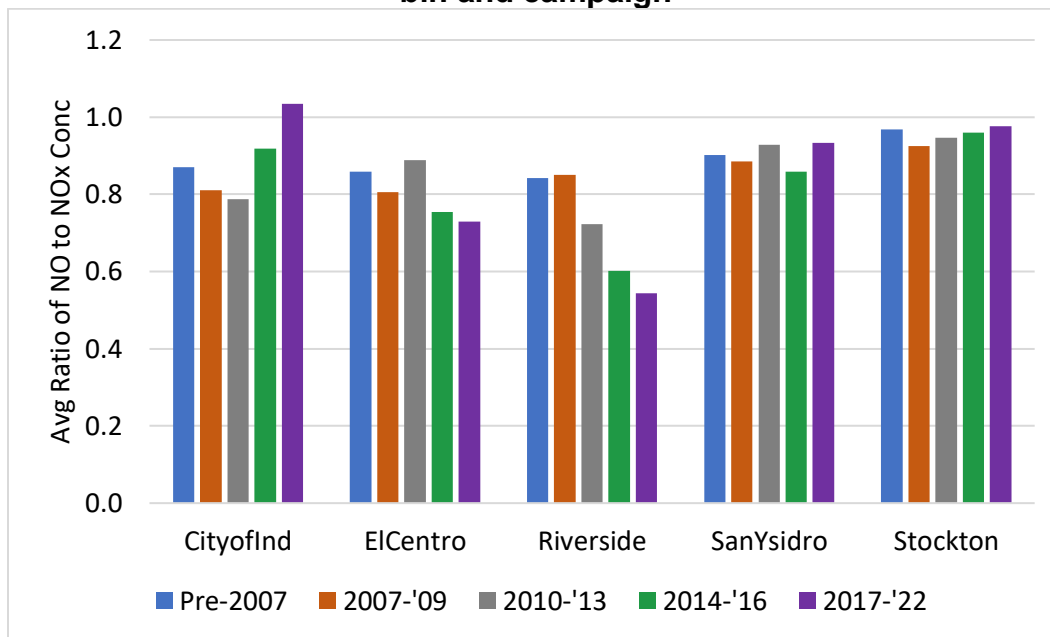


Appendix D

HDV Emission Measurements: NO/NO_x Ratio and NO Emission Rates

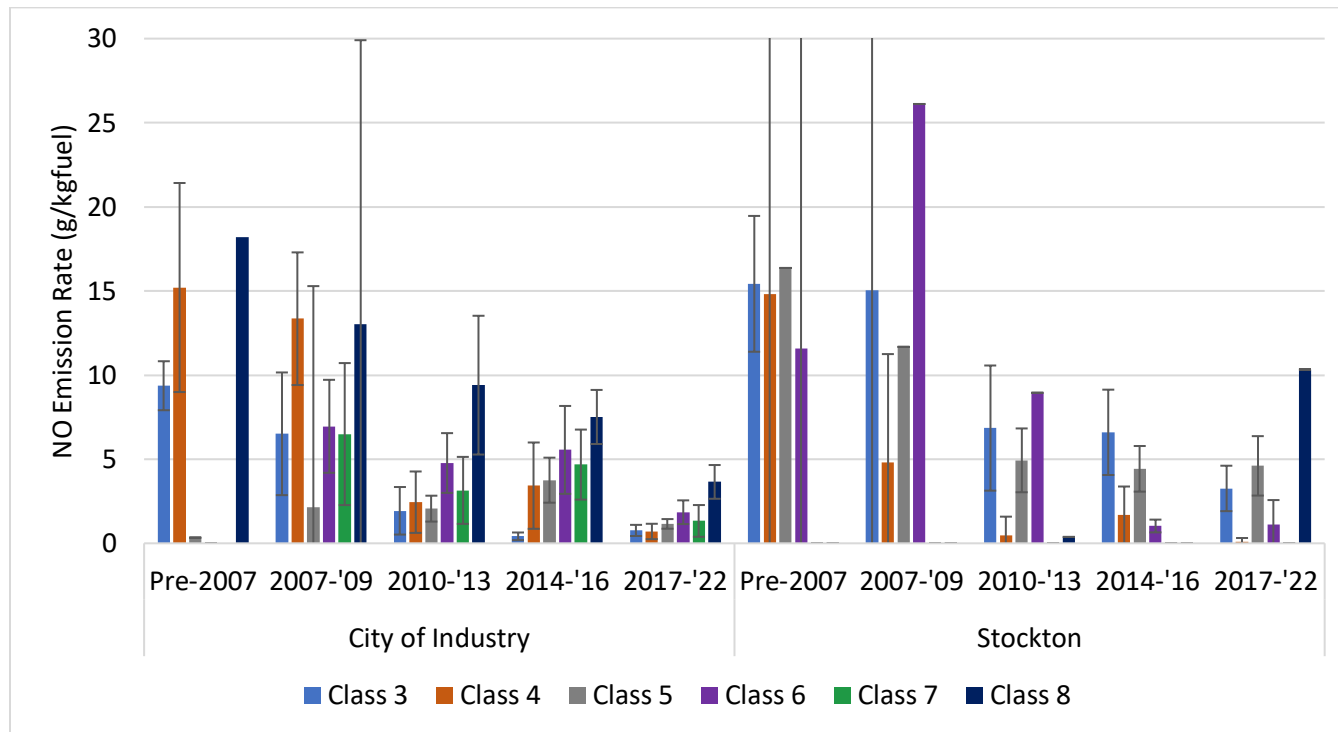
This appendix contains further details of the HDV emissions measurements. The first figure presents the average ratio of NO to NO_x concentrations for diesel-powered HDVs by model year and campaign. To limit the noise caused by limited sample sizes, only campaigns with at least 50 valid HDV measurements are included. As with the diesel-powered LDVs, the NO tends to make up approximately 80% of the NO_x by concentration, with variation across campaigns and model years. There is less consistency in trends by model year in the HDV data than the LDV data, likely due in part to the much smaller sample sizes involved.

Average ratio of NO to NO_x concentration for diesel-powered HDVs by model year bin and campaign

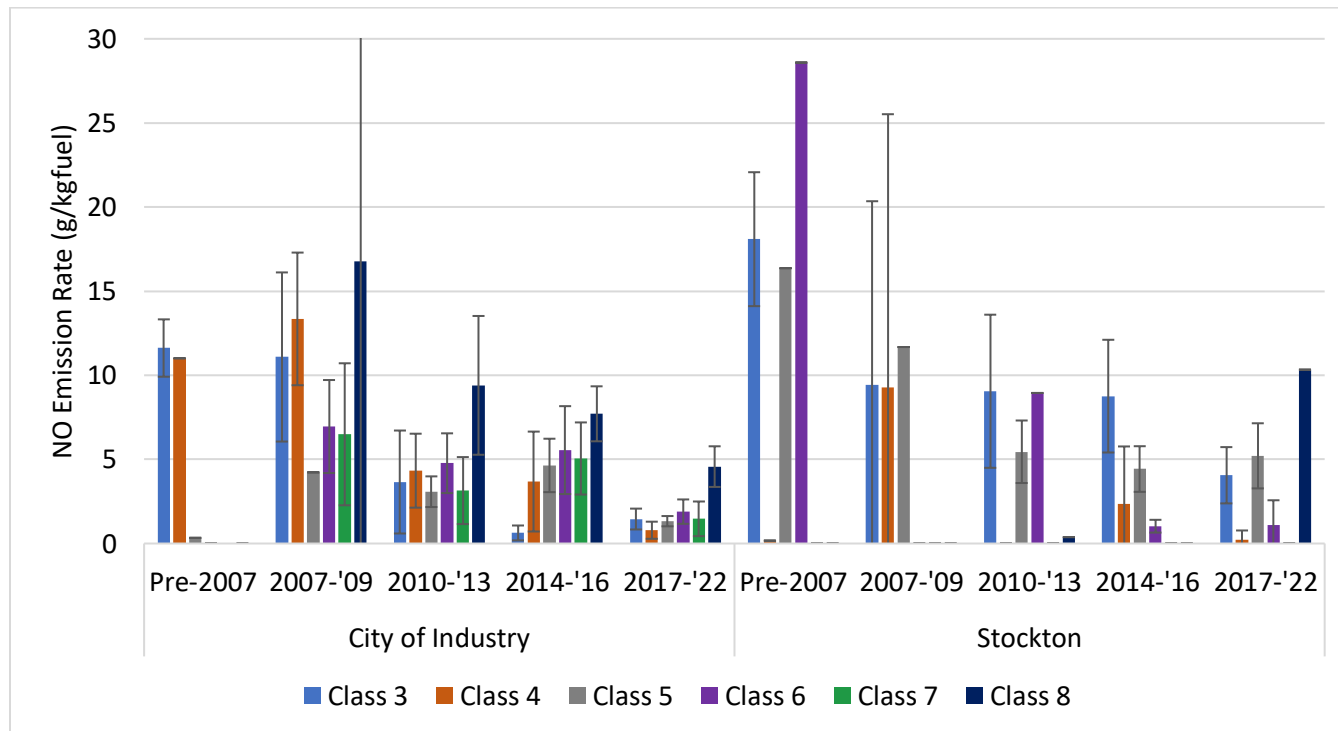


The NO emission rates for City of Industry and Stockton are presented in the following figures. Very few valid HDV emissions measurements were made during the other campaigns with little coverage across the entire matrix of truck class and model year bin. Missing bars indicate that no valid measurements were made of that combination of truck class and model year bin. Error bars indicate 95% confidence intervals; missing bars indicate that too few valid measurements were made to calculate the confidence interval.

HDV NO Emission Rates – All Fuel Types



HDV NO Emission Rates – Diesel Fuel Only



Appendix E

Ammonia Emissions Measurements

This appendix presents the results of the analysis of ammonia (NH_3) RSD measurements. Only the DU instrument had the capability to make NH_3 measurements, so findings are only available for Fresno, Oakland, Stockton, and West LA. Ammonia can be produced by 3-way catalysts, so it can be expected that ammonia emissions are more likely to be observed from gasoline-powered vehicles than from diesel-powered vehicles. Figure D-1 presents the ammonia emission rates from diesel and non-diesel (consisting primarily of gasoline, hybrid, and gaseous-fueled vehicles) light-duty vehicles (LDVs) at the four campaigns with available data. ERG was unable to determine why the Fresno campaign appeared to be an outlier in the non-diesel emission rate.

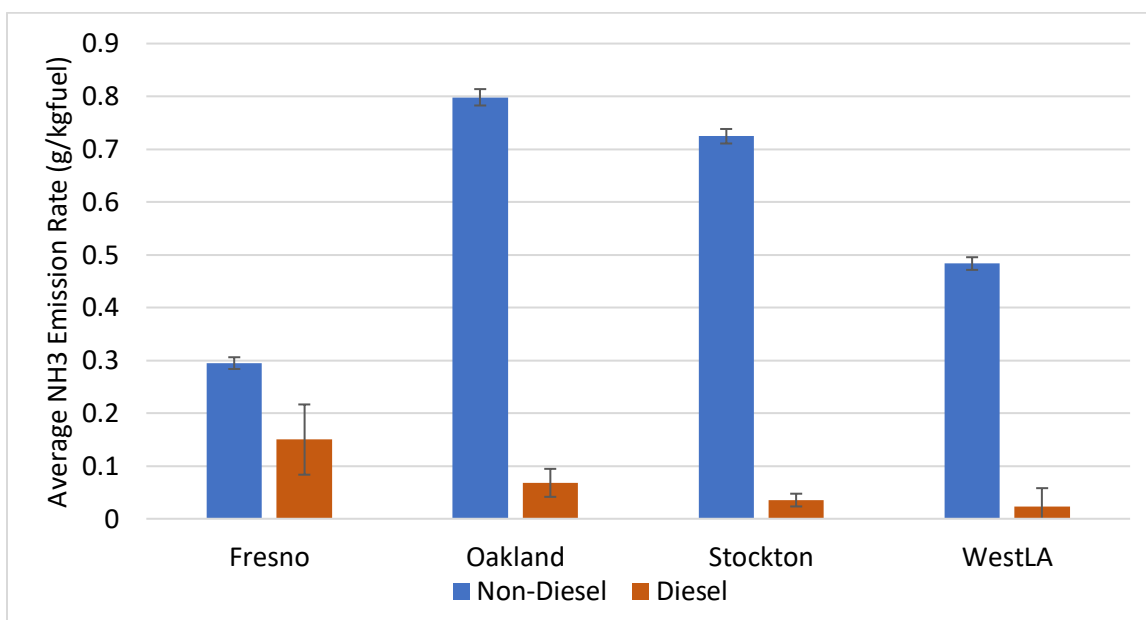


Figure D-1. Average NH_3 emission rates of LDVs by campaign and fuel type. Error bars represent 95% confidence intervals (CI).

Because of the small number of diesel-powered vehicles, and their very low emission rates as compared to the remaining vehicle fleet, the remaining LDV analyses will exclude diesel vehicles. Figure D2 presents the average emission rates of LDVs by campaign and model year bin. Newer model years tend toward lower NH_3 emission rates.

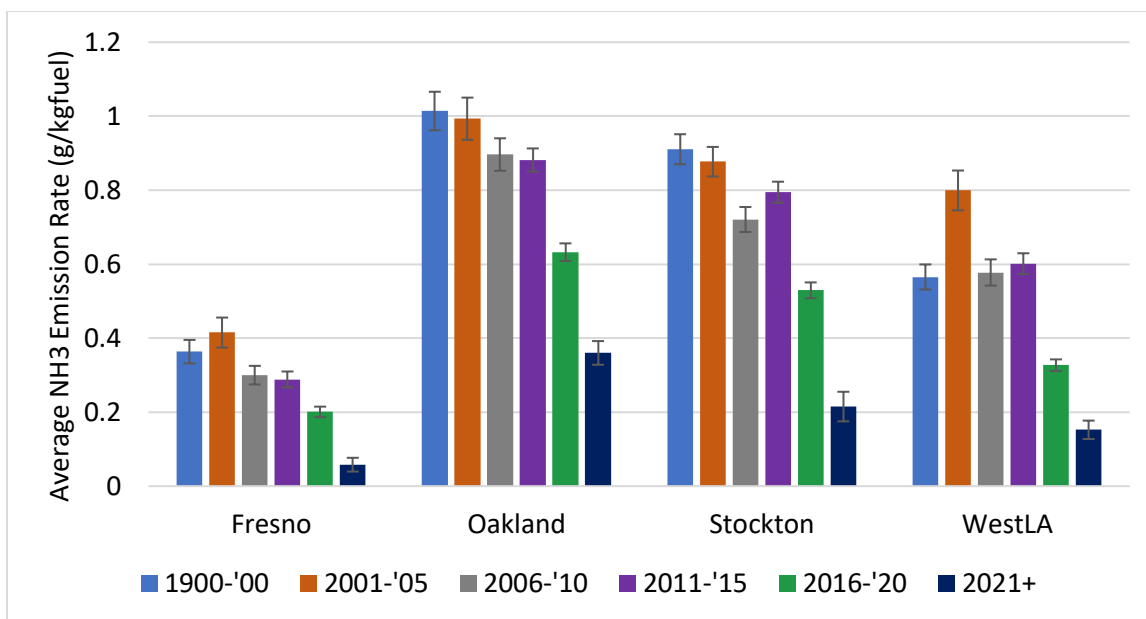


Figure D-2. Average LDV NH₃ emission rates by campaign and model year bin (excluding diesel-powered vehicles). Error bars represent 95% CI.

ERG also analyzed the ammonia emissions from (non-diesel-powered) LDVs registered in disadvantaged communities (DACs) as compared to other vehicles. Figure D-3 presents the average NH₃ emission rates by campaign and whether the vehicle was registered in a DAC or and Assembly Bill 617 community.

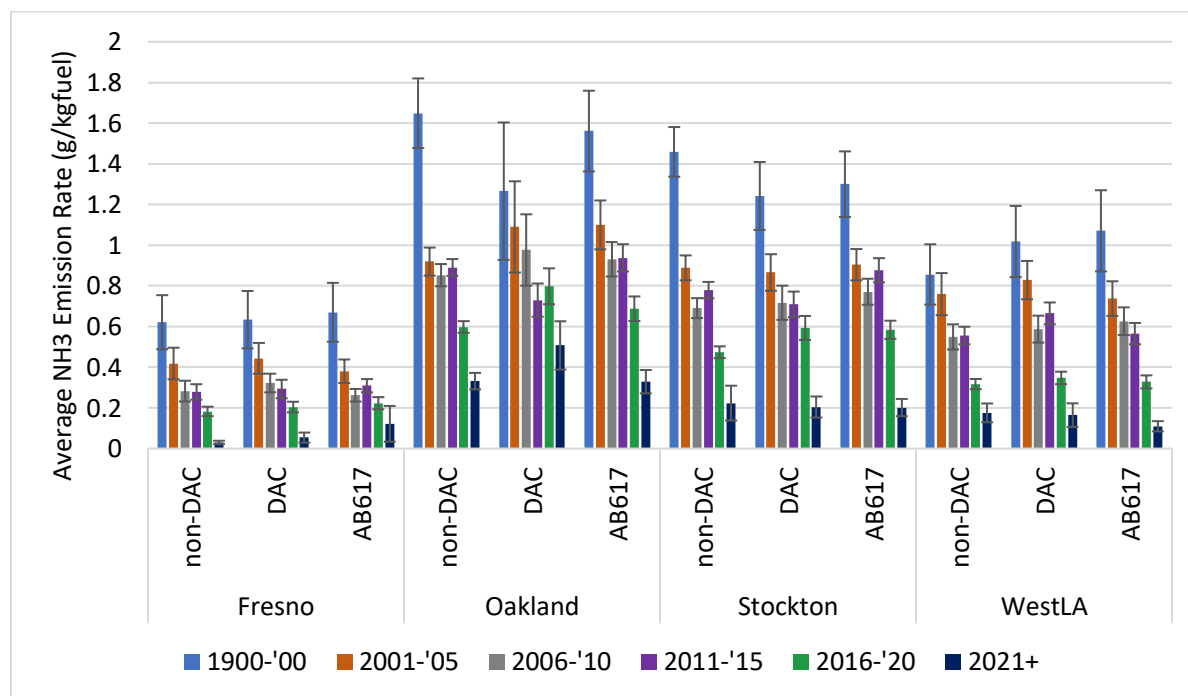


Figure D-3. Average non-diesel NH₃ emission rates by campaign and community DAC status.

DU has been making NH_3 emission measurements at the historical La Brea RSD site since adding that capability prior to their 2008 campaign. Figure D-4 presents the overall average NH_3 emission rates observed at each La Brea campaign since 2008.

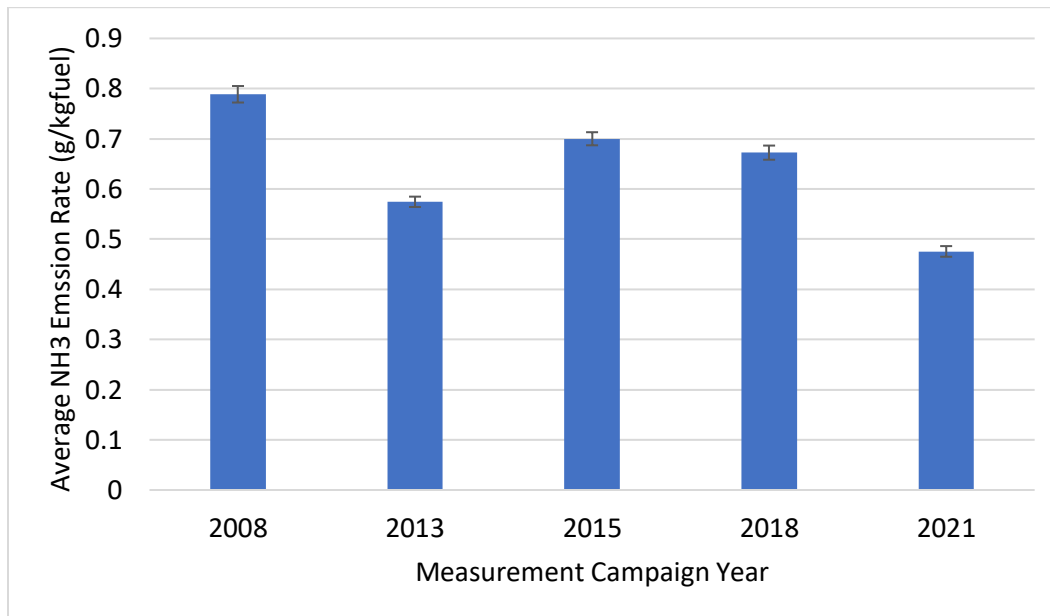


Figure D-4. Overall average NH_3 emission rate observed at the La Brea RSD site by campaign year. Error bars indicate 95% CI.

ERG also reviewed the ammonia emissions results from heavy-duty vehicle (HDV) measurements. Figure D-5 presents the average NH_3 emission rate from HDVs by campaign and fuel type, grouped similarly to the analysis of LDVs. As with those vehicles, the diesel-powered HDVs emit NH_3 at much lower levels. No ammonia emissions of diesel-powered HDVs were successfully made in the Oakland campaign.

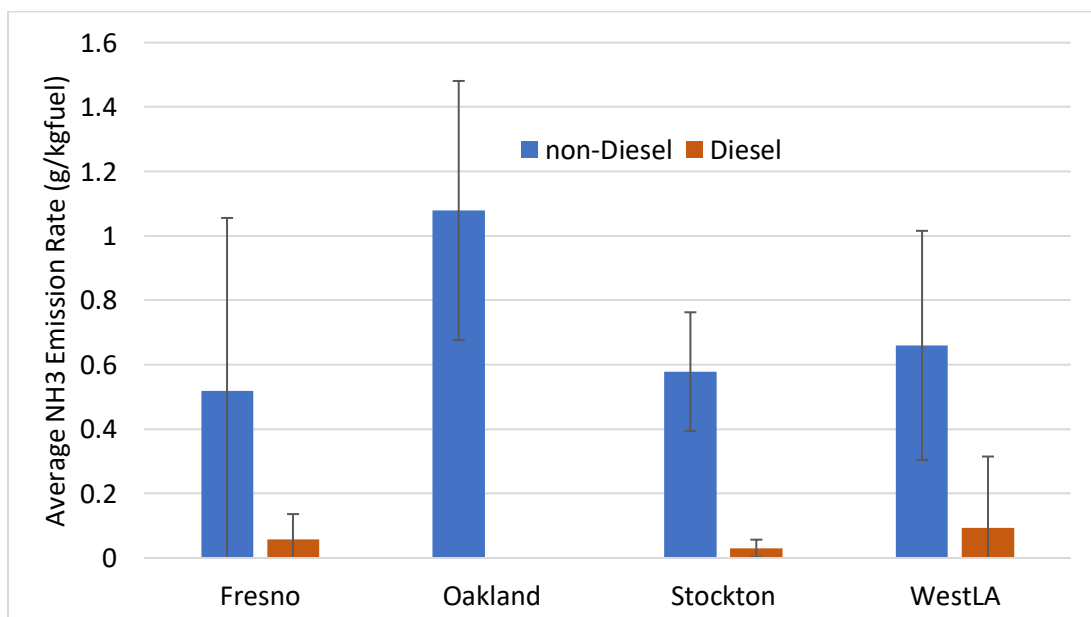


Figure D-5. Average NH_3 emission rates from HDVs by campaign and fuel type. Error bars indicate 95% CI.

