Senate Bill 604 Analysis: Direct Environmental Benefit of Alternatively Fueled Vehicles

Chris Kite
TCEQ Air Quality Division

Texas Technical Working Group
for Mobile Source Emissions
February 4, 2021

Senate Bill 604 from the 2019 Texas Legislature

- Article 6 of Senate Bill 604 (SB604) required the following agencies to participate in a study on imposing fees on alternatively fueled vehicles:
  - Texas Department of Motor Vehicles (TxDMV)
  - Public Utility Commission of Texas (PUC)
  - Texas Department of Transportation (TxDOT)
  - Department of Public Safety of the State of Texas (DPS)
  - Texas Commission on Environmental Quality (TCEQ)
- The TCEQ had the responsibility to examine "the projected direct environmental benefit of alternatively fueled vehicles on vehicle emissions in this state."
- Section 502.004 of the Texas Transportation Code defines an alternatively fueled vehicle (AFV) as "one that is capable of using a fuel other than gasoline or diesel fuel."

Scope of AFV Environmental Benefit Analysis (1 of 2)

- TCEQ primarily focused on light-duty cars and trucks that account for the majority of on-road vehicles and over 98% of current AFV registrations in Texas.
- According to the TxDMV *2019 Alternatively Fueled Vehicle Report*, battery electric vehicles (BEVs) represent "the largest percentage increase of any AFV type year-over-year."
- Plug-in hybrid electric vehicles (PHEVs) that can operate exclusively on either gasoline or electricity were included as AFVs for this analysis.
- Hybrid electric vehicles (HEVs) that can only be powered by gasoline were not included as AFVs for this analysis, per the definition that requires a fuel "other than gasoline or diesel."
- SB604 specified the "direct environmental benefit of AFVs on vehicle emissions", so impacts upstream of the primary energy source (e.g., gas station pump or electric charging station) were not included such as:
  - extraction of crude oil, refining, and transport by pipeline and/or truck; and
  - power plant operation along with the extraction and transport of natural gas and coal.

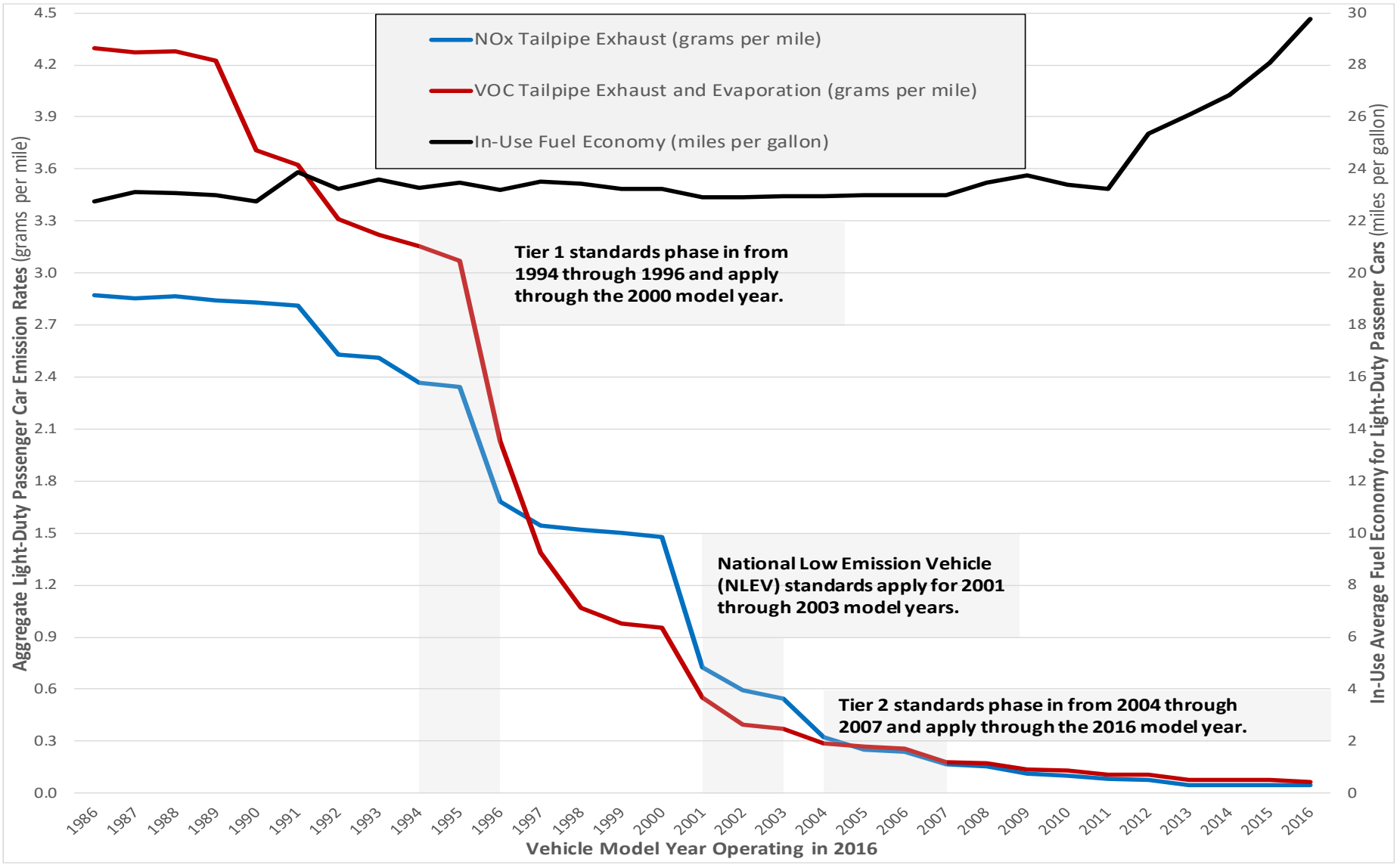
Scope of AFV Environmental Benefit Analysis (2 of 2)