Due to low valid counts of HDV emissions readings, ERG isolated the final HDV analyses to only the Stockton campaign. Figure D-6 presents the NH_3 emission rate trends by fuel type and model year bin for all HDVs observed at Stockton. The limited sample size (1,516 total measurements are represented in the graph) and high rate of measurement variability prevents identifying any statistically-significant trends in the findings.

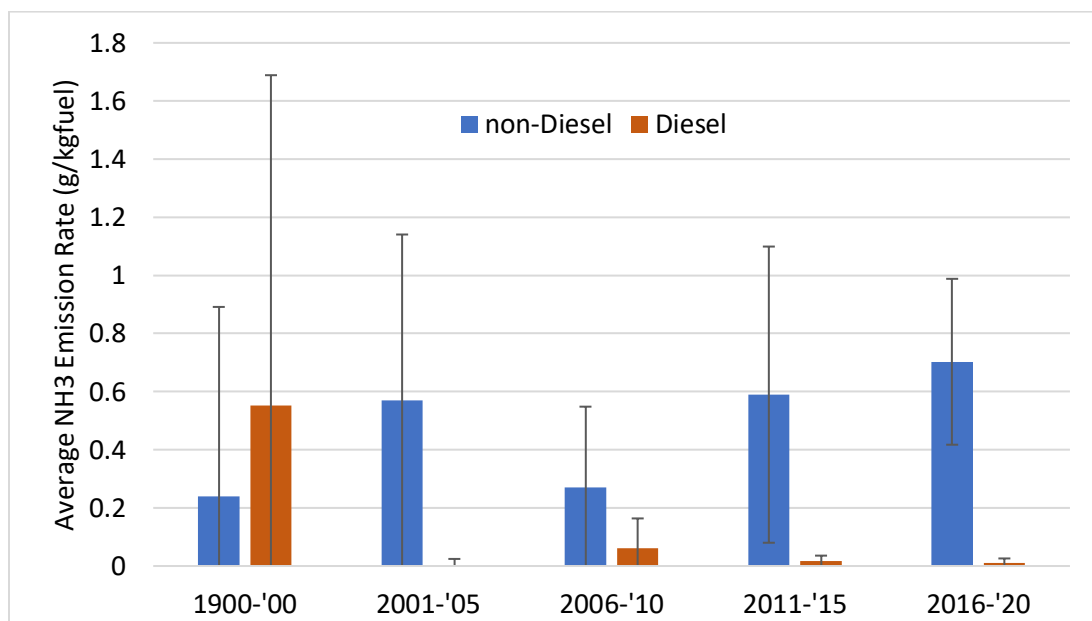


Figure D-6. Average NH_3 emission rates from HDVs by fuel type and model year bin for the Stockton campaign. Error bars indicate 95% CI.

Figure D-7 presents similar findings, binned by truck class instead of model year bin. Again, the limited sample size prevents resolving statistically significant differences in NH_3 emissions within each fuel type across truck classes.

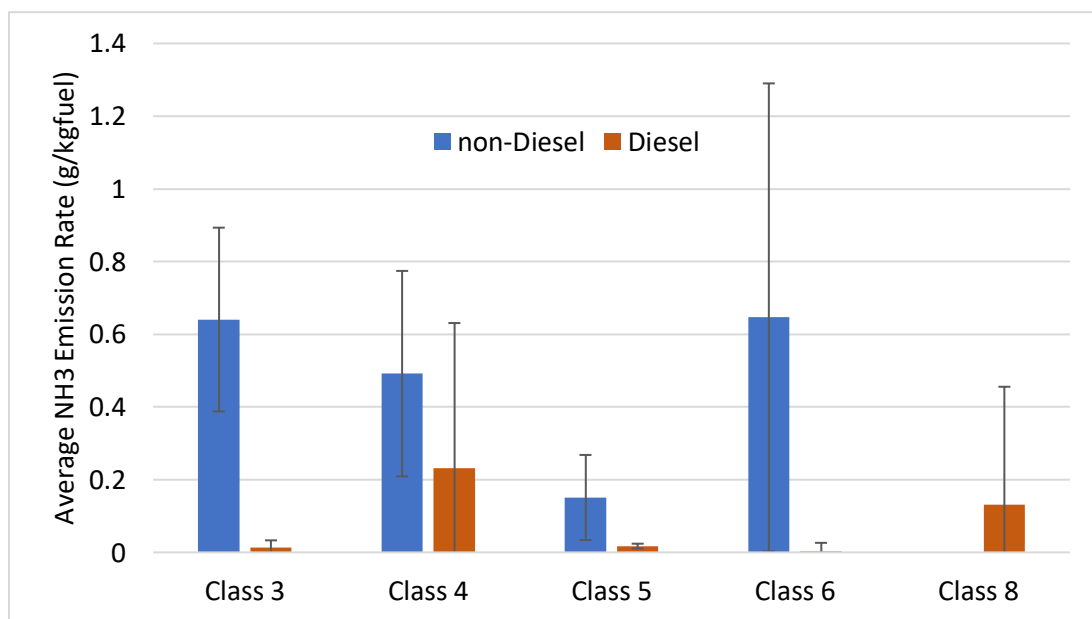


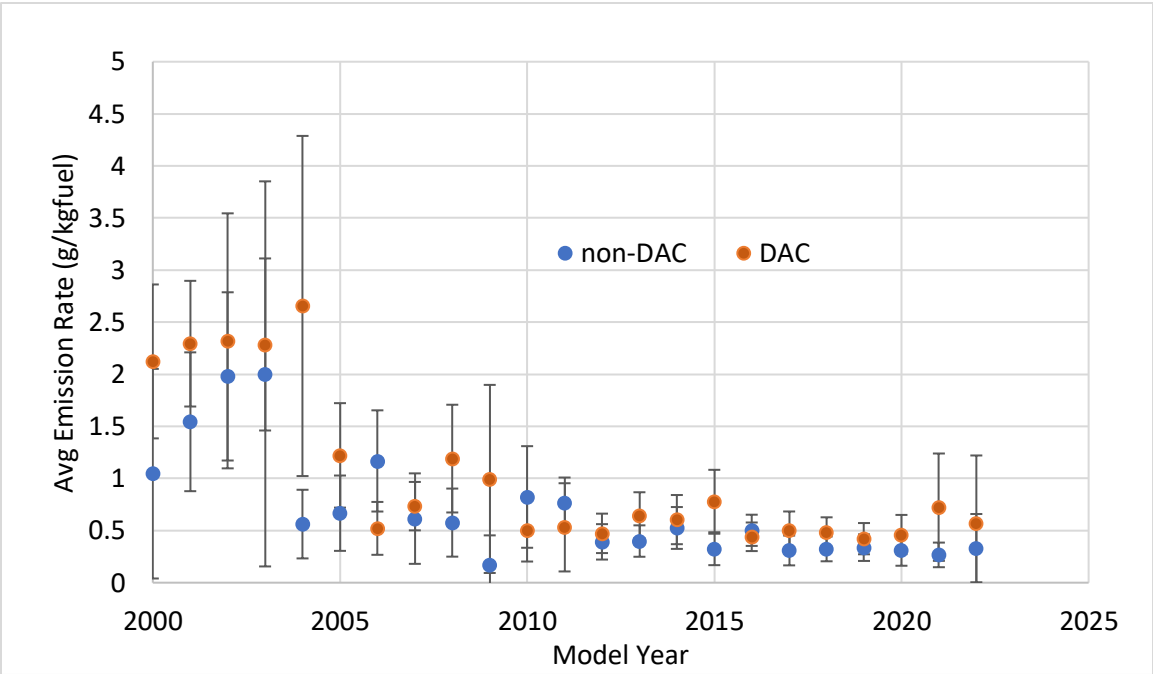
Figure D-7. Average NH_3 emission rates from HDVs by fuel type and truck class for the Stockton campaign. Error bars indicate 95% CI

Appendix F

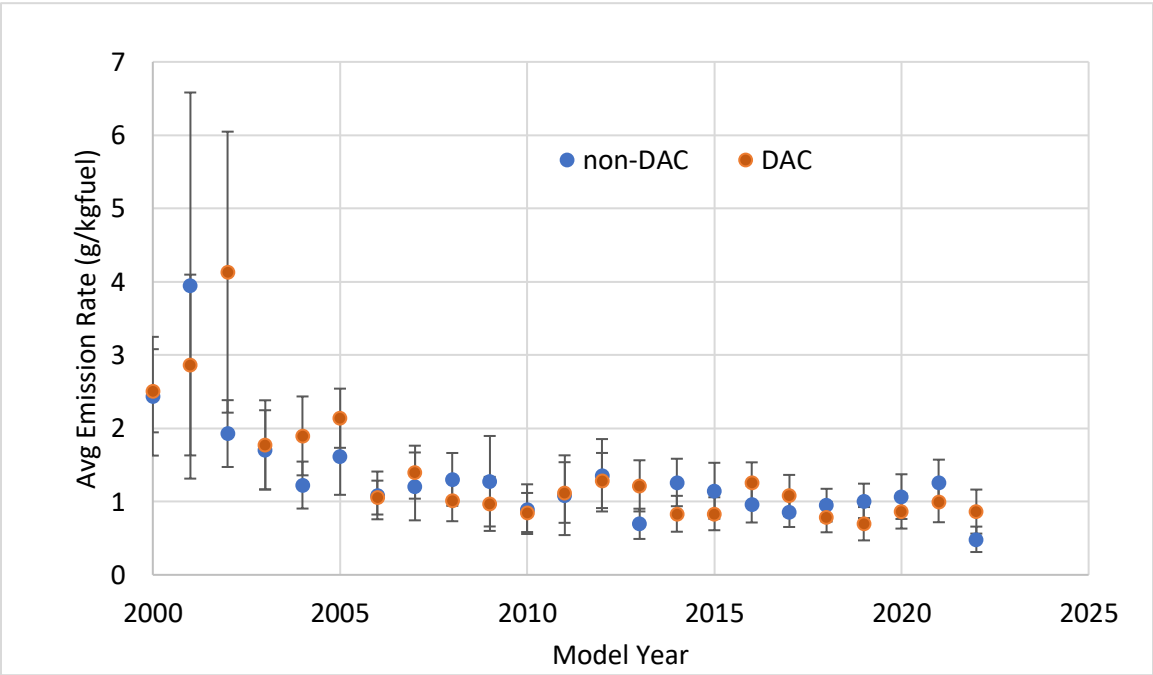
Average LDV Emission Rates by Campaign and Model Year

This appendix presents the LDV emission rates by vehicle model year for DAC and non-DAC observed at each campaign. Emission rates are presented for HC, CO, and NO.

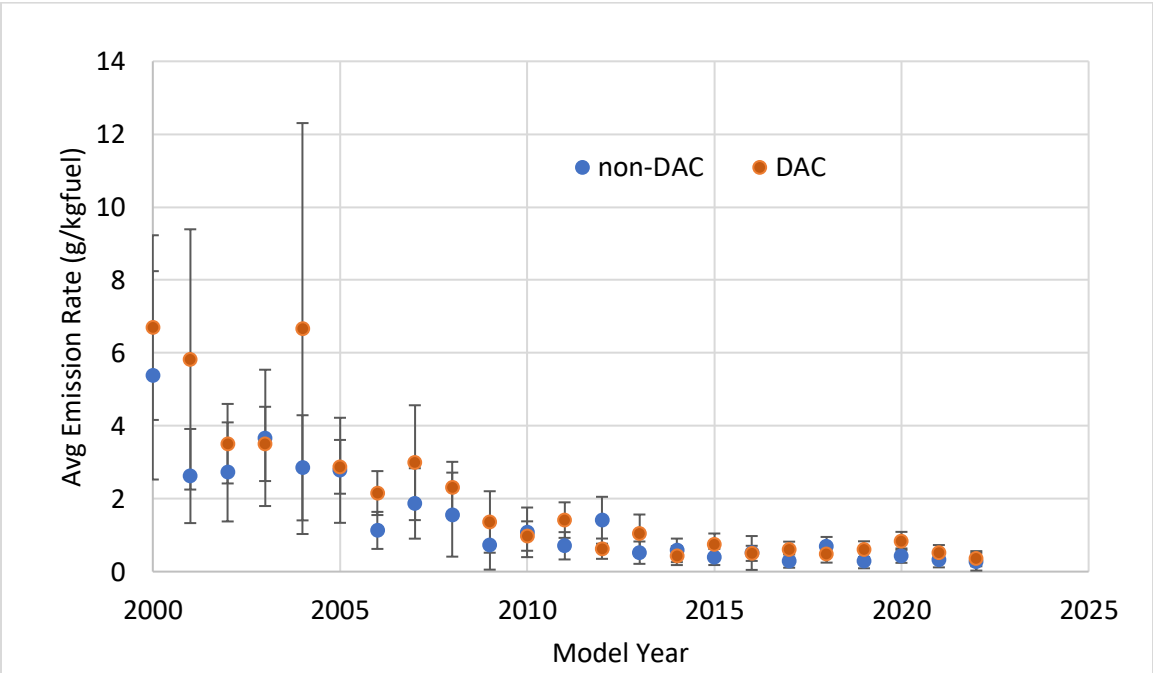
Model Year Average HC Emission Rates - Bakersfield



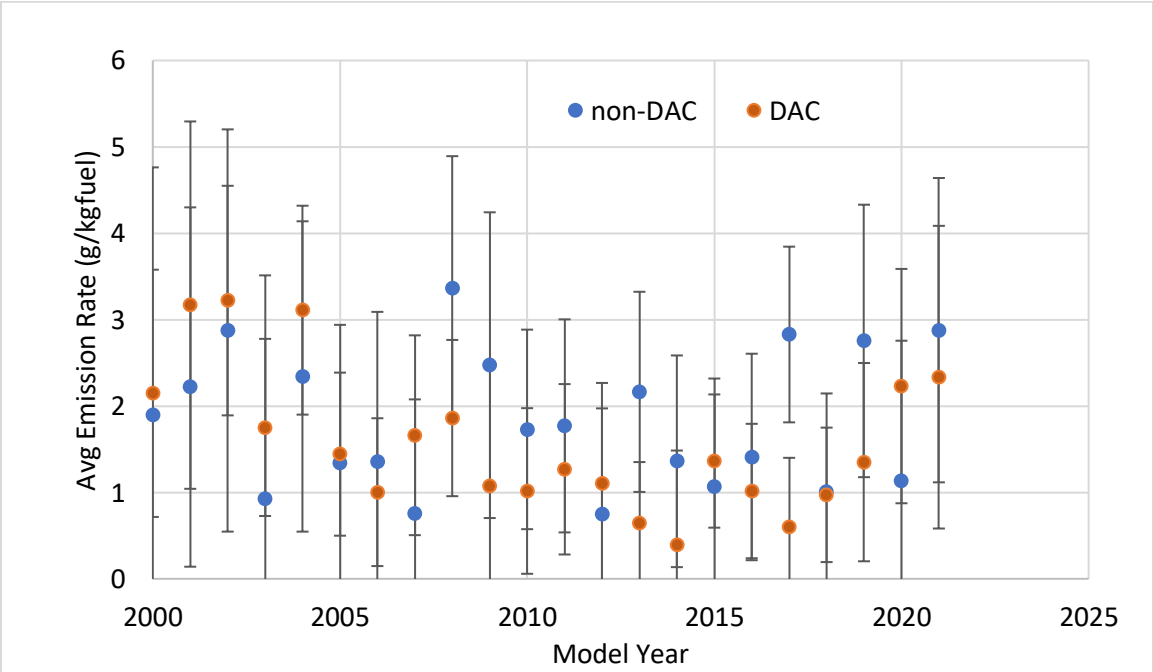
Model Year Average HC Emission Rates – City of Industry



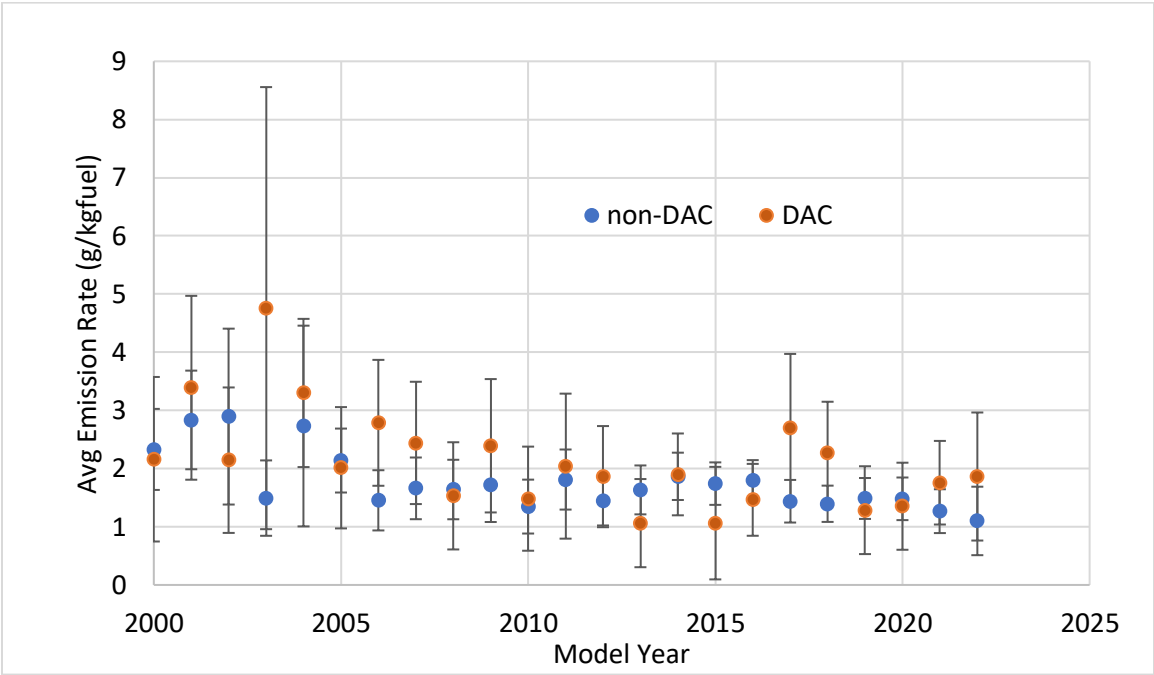
Model Year Average HC Emission Rates – El Centro



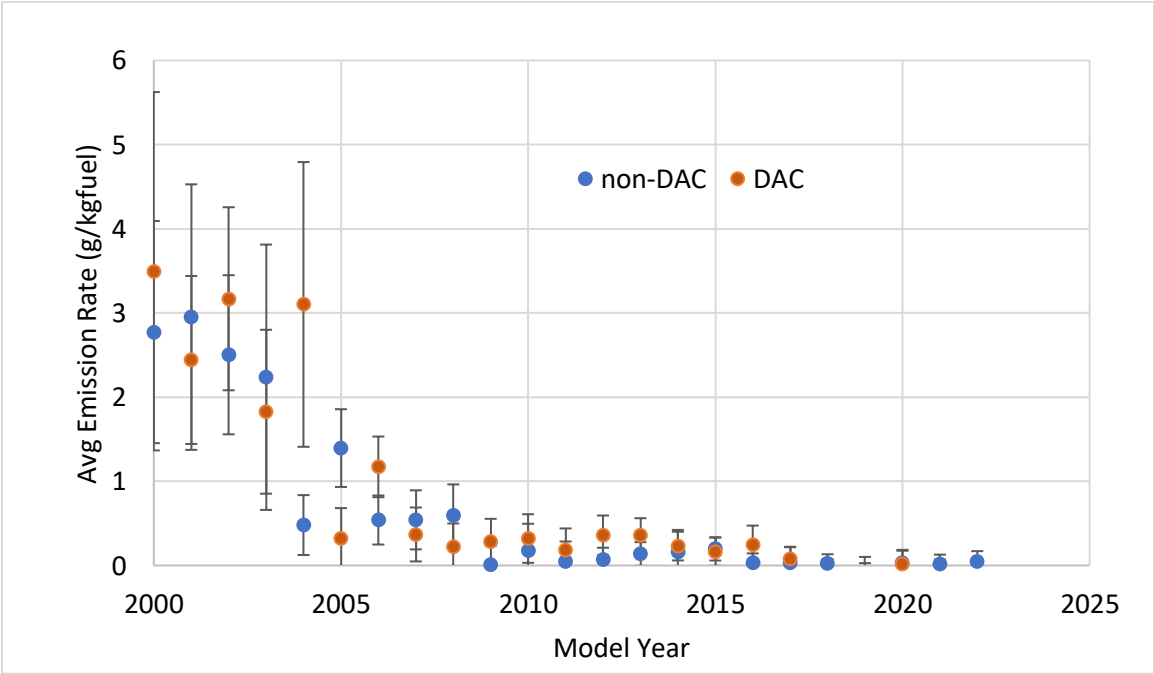
Model Year Average HC Emission Rates – Fresno



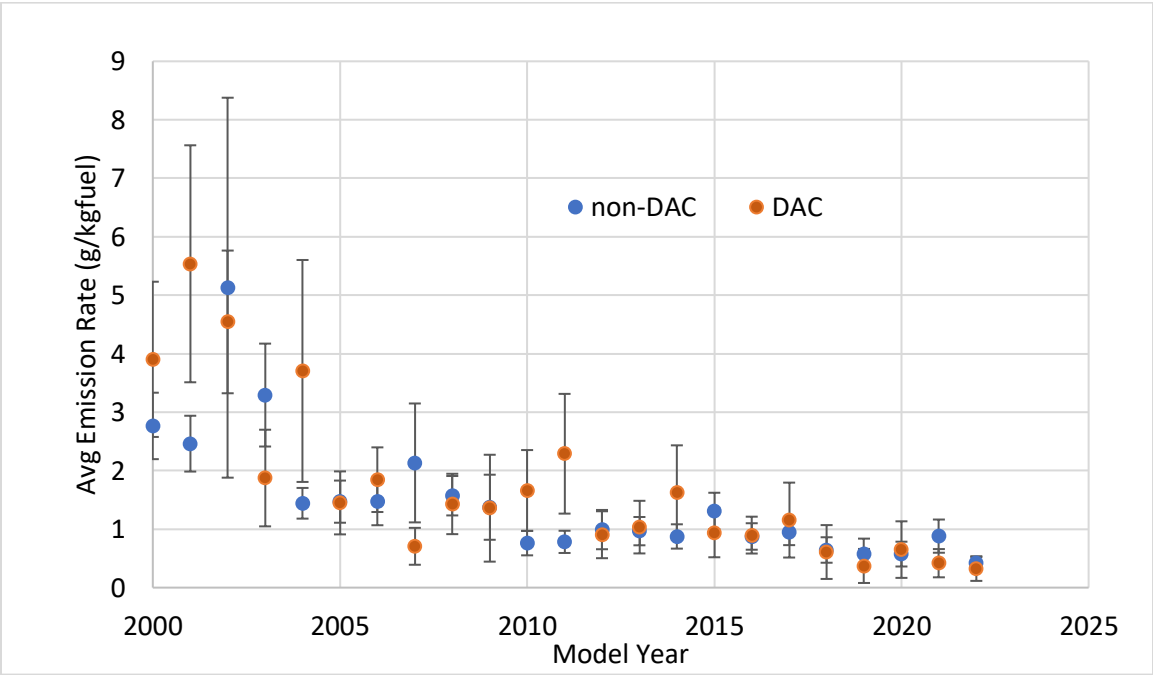
Model Year Average HC Emission Rates – Oakland



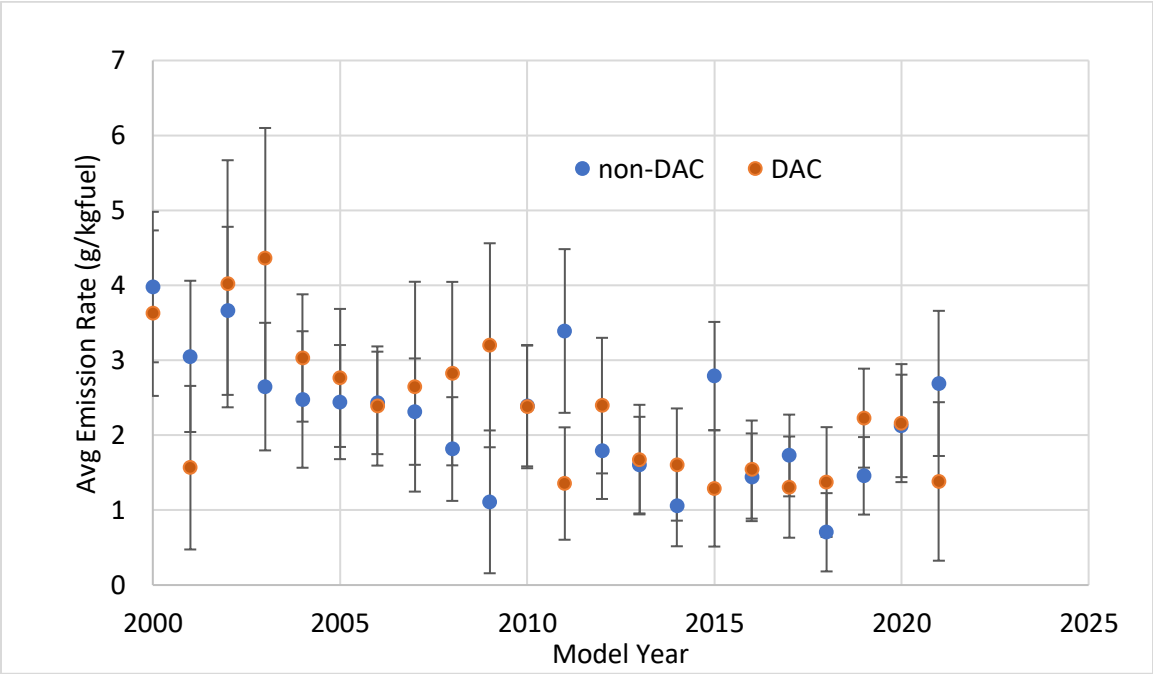
Model Year Average HC Emission Rates – Riverside



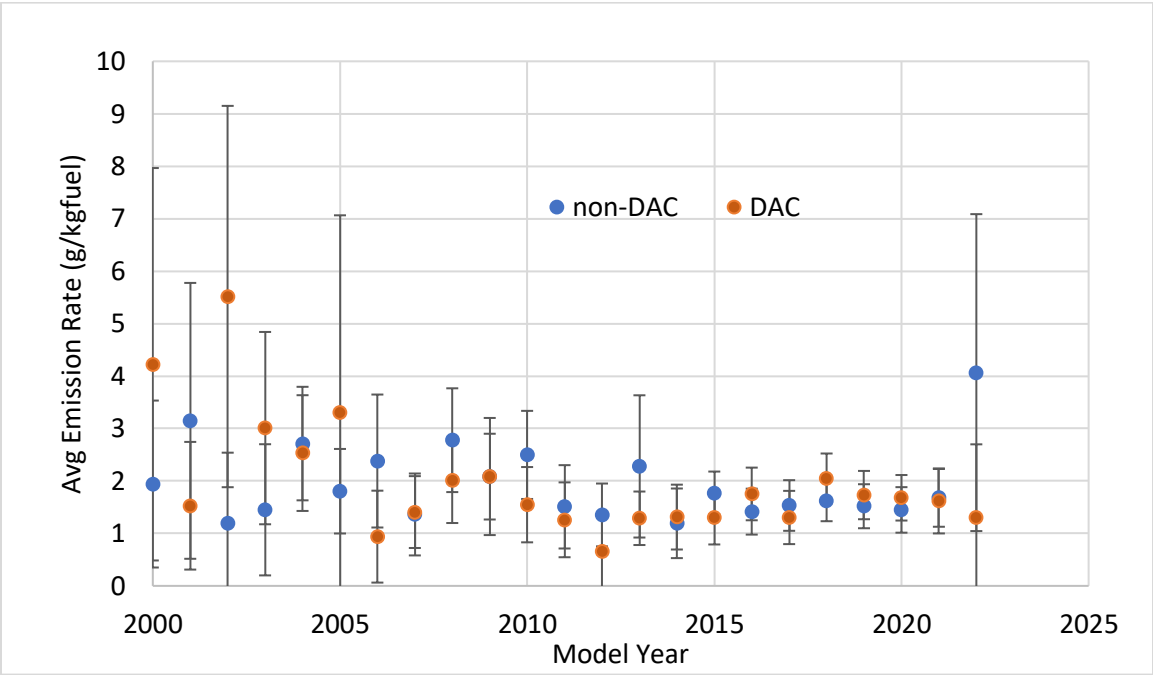
Model Year Average HC Emission Rates – San Ysidro



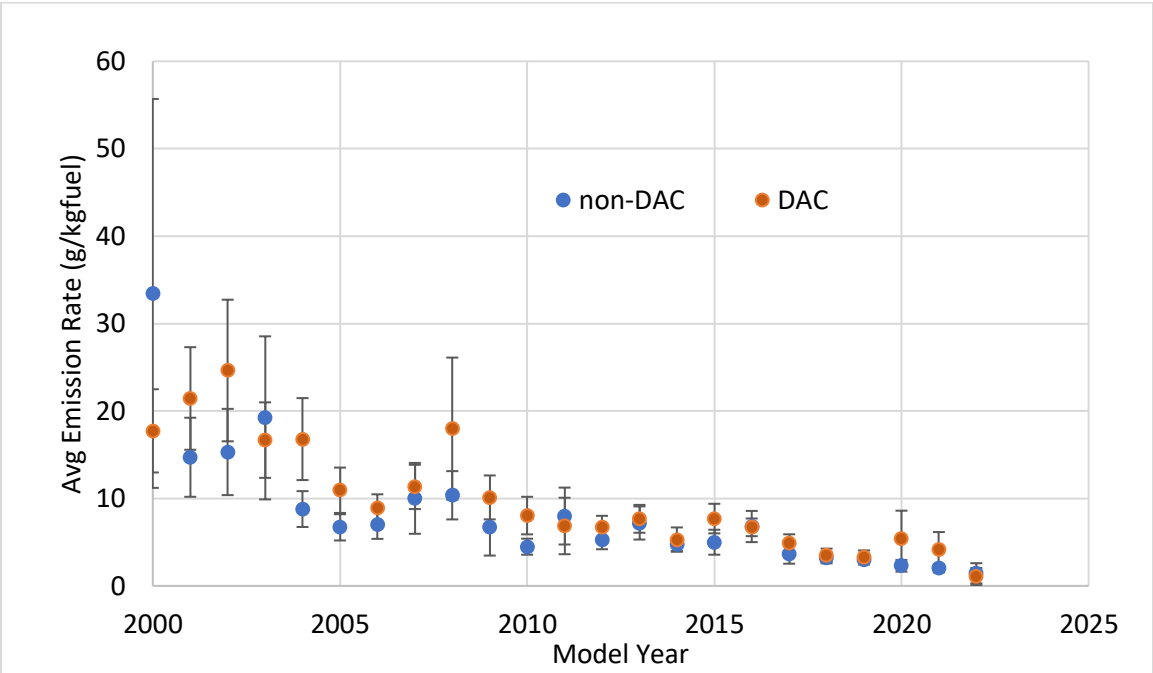
Model Year Average HC Emission Rates – Stockton



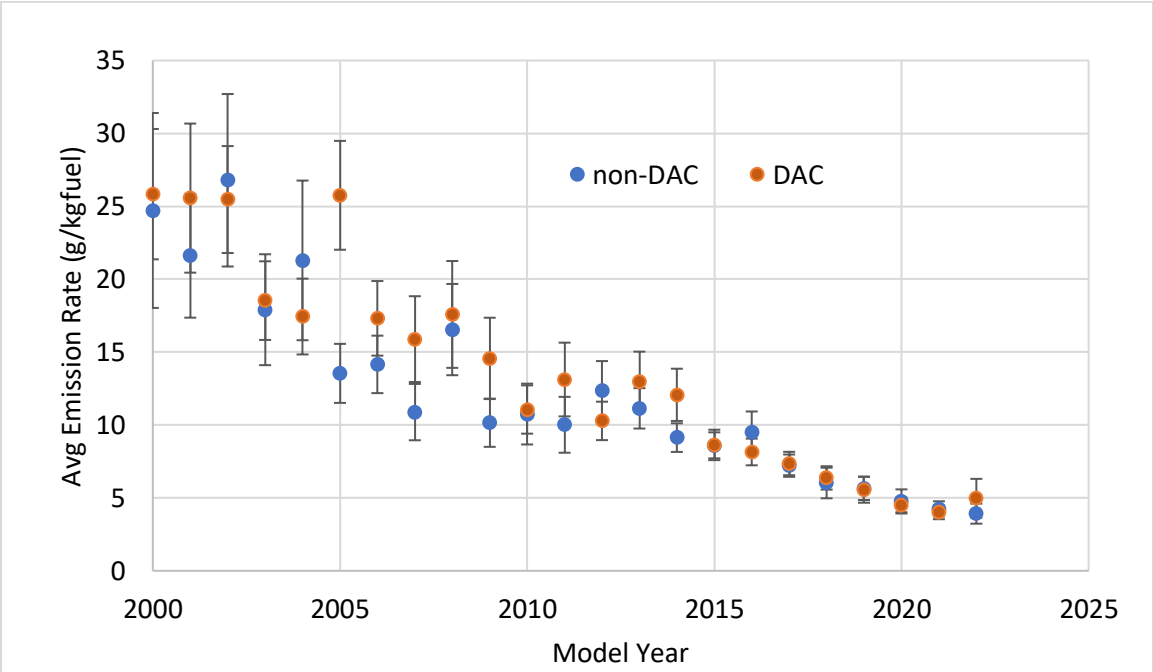
Model Year Average HC Emission Rates – West LA



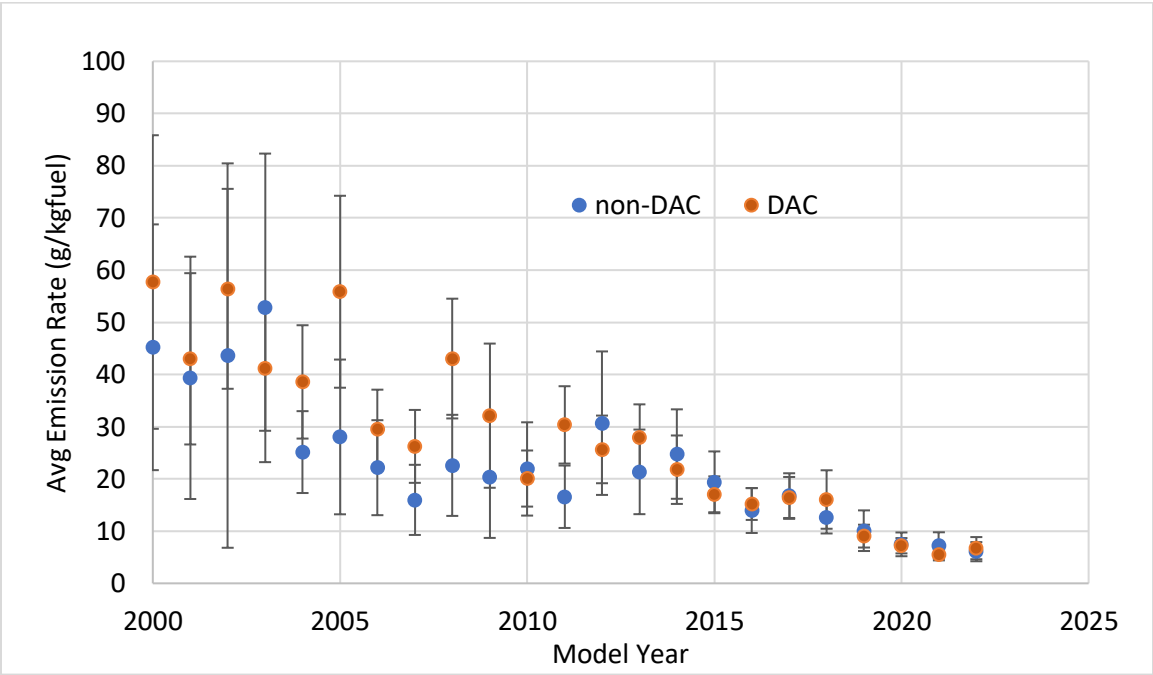
Model Year Average CO Emission Rates – Bakersfield



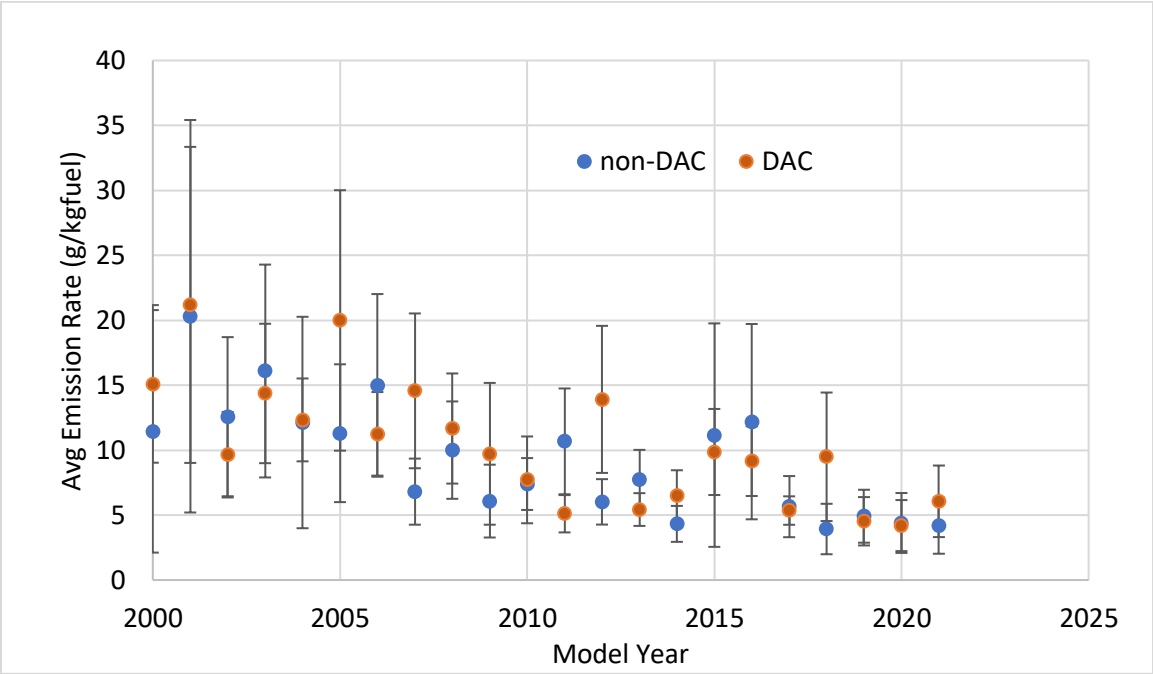
Model Year Average CO Emission Rates – City of Industry



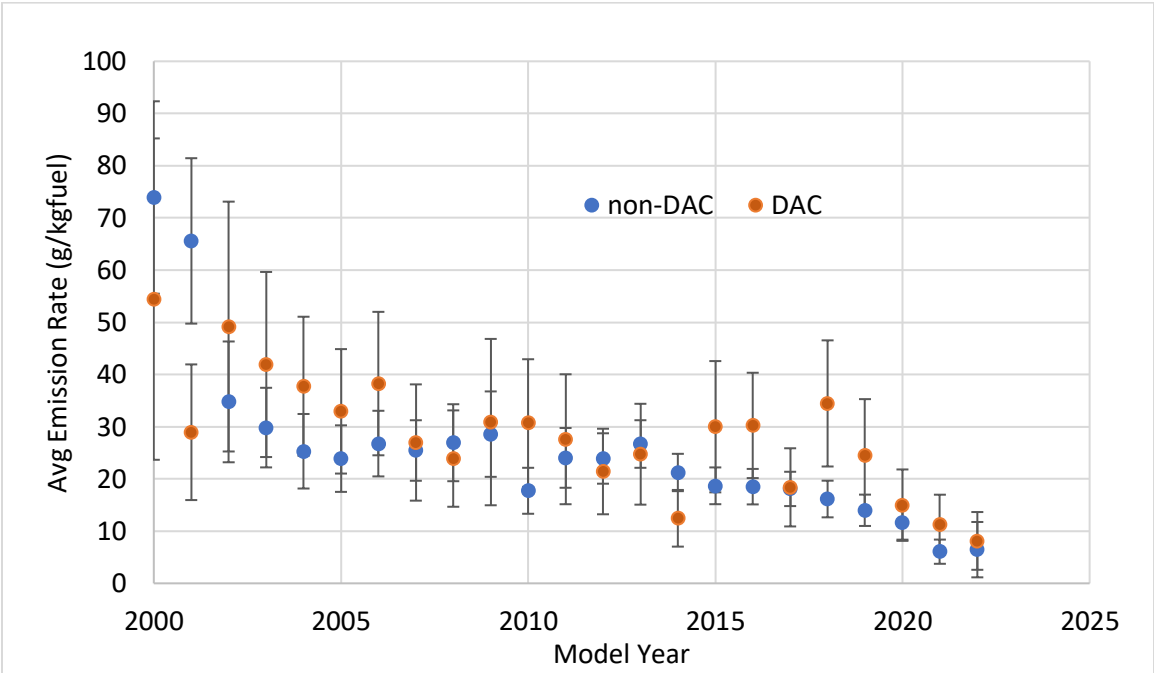
Model Year Average CO Emission Rates – El Centro



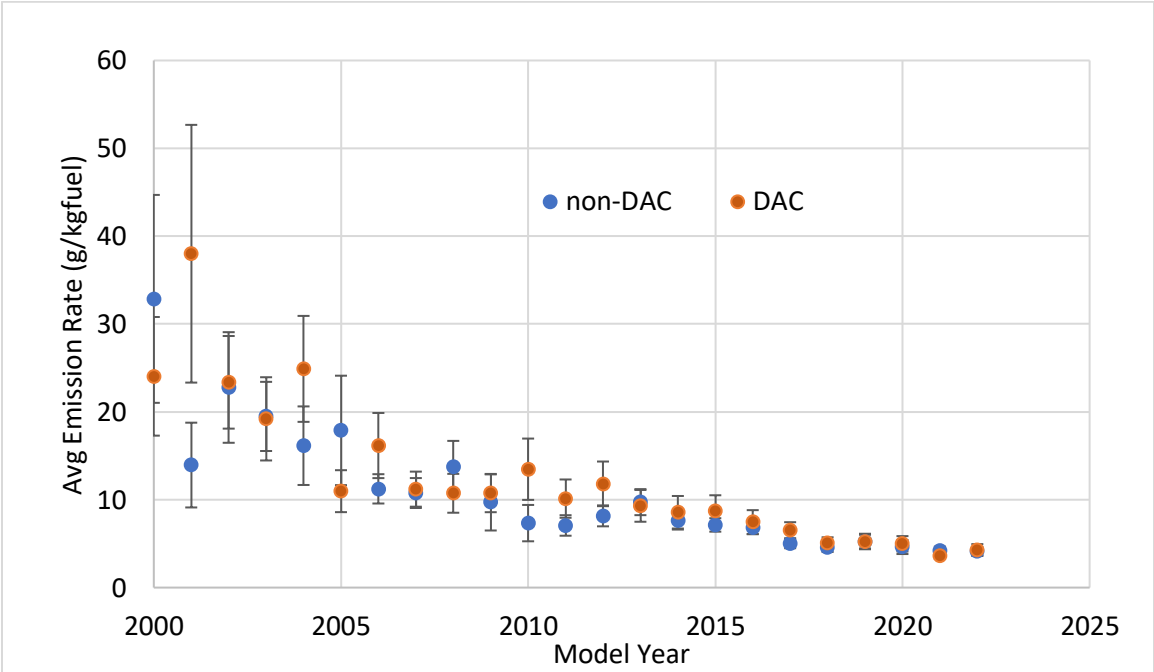
Model Year Average CO Emission Rates – Fresno