- 2028 was chosen as a future year for the analysis because:
  - current federal vehicle emissions regulations will be phased-in by the 2026 model year; and
  - it coincides with an on-road emissions inventory developed in 2019 by the Texas A&M Transportation Institute (TTI) for TCEQ air quality modeling efforts.
- 2016 was chosen an historical reference year because:
  - it was the last model year for Tier 2 light-duty emissions standards just before the more stringent Tier 3 standards began phasing-in with the 2017 model year; and
  - it was also part of the 2019 TTI study.
- The U.S. Environmental Protection Agency (EPA) 2014a version of the Motor Vehicle Emission Simulator (MOVES2014a) model was used for both the TTI study and this analysis to develop emissions estimates for:
  - Nitrogen Oxides (NO_X);
  - Volatile Organic Compounds (VOC);
  - Carbon Monoxide (CO);
  - Carbon Dioxide (CO_2);
  - Sulfur Dioxide (SO_2);
  - Ammonia (NH_3); and
  - Particulate Matter at or below 2.5 microns ($PM_{2.5}$) and 10 microns (PM_{10}).

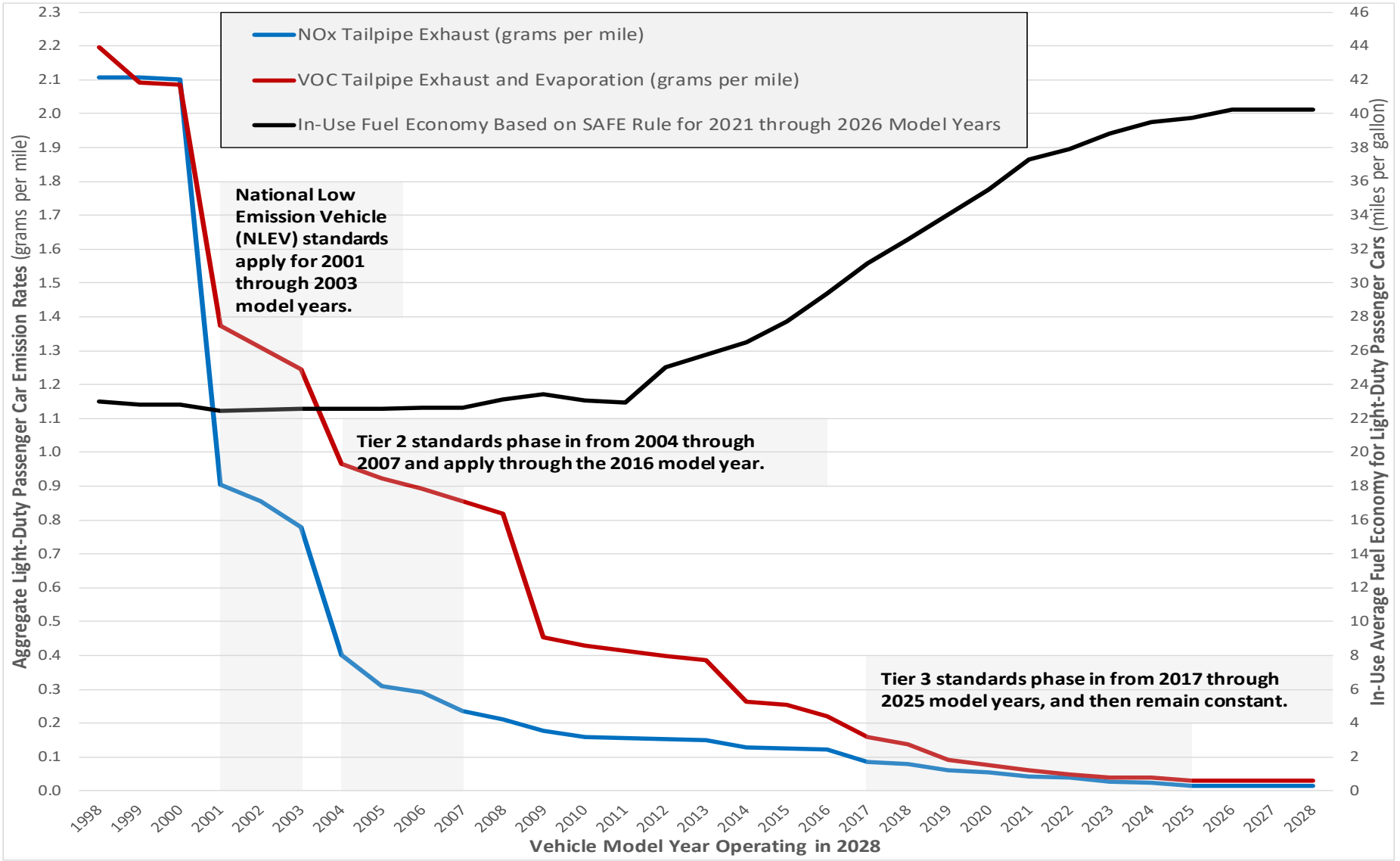
Key Points About Environmental Benefits of AFVs

- There will be minimal direct environmental benefits from projected sales of AFVs because federal regulations apply the same emissions and fuel economy standards to all fuel types.
- Vehicle manufacturers must meet tailpipe emissions and fuel economy standards based on their fleet averages per model year and not on individual vehicle sales.
- The U.S. EPA Tier 3 rule specifies that light-duty fleet average emission standards:
  - "are applicable regardless of the type of fuel that the vehicle is designed to use"; and
  - "vehicles certified to operate on any fuel (e.g., gasoline, diesel fuel, E85, compressed natural gas, liquefied natural gas, hydrogen, and methanol) are all subject to the same standards."
- Manufacturers use sales of electric vehicles to meet fleet average standards for tailpipe emissions and fuel economy:
  - sales of zero-emitting electric vehicles allow manufacturers to sell other vehicles that emit above the fleet average standard;
  - under averaging, banking, and trading (ABT) programs, manufacturers that exceed fleet average standards achieve "credits" that can be sold to other manufacturers that need them for compliance purposes; and
  - it is not expected that sales from electric-only vehicle manufacturers will result in additional emissions reductions from the overall fleet.