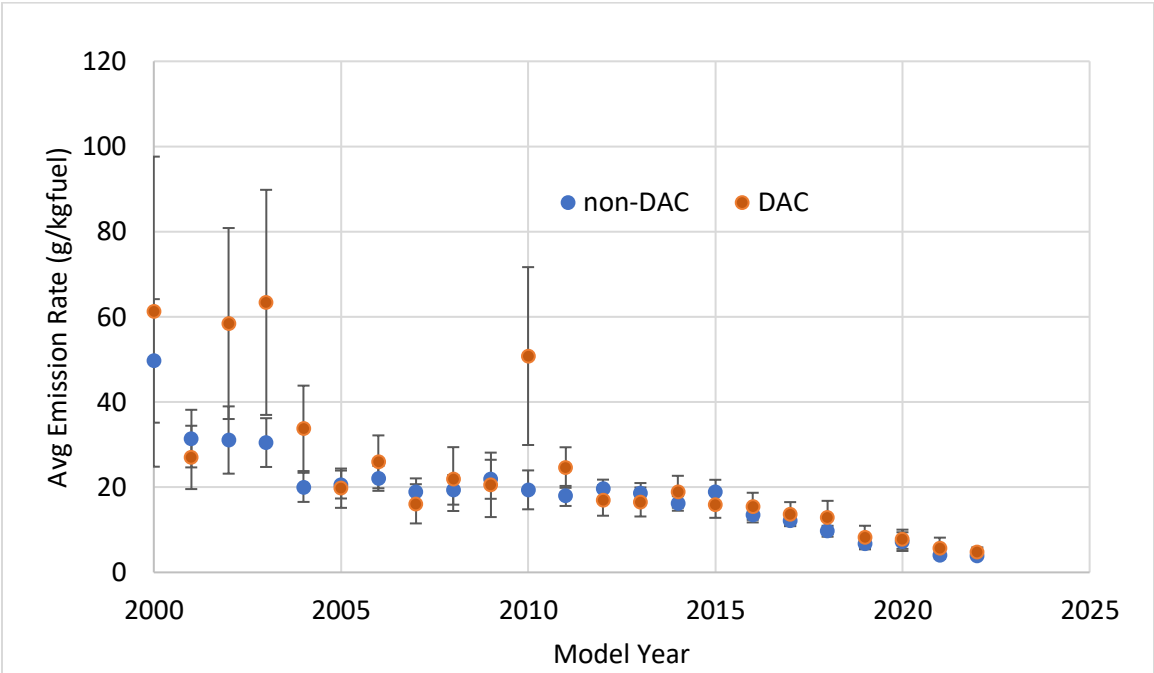
Model Year Average CO Emission Rates – Oakland



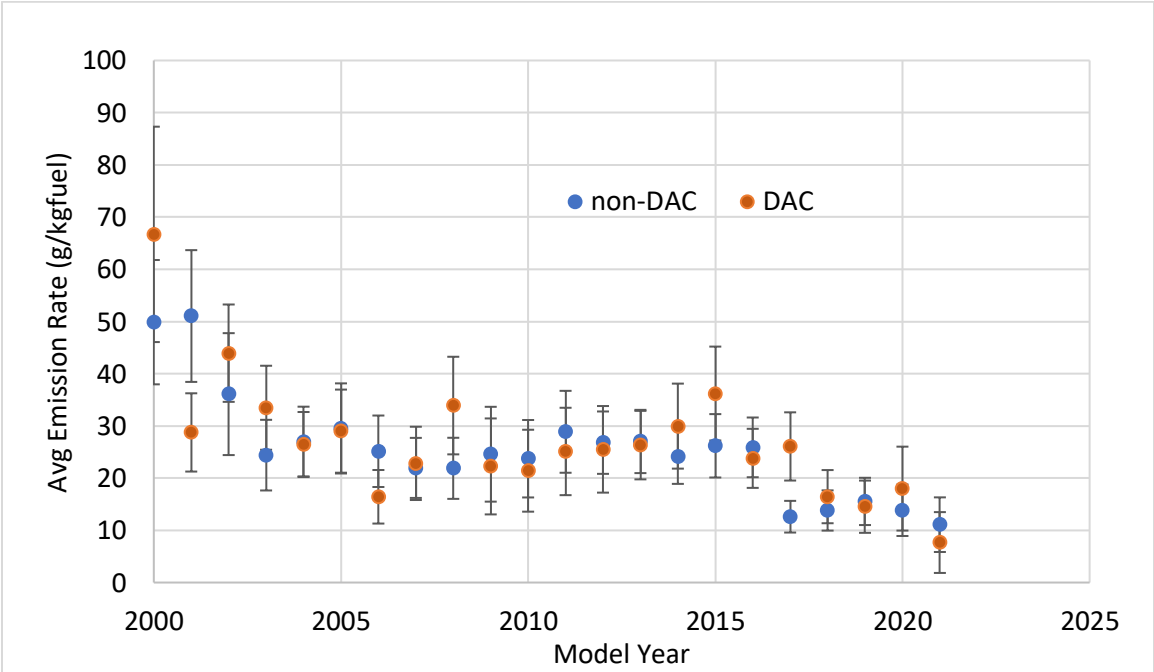
Model Year Average CO Emission Rates – Riverside



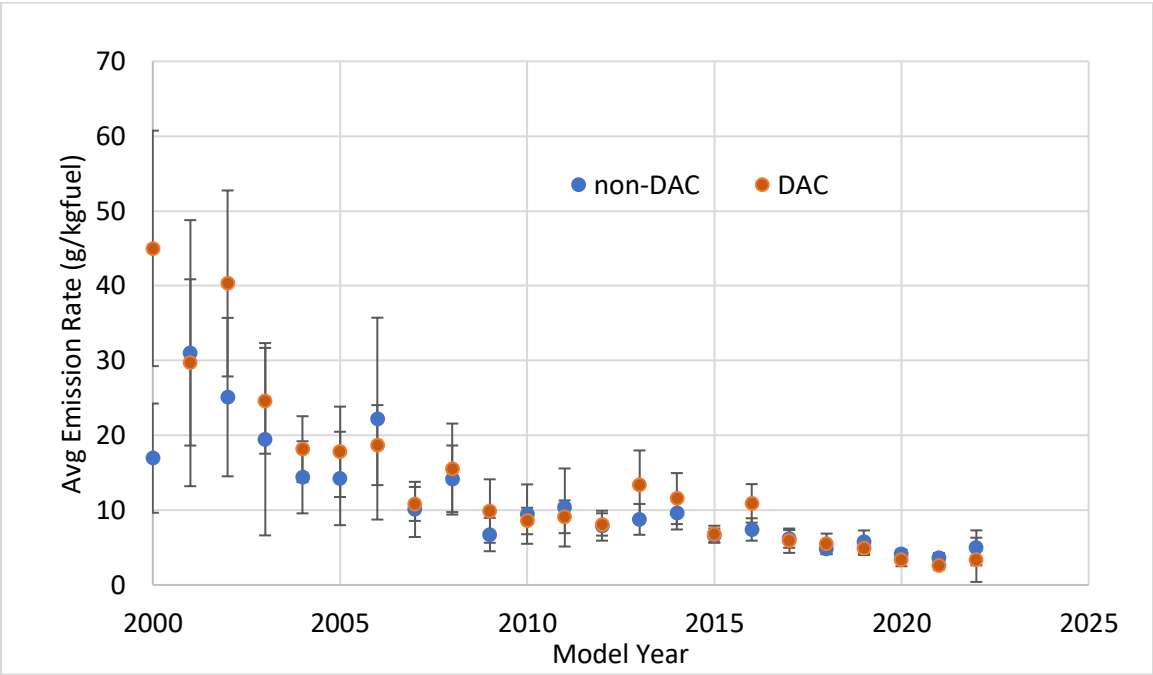
Model Year Average CO Emission Rates – San Ysidro



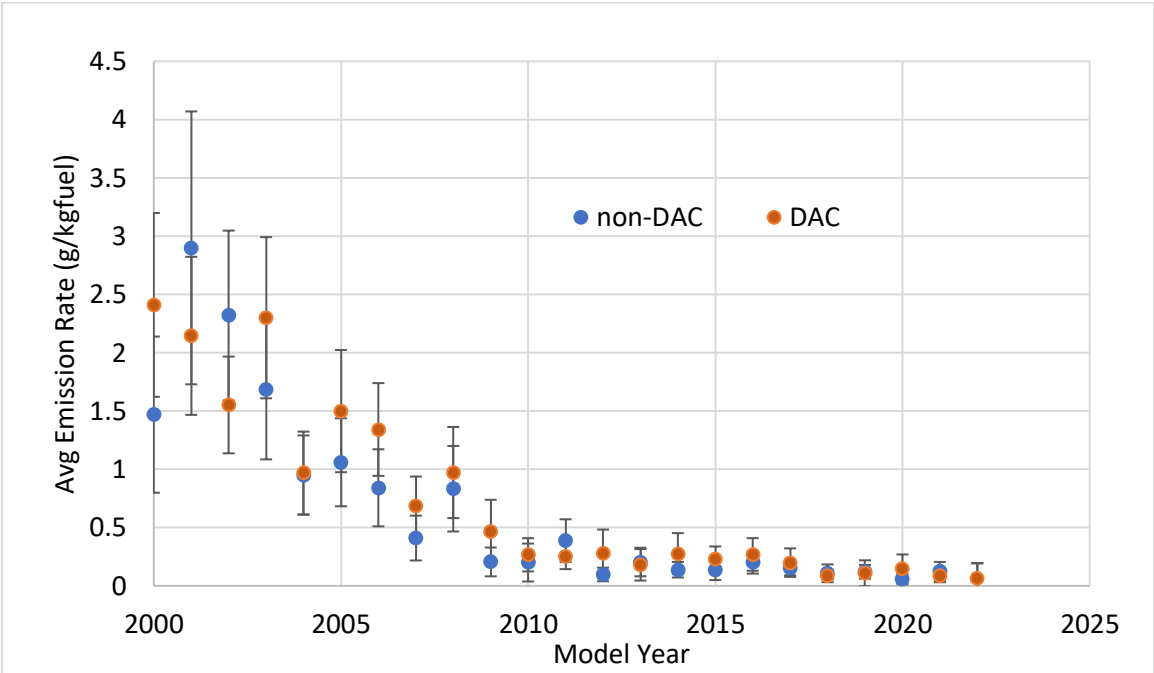
Model Year Average CO Emission Rates – Stockton



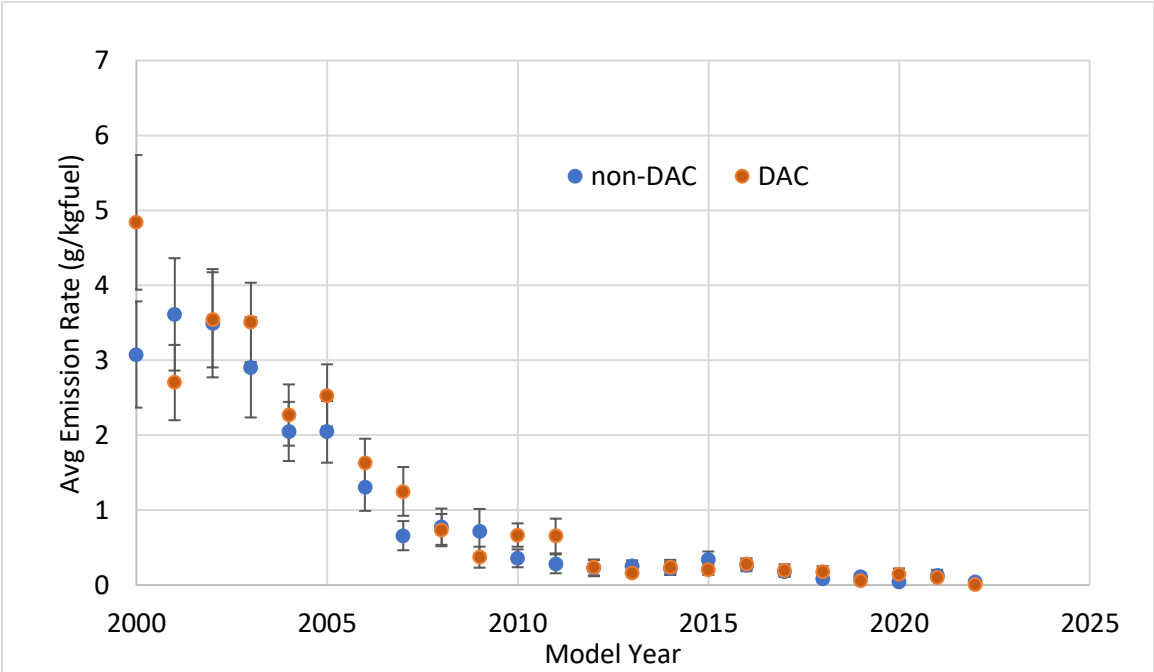
Model Year Average CO Emission Rates – West LA



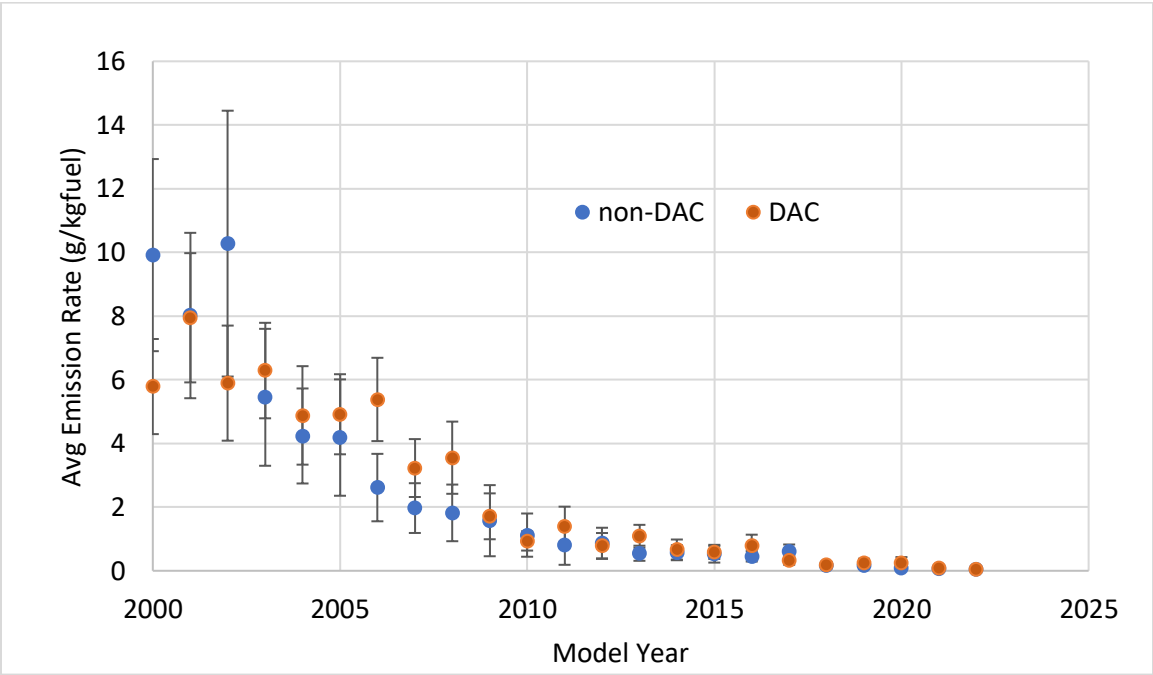
Model Year Average NO Emission Rates – Bakersfield



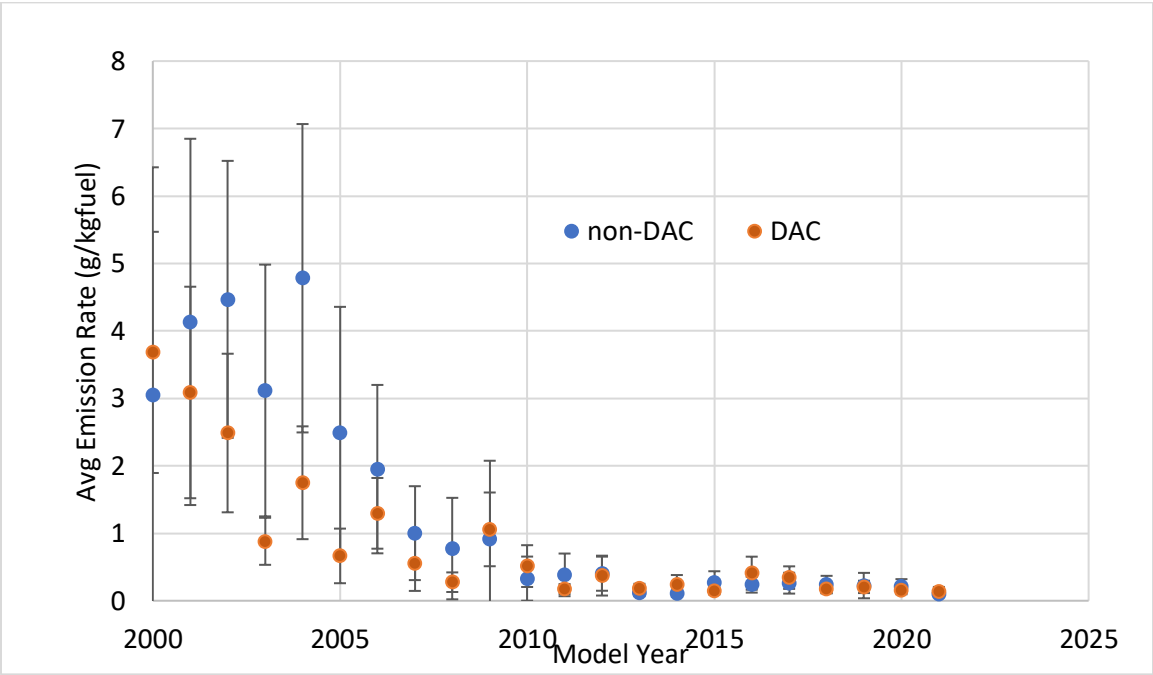
Model Year Average NO Emission Rates – City of Industry



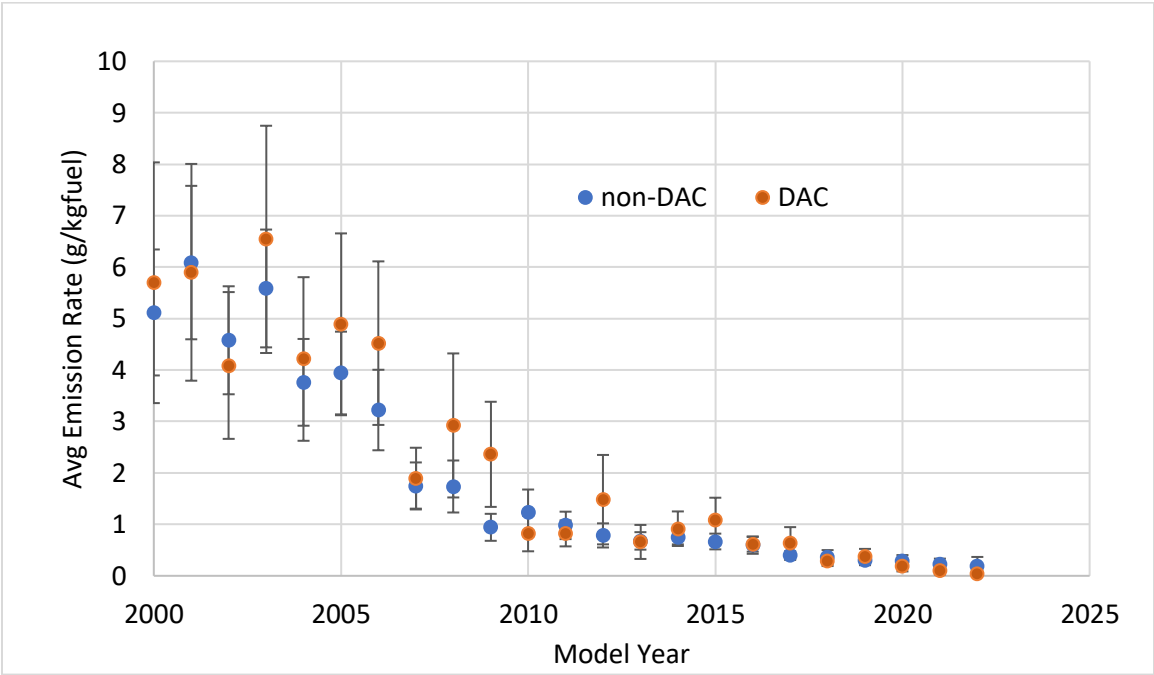
Model Year Average NO Emission Rates – El Centro



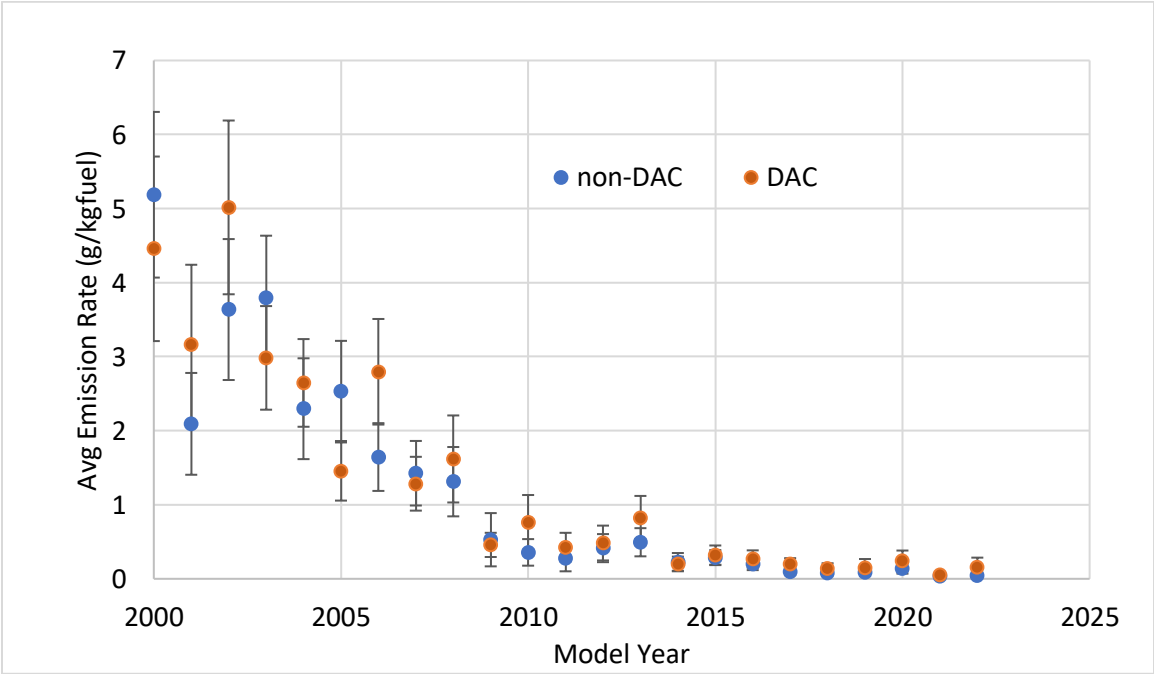
Model Year Average NO Emission Rates – Fresno