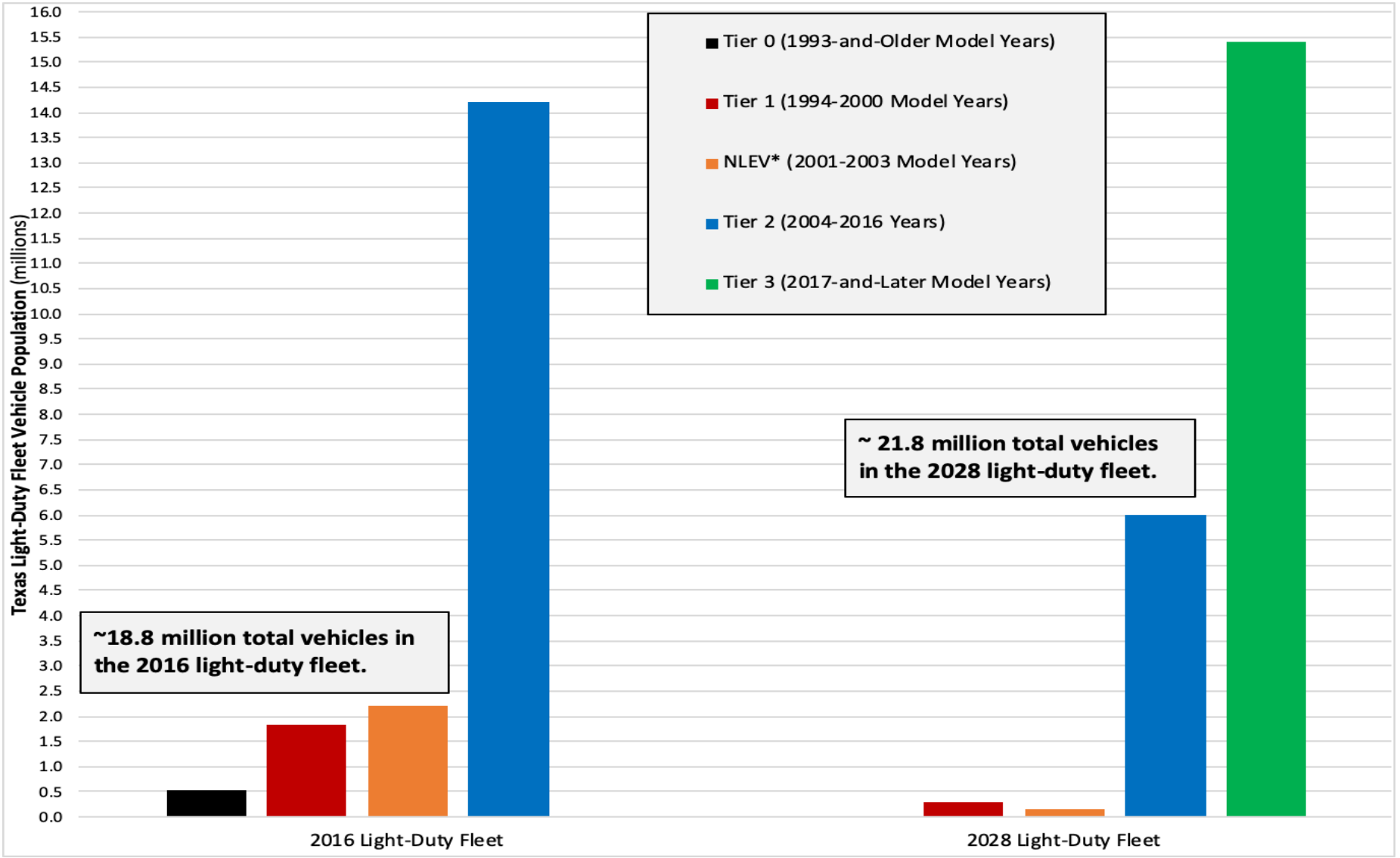
MOVES2014a Passenger Car NO_X, VOC, and Fuel Economy Rates by Model Year Operating in 2016