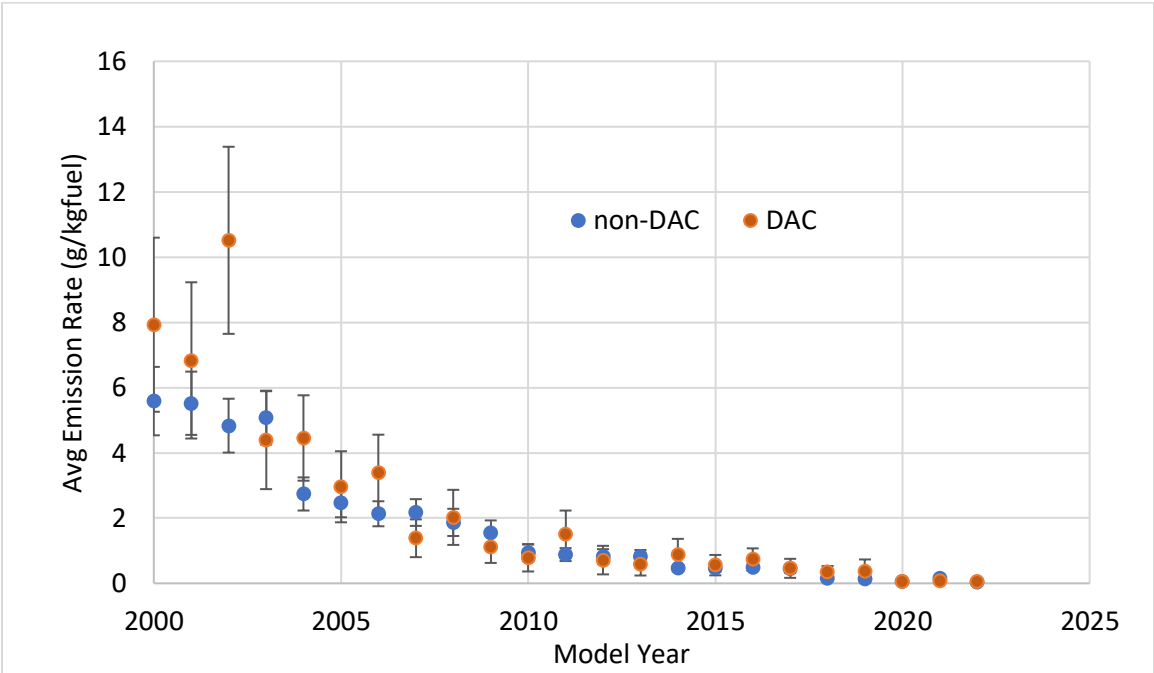
Model Year Average NO Emission Rates – Oakland



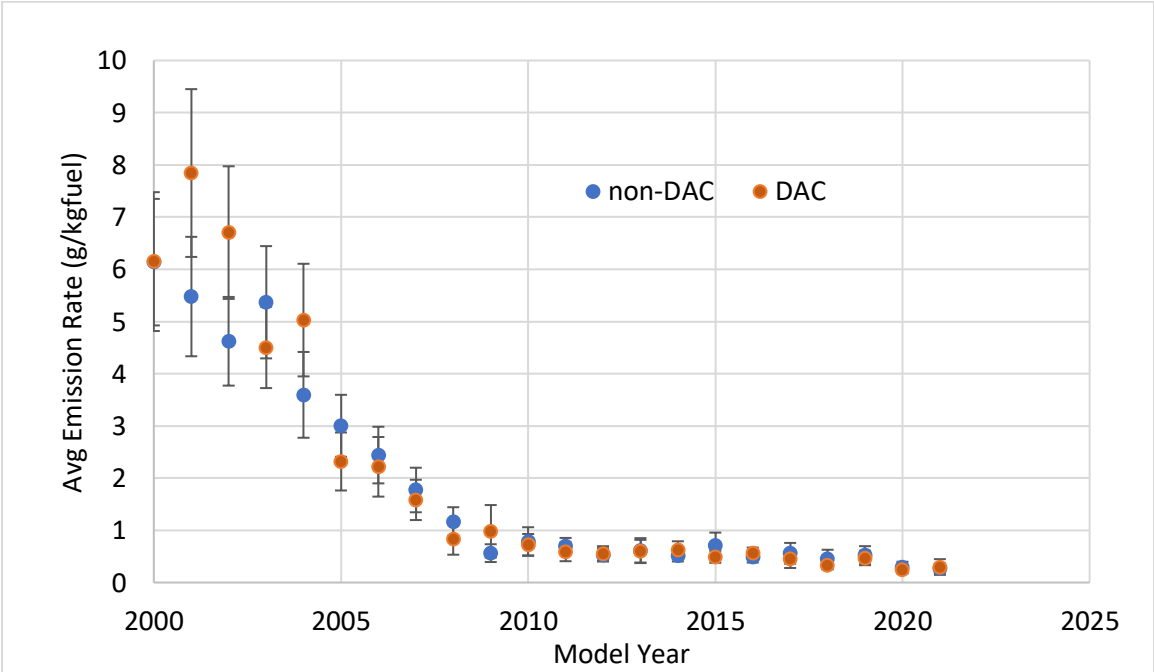
Model Year Average NO Emission Rates – Riverside



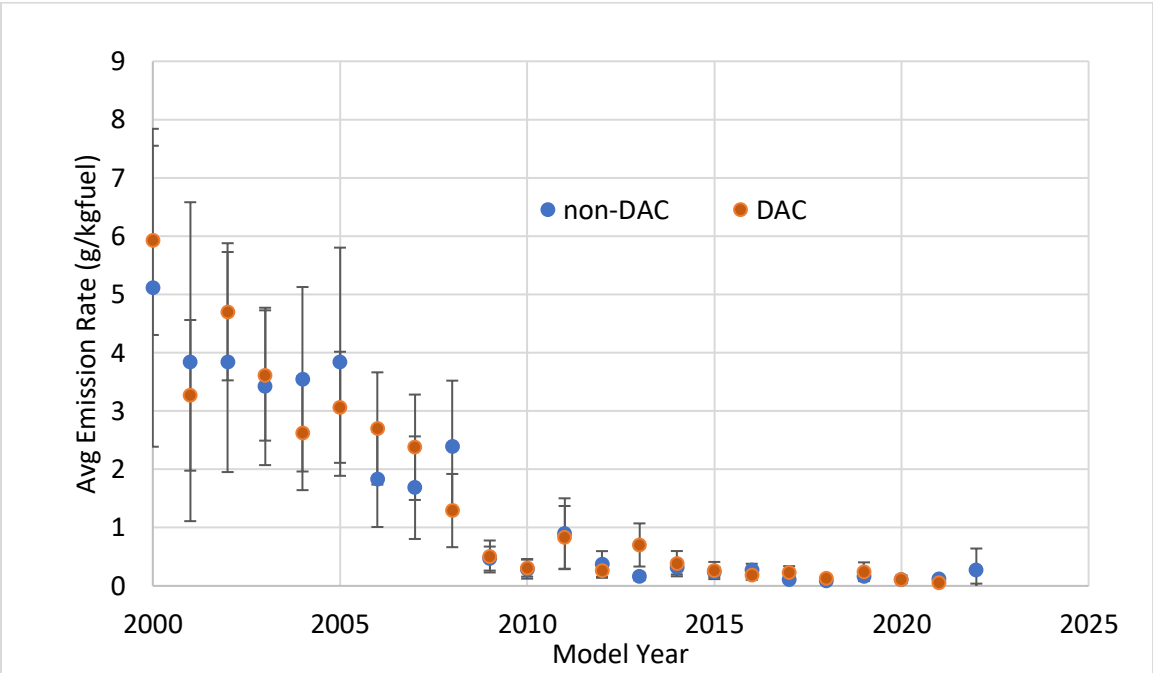
Model Year Average NO Emission Rates – San Ysidro



Model Year Average NO Emission Rates – Stockton



Model Year Average NO Emission Rates – West LA

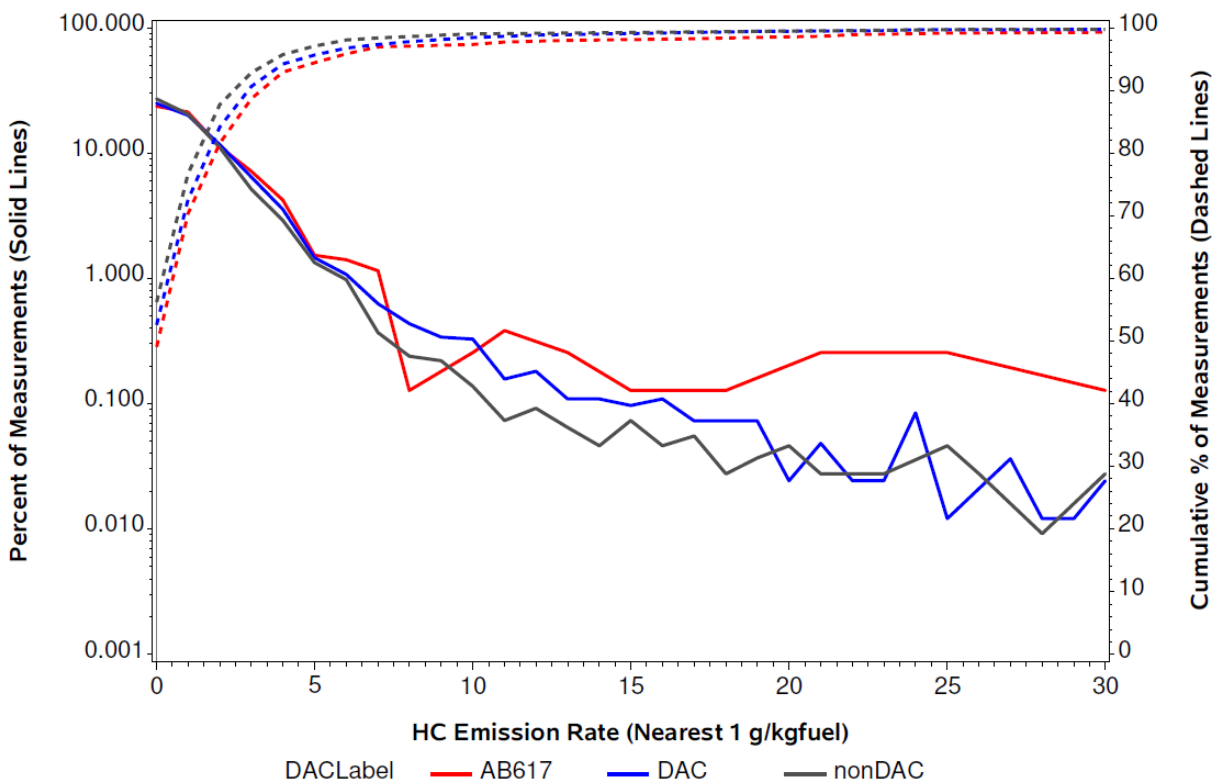


Appendix G

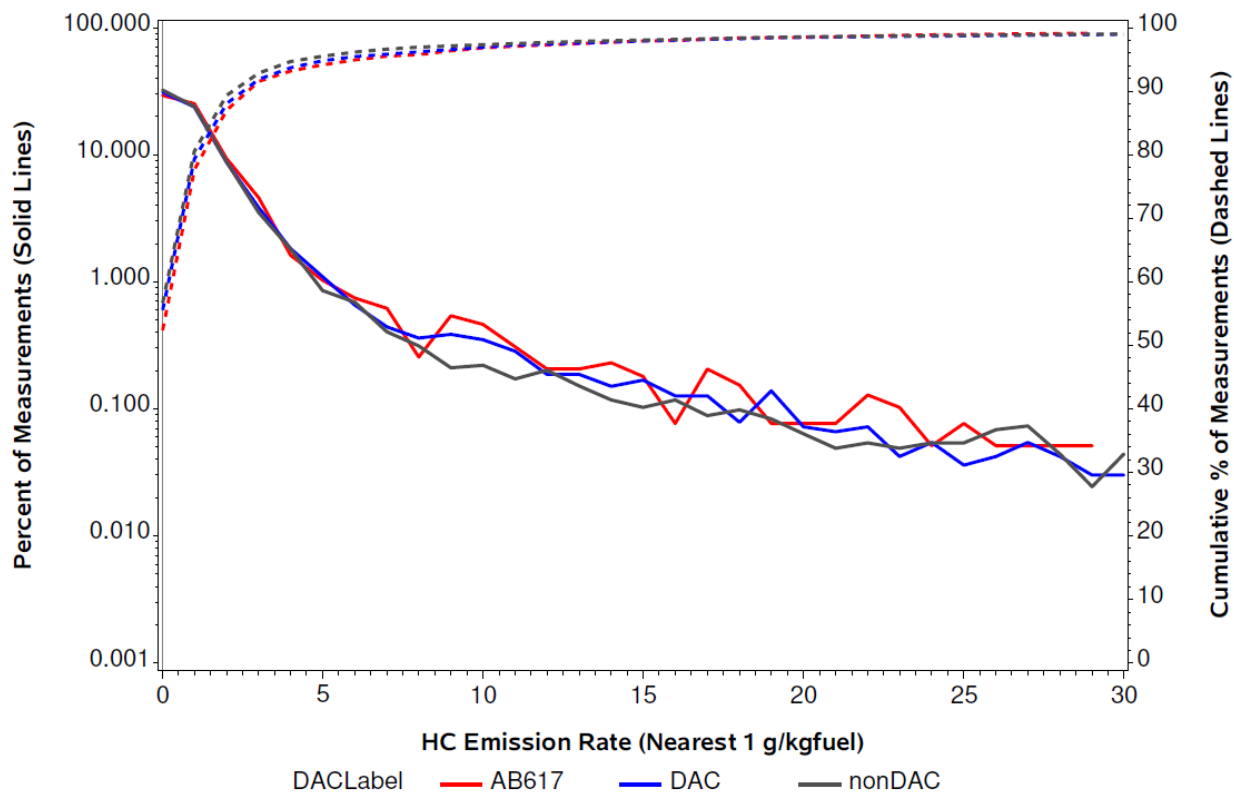
Distributions of Binned Emission Rates and Cumulative Emission Rates

This appendix presents the distributions of binned emission rates and the cumulative emission rates measured for LDVs at each RSD campaign. Emission rates are presented for three community type's vehicles: non-DAC, DAC, and AB617. Plots are grouped first for HC, then CO, then NO emission rates. HC emission rates are binned to the nearest 1 g/kgfuel, CO emission rates are binned to the nearest 5 g/kgfuel, and NO emission rates are binned to the nearest 0.2 g/kgfuel. Note that the cumulative distributions generally start at around 40% to 50% at the zero emission point of the x-axis; this is due to the noise signature of the RSD equipment, which would read an approximately normal distribution around zero in the presence of clean (or background-equivalent emitting) vehicles.

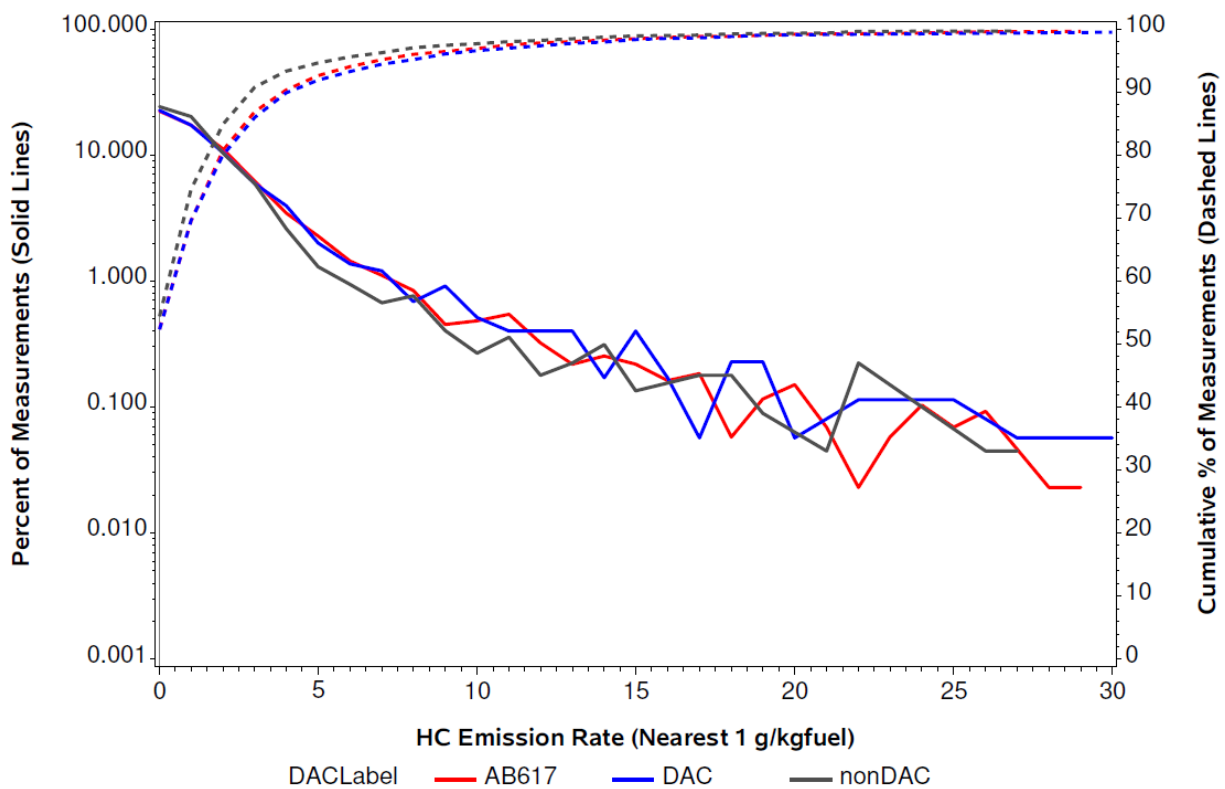
HC Emission Rate Distributions - Bakersfield



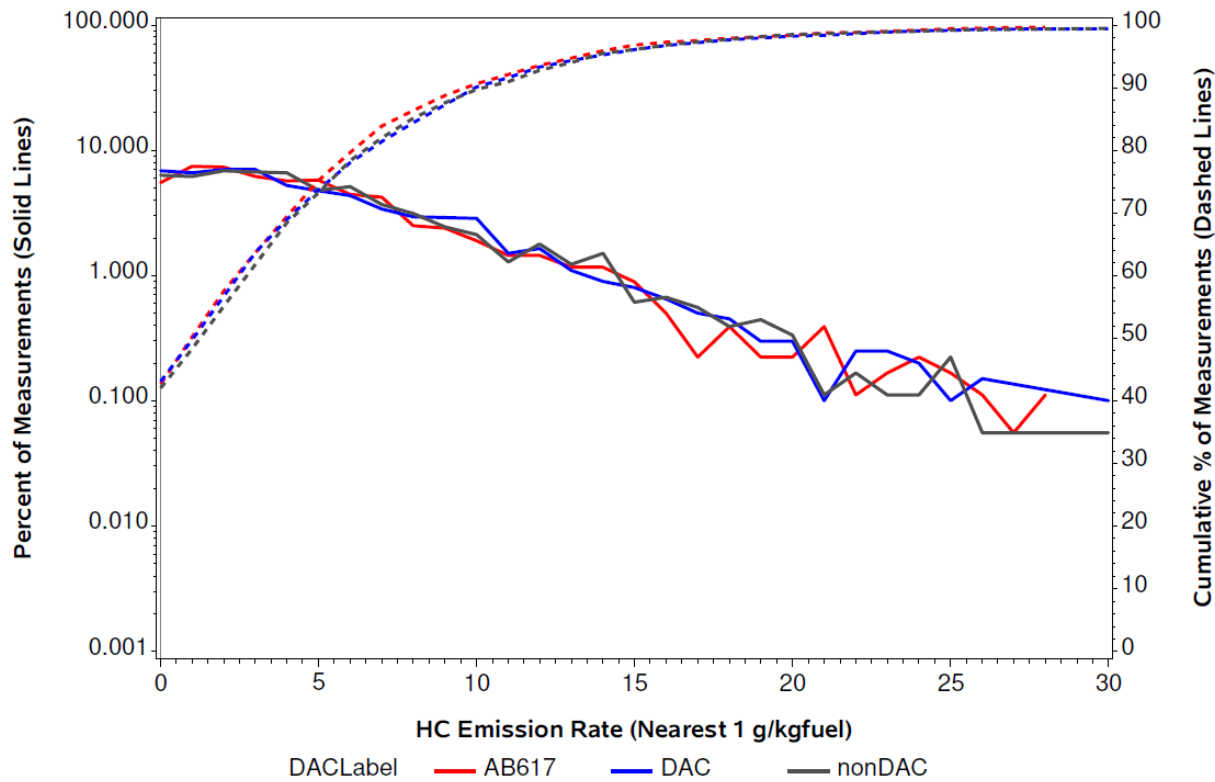
HC Emission Rate Distributions – City of Industry



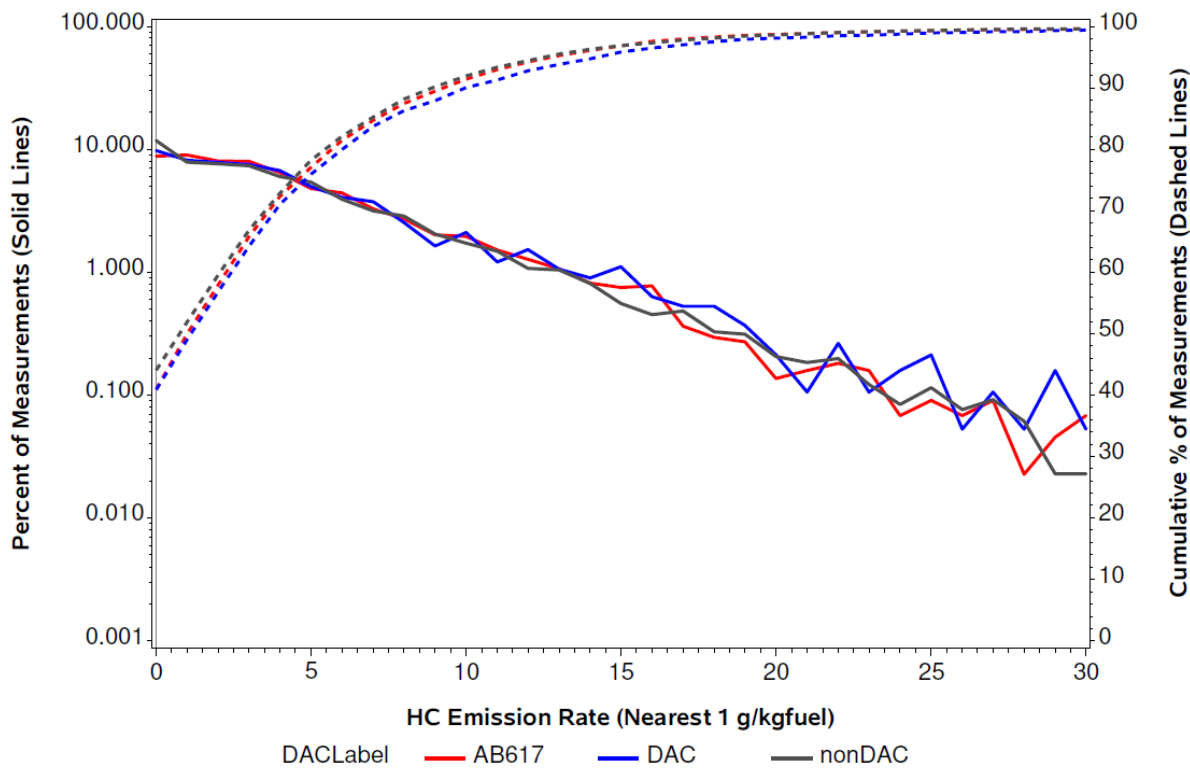
HC Emission Rate Distributions – El Centro



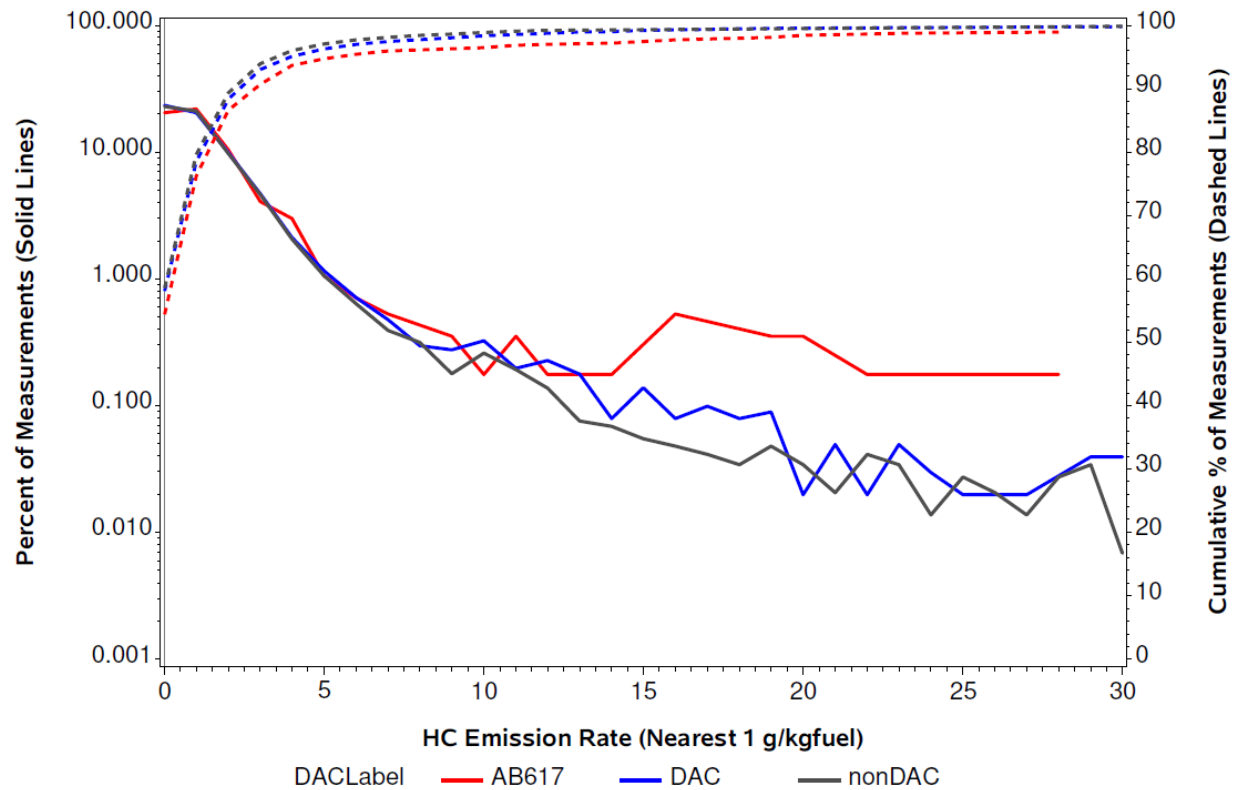
HC Emission Rate Distributions - Fresno



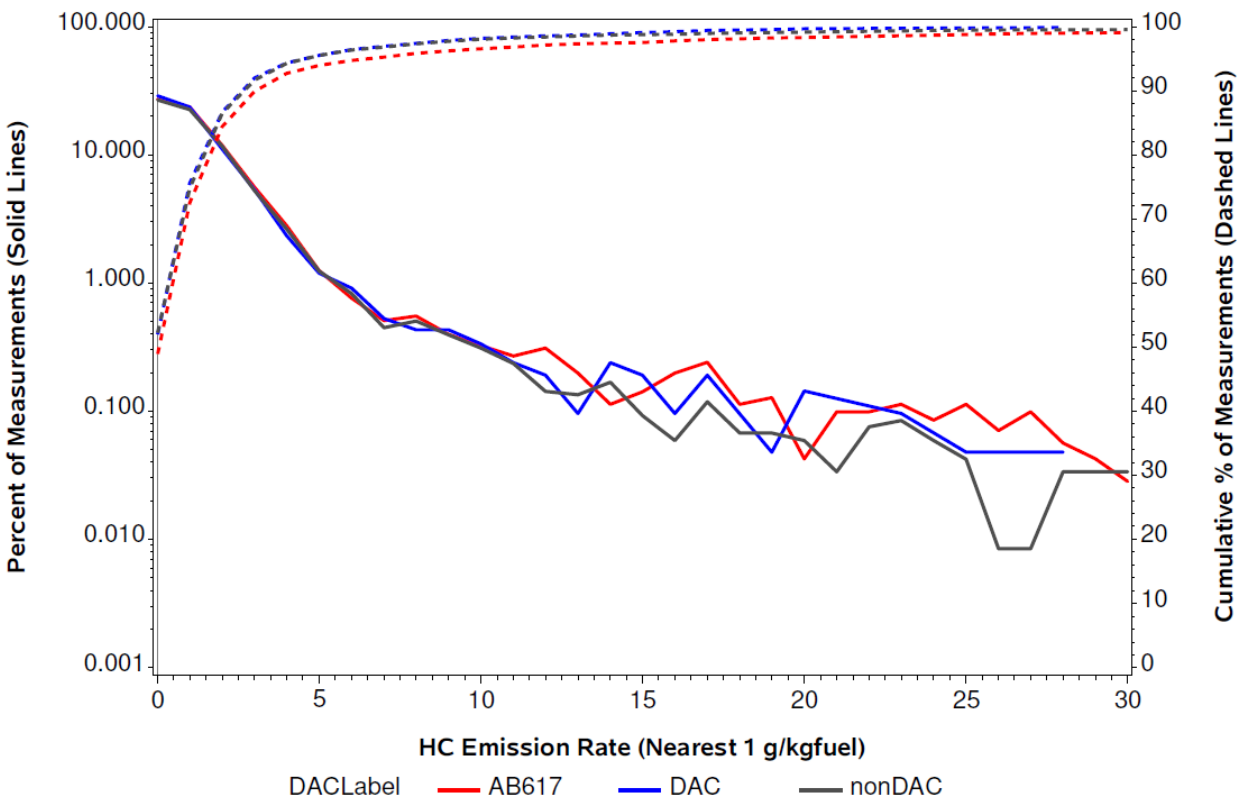
HC Emission Rate Distributions - Oakland



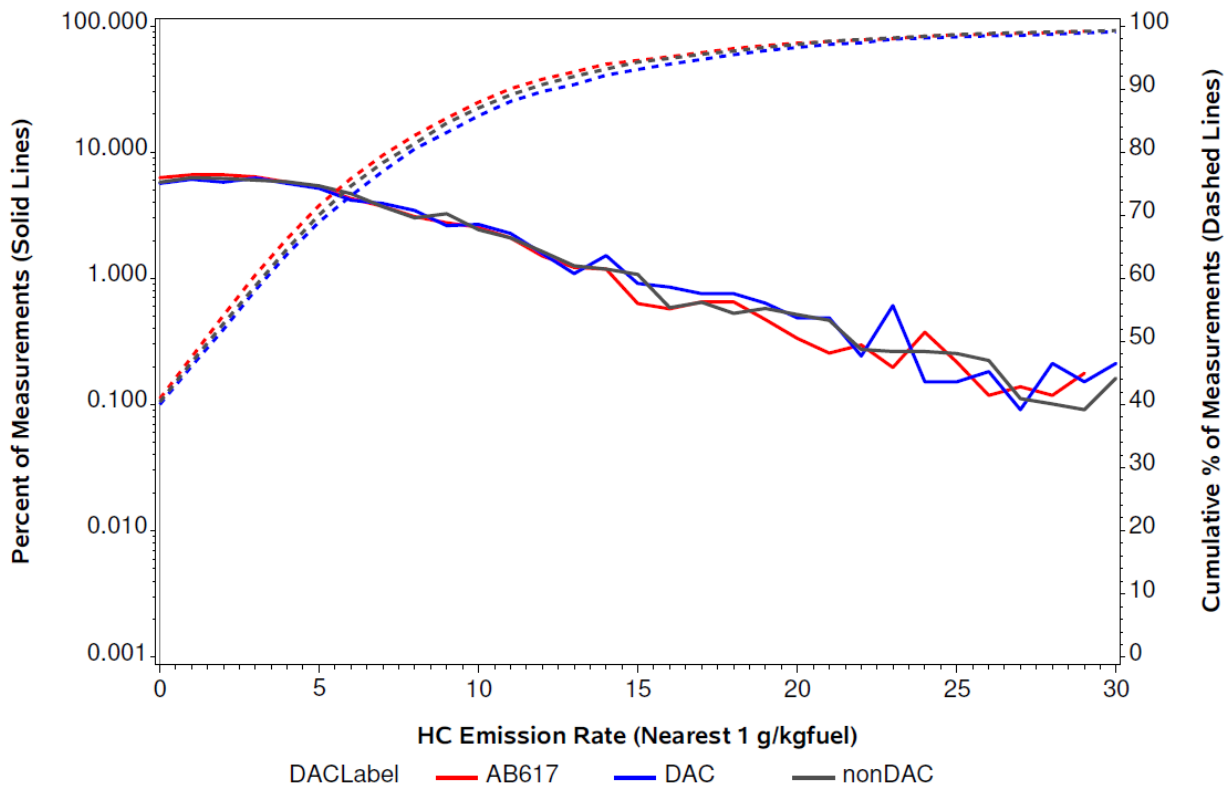
HC Emission Rate Distributions - Riverside



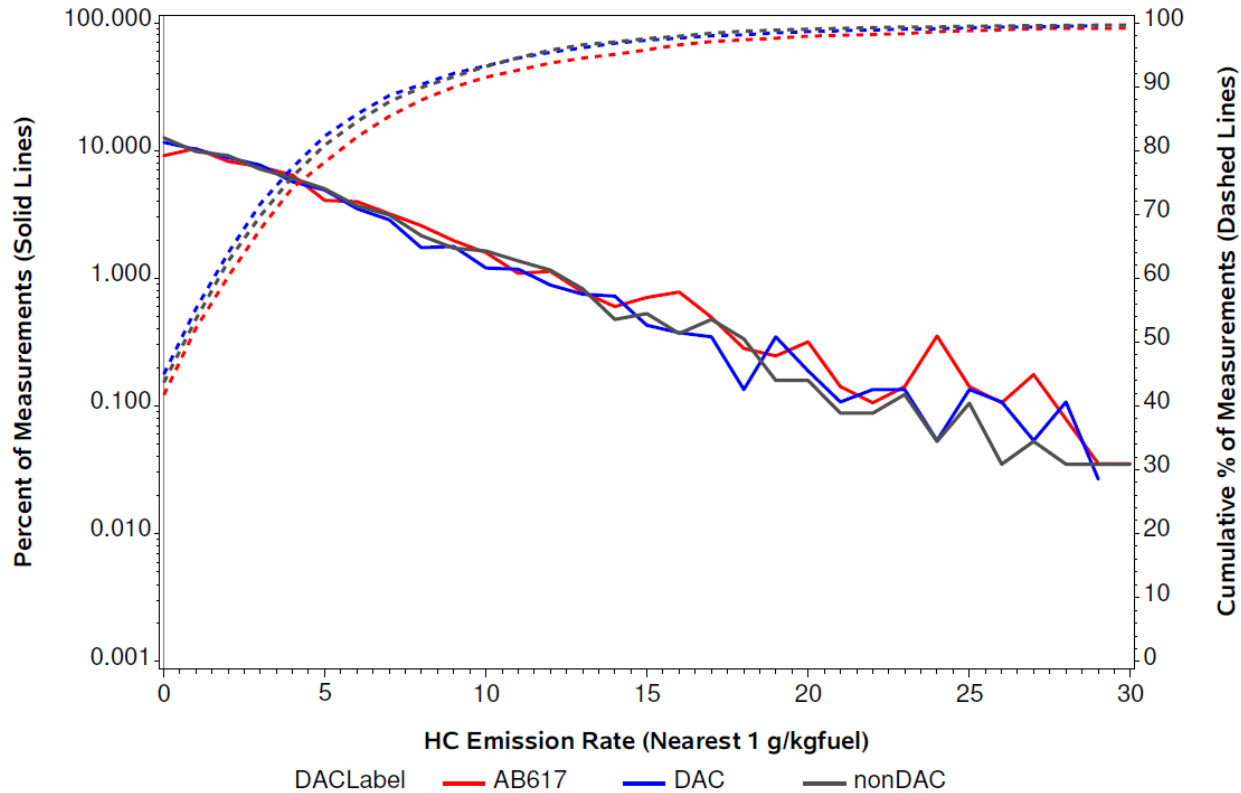
HC Emission Rate Distributions – San Ysidro



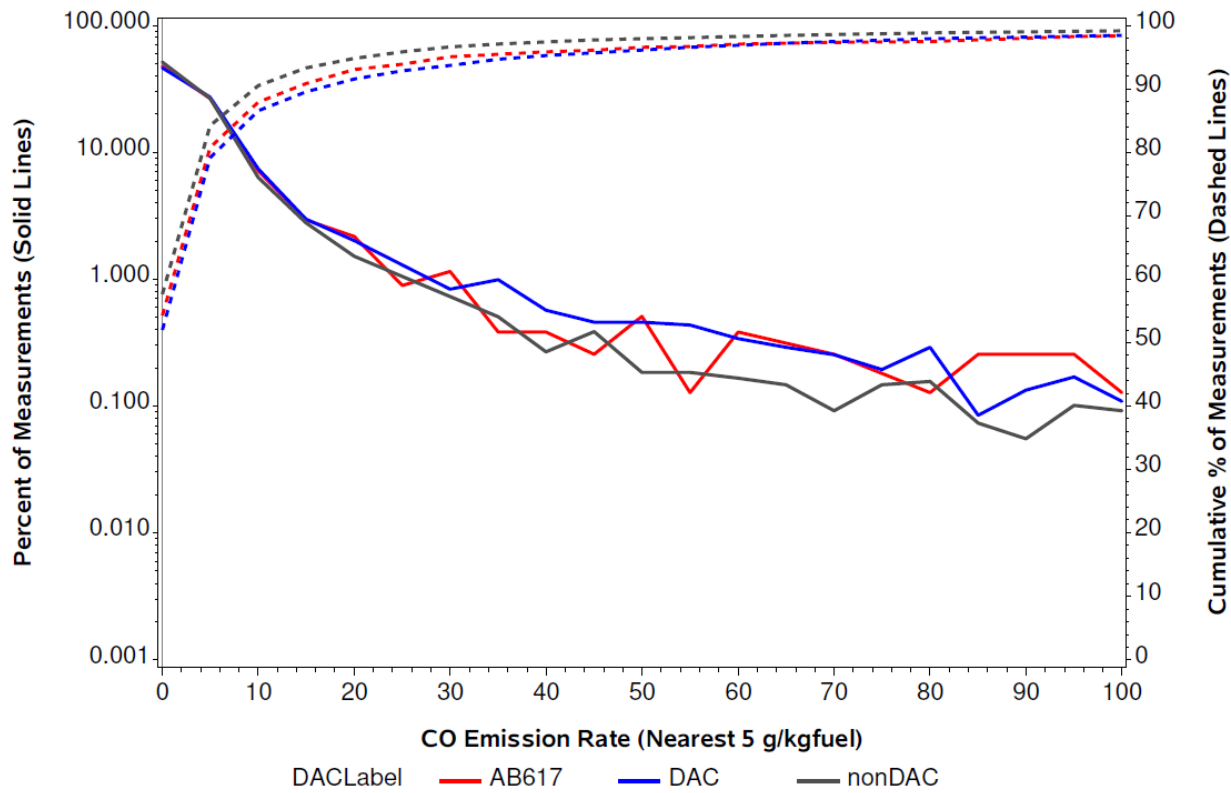
HC Emission Rate Distributions – Stockton



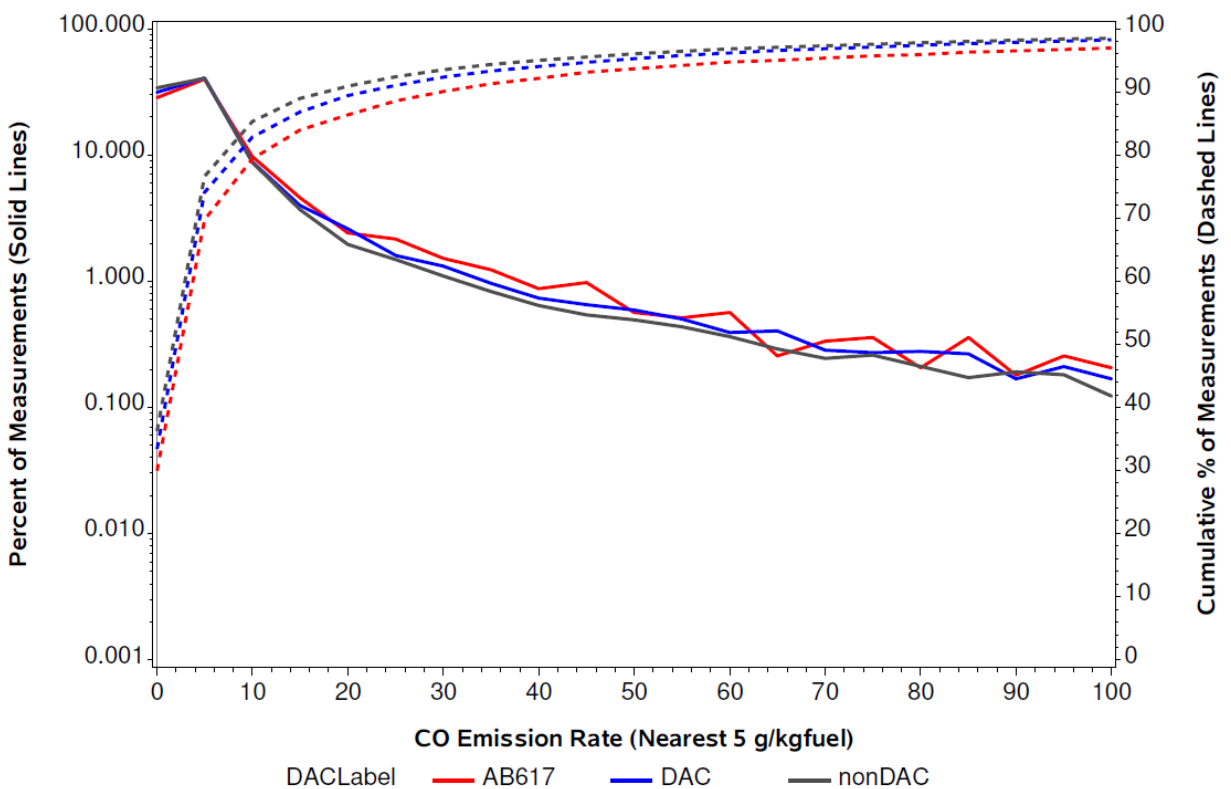
HC Emission Rate Distributions – West LA



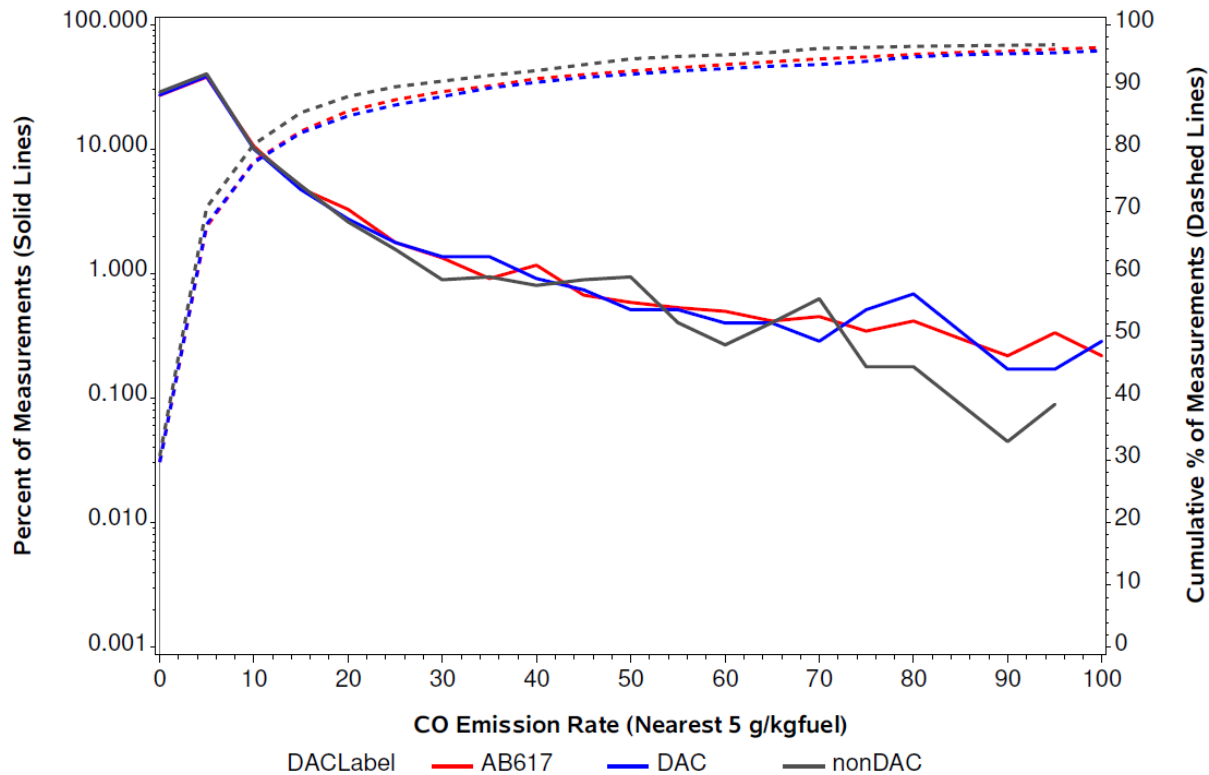
CO Emission Rate Distributions - Bakersfield



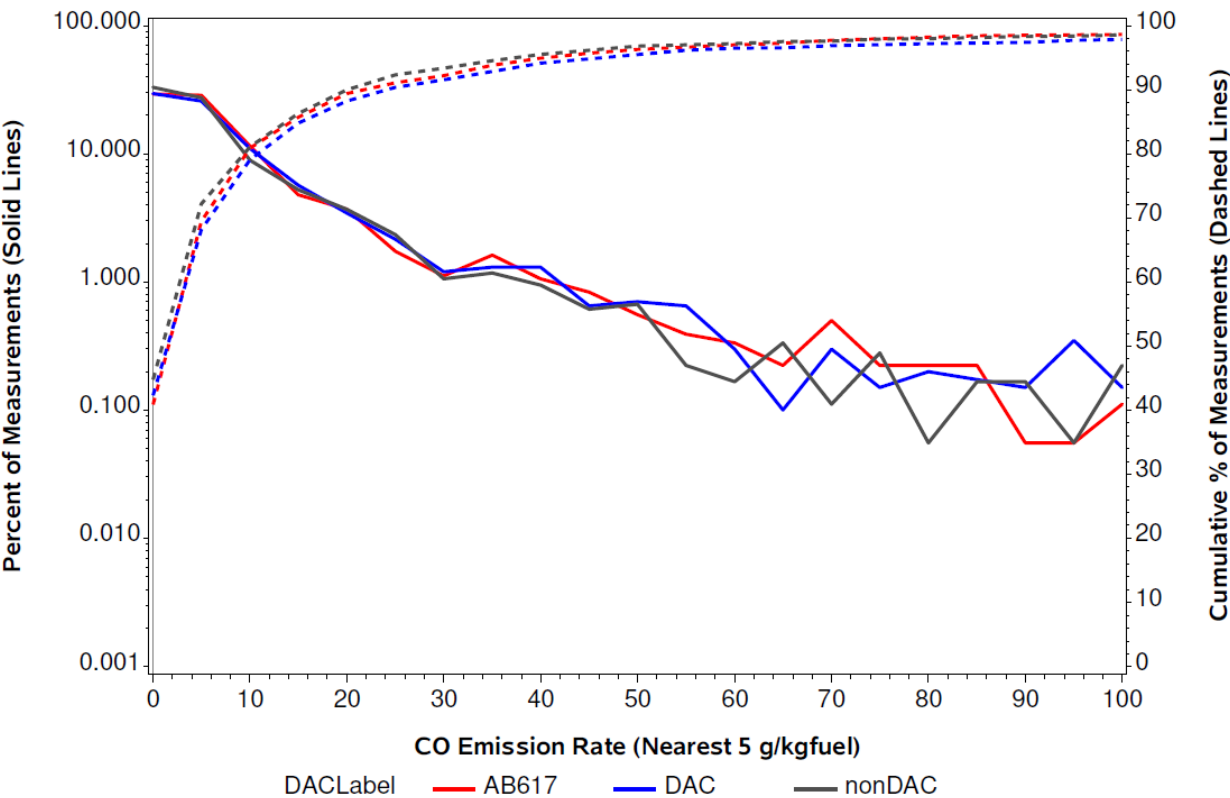
CO Emission Rate Distributions – City of Industry



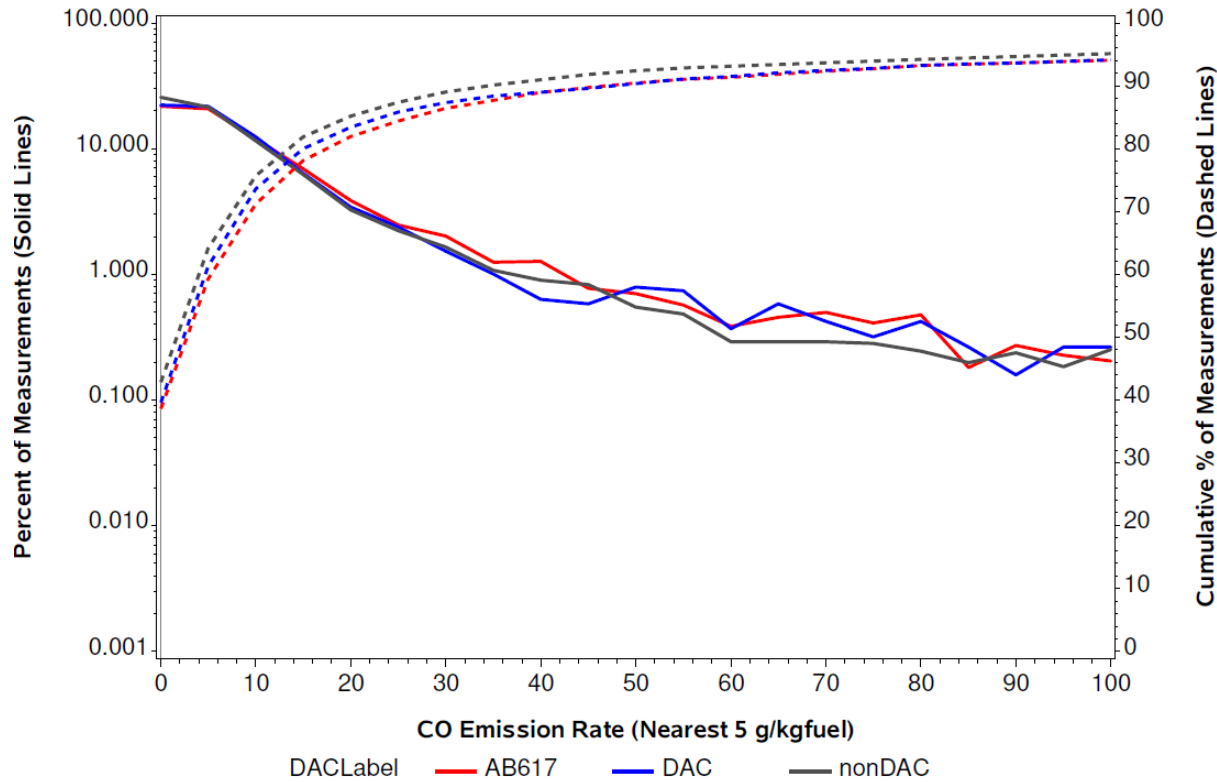
CO Emission Rate Distributions – El Centro



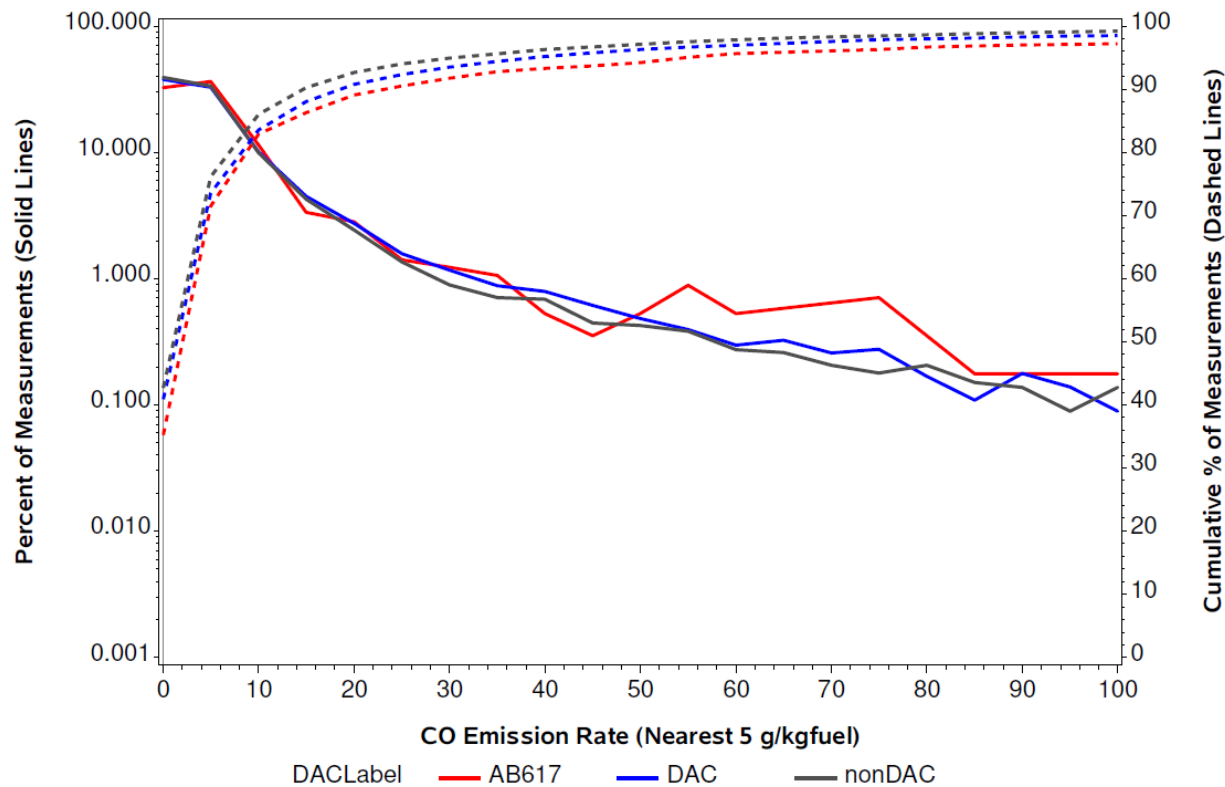
CO Emission Rate Distributions – Fresno



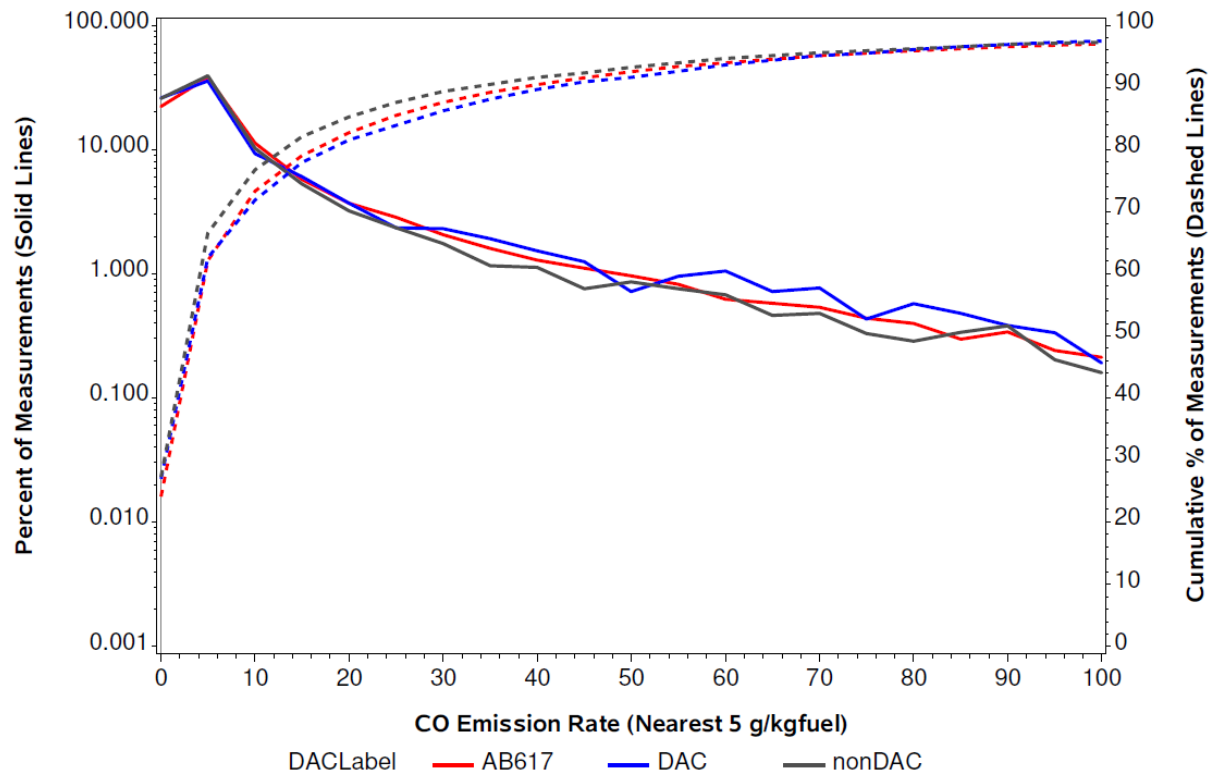
CO Emission Rate Distributions - Oakland



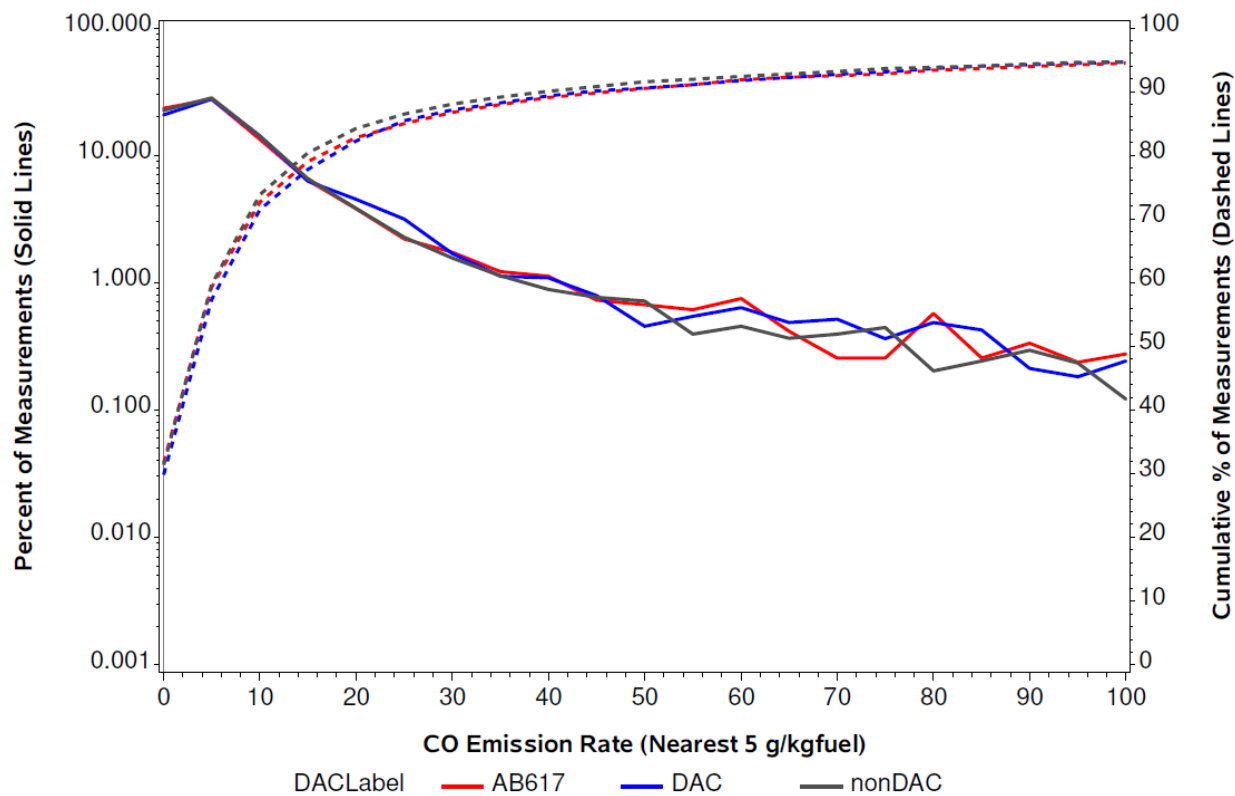
CO Emission Rate Distributions – Riverside



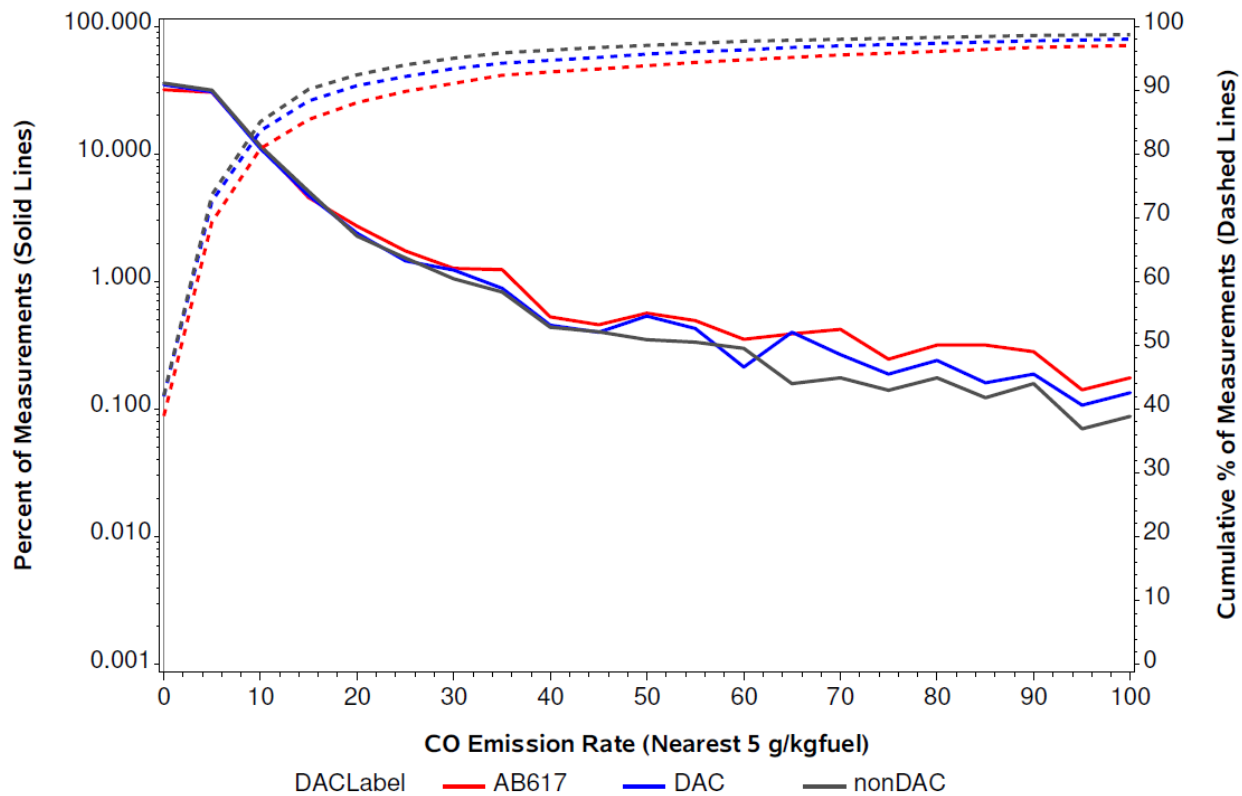
CO Emission Rate Distributions – San Ysidro



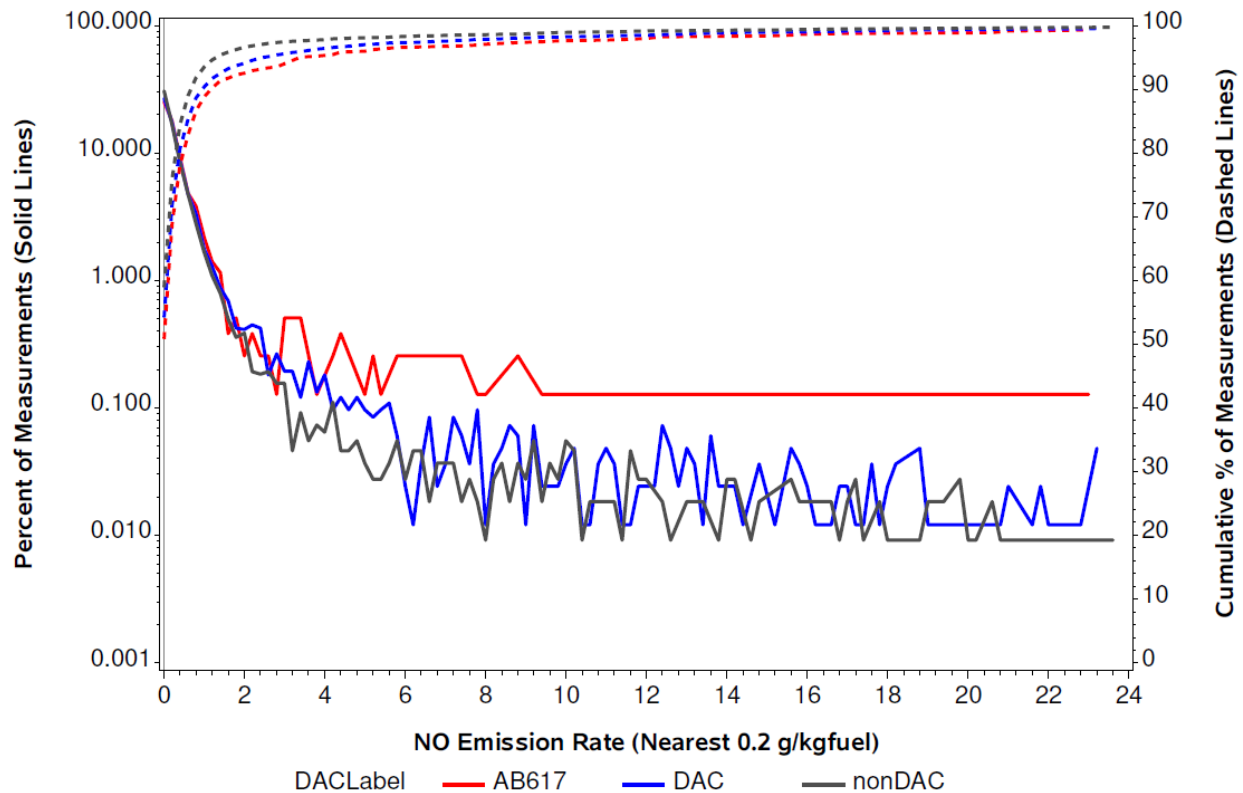
CO Emission Rate Distributions – Stockton



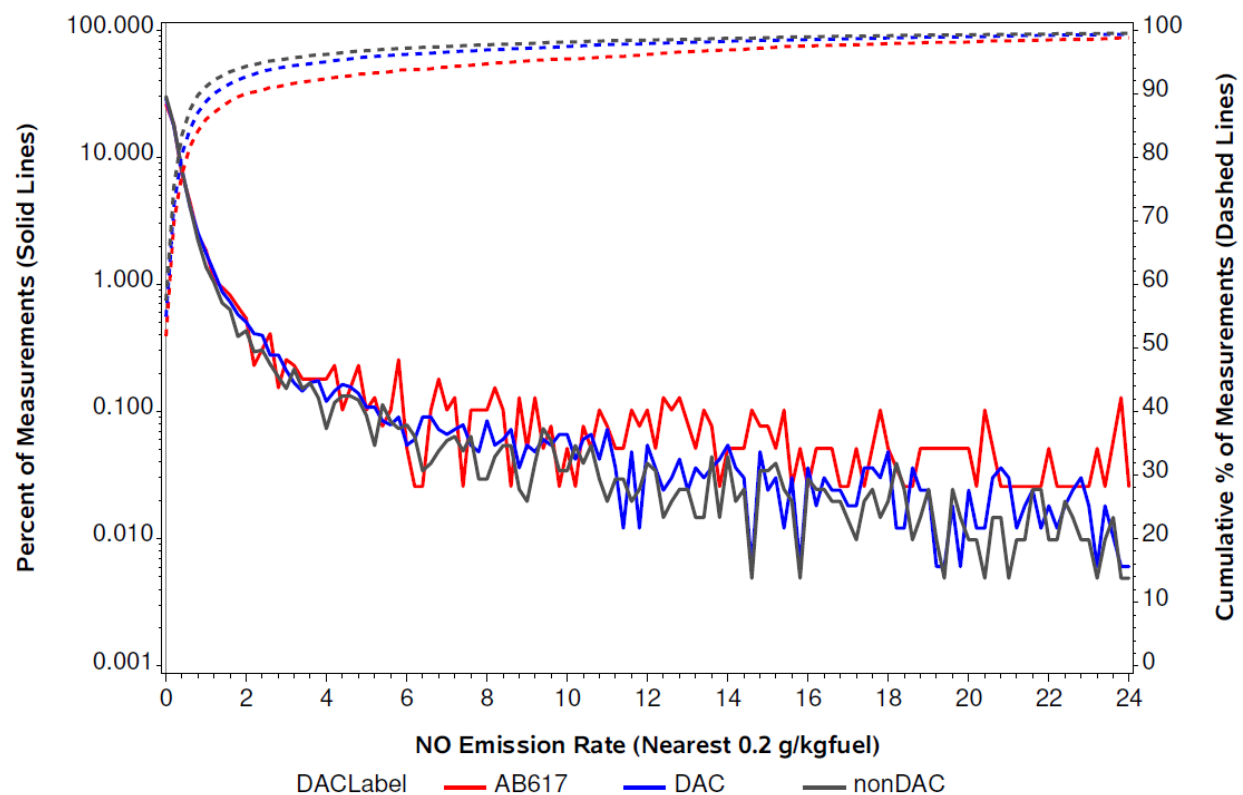
CO Emission Rate Distributions – West LA



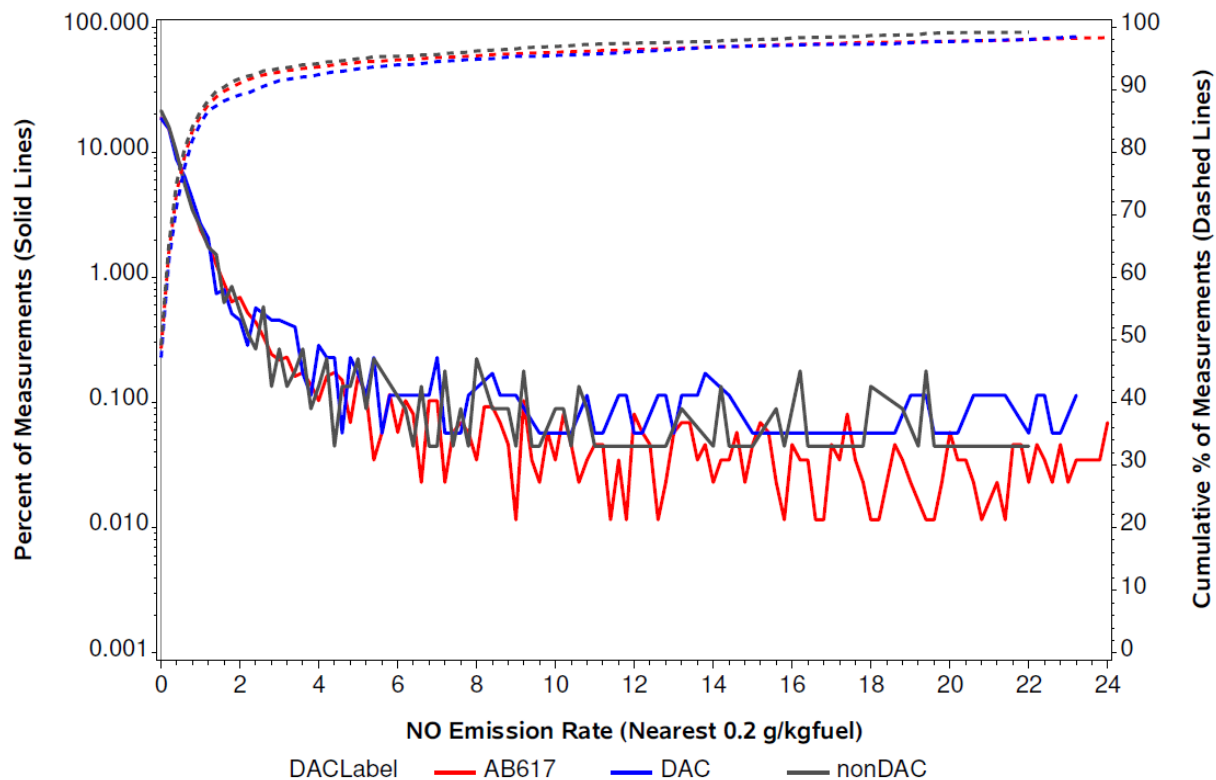
NO Emission Rate Distributions - Bakersfield



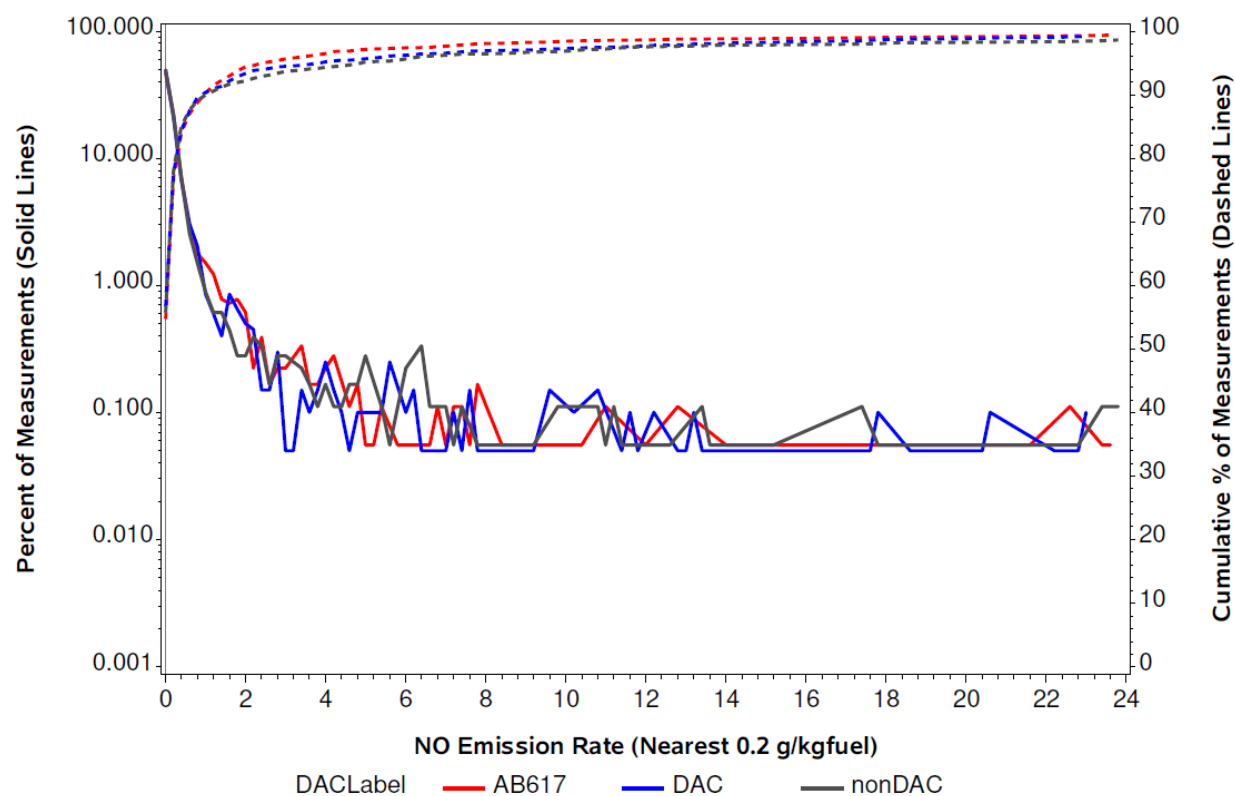
NO Emission Rate Distributions – City of Industry



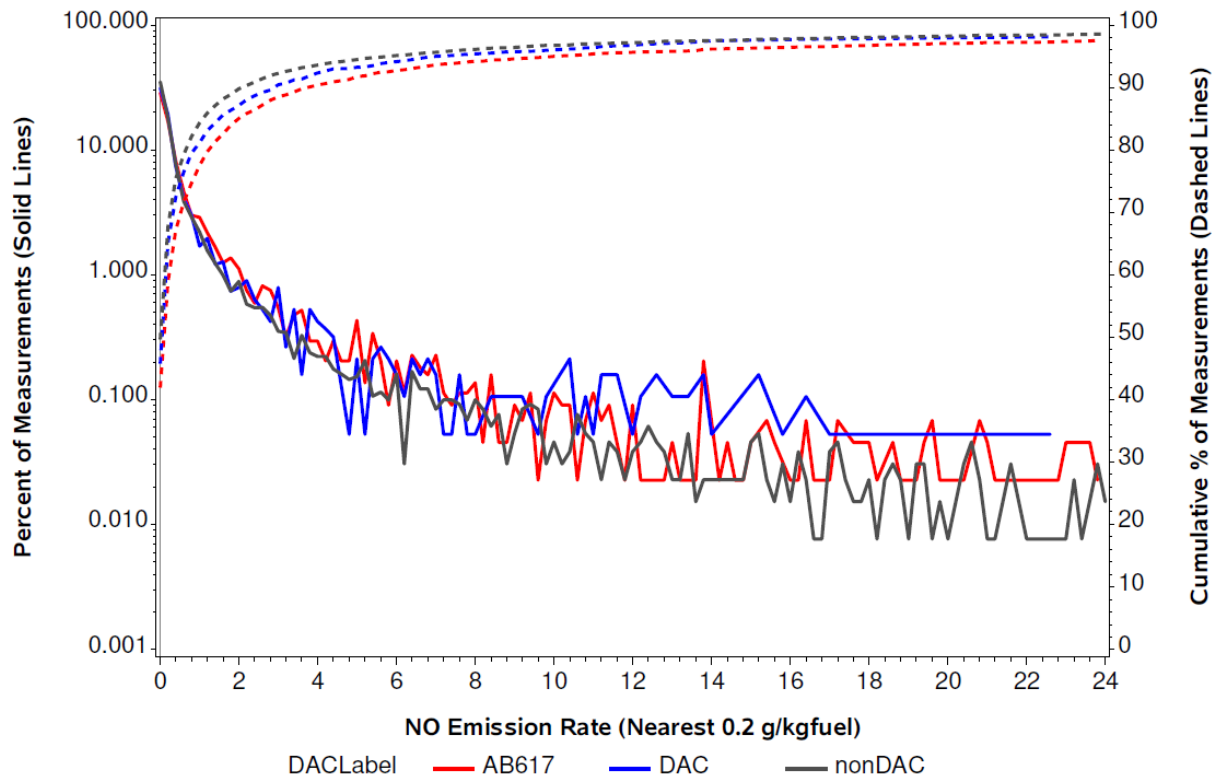
NO Emission Rate Distributions – El Centro



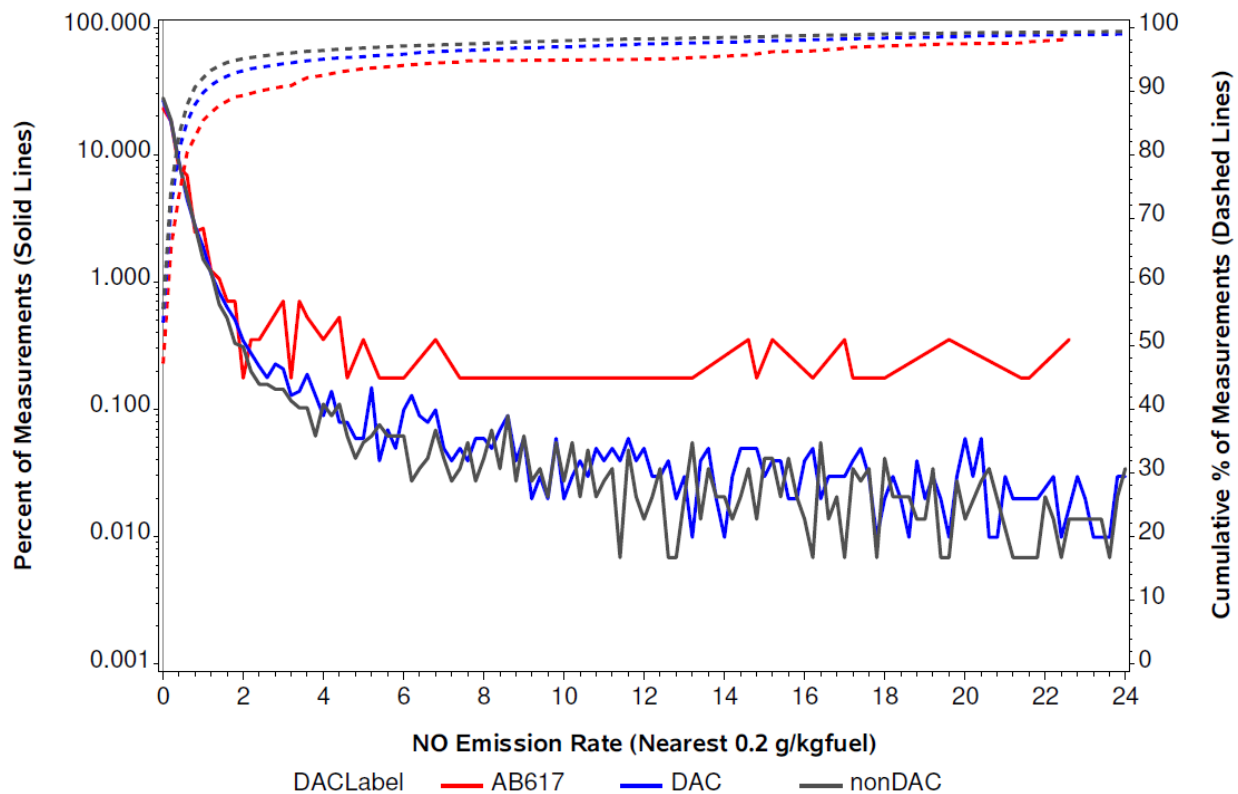
NO Emission Rate Distributions – Fresno



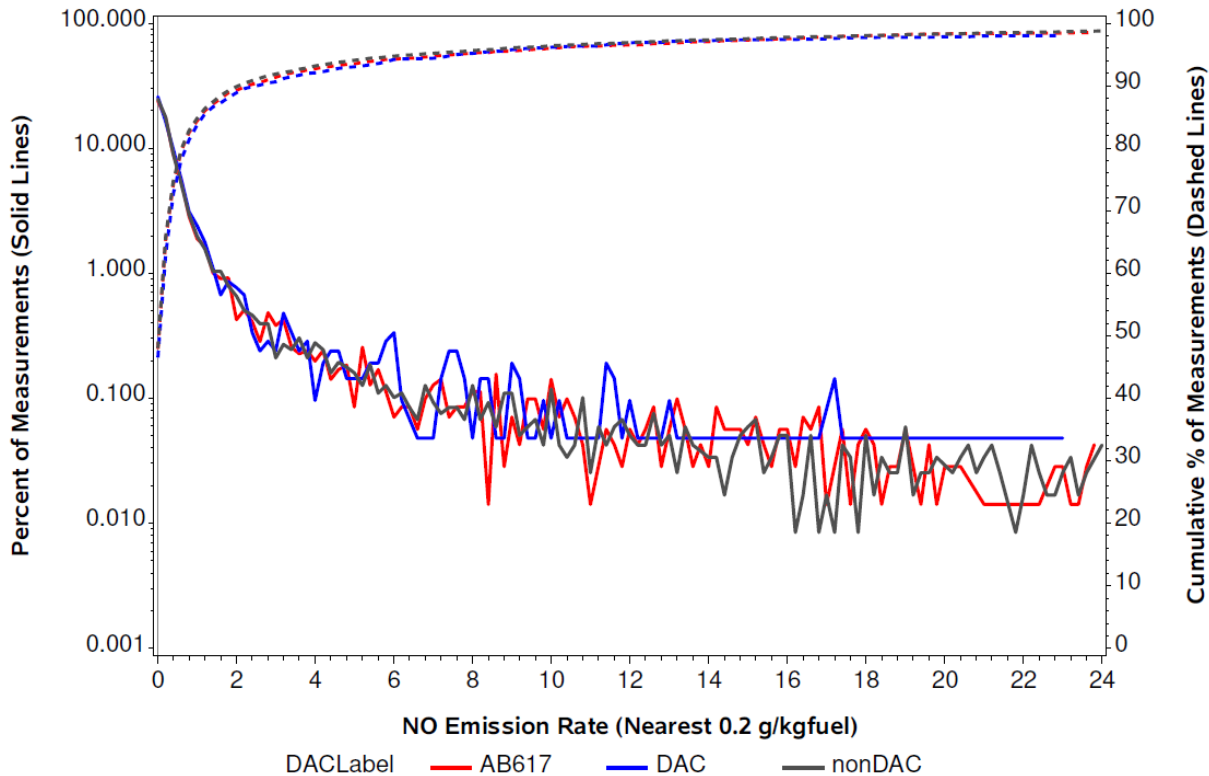
NO Emission Rate Distributions - Oakland



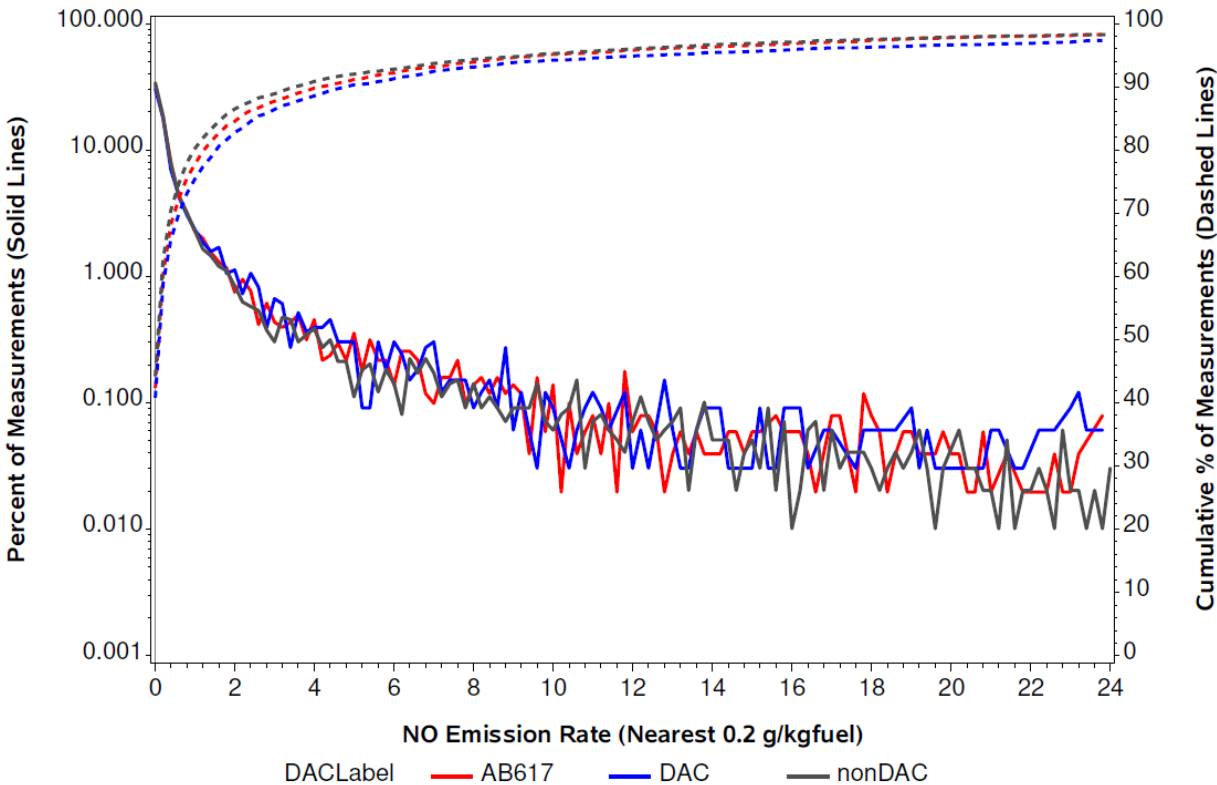
NO Emission Rate Distributions – Riverside



NO Emission Rate Distributions – San Ysidro



NO Emission Rate Distributions – Stockton



NO Emission Rate Distributions – West LA