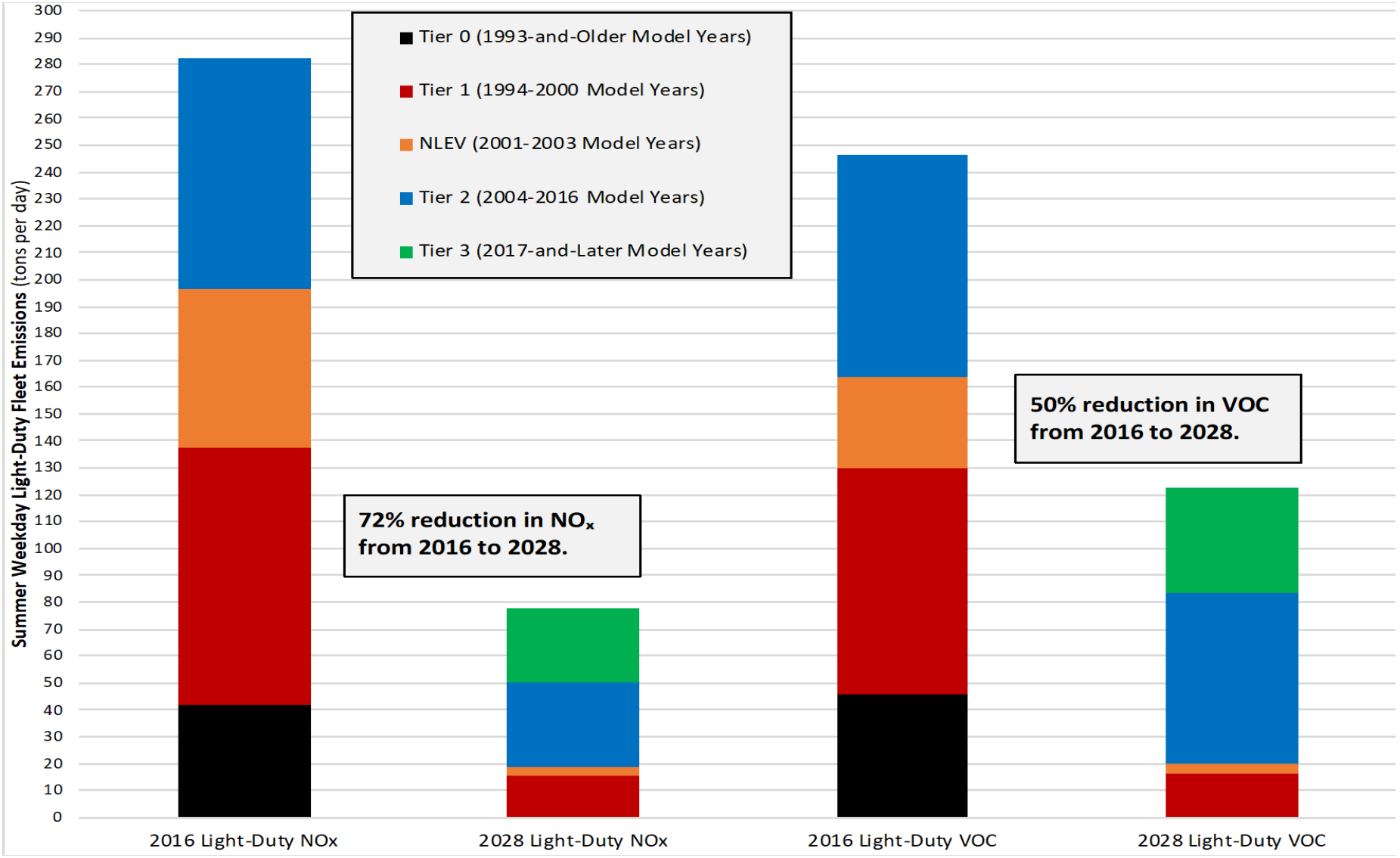
MOVES2014a Passenger Car NO_X, VOC, and Fuel Economy Rates by Model Year Operating in 2028



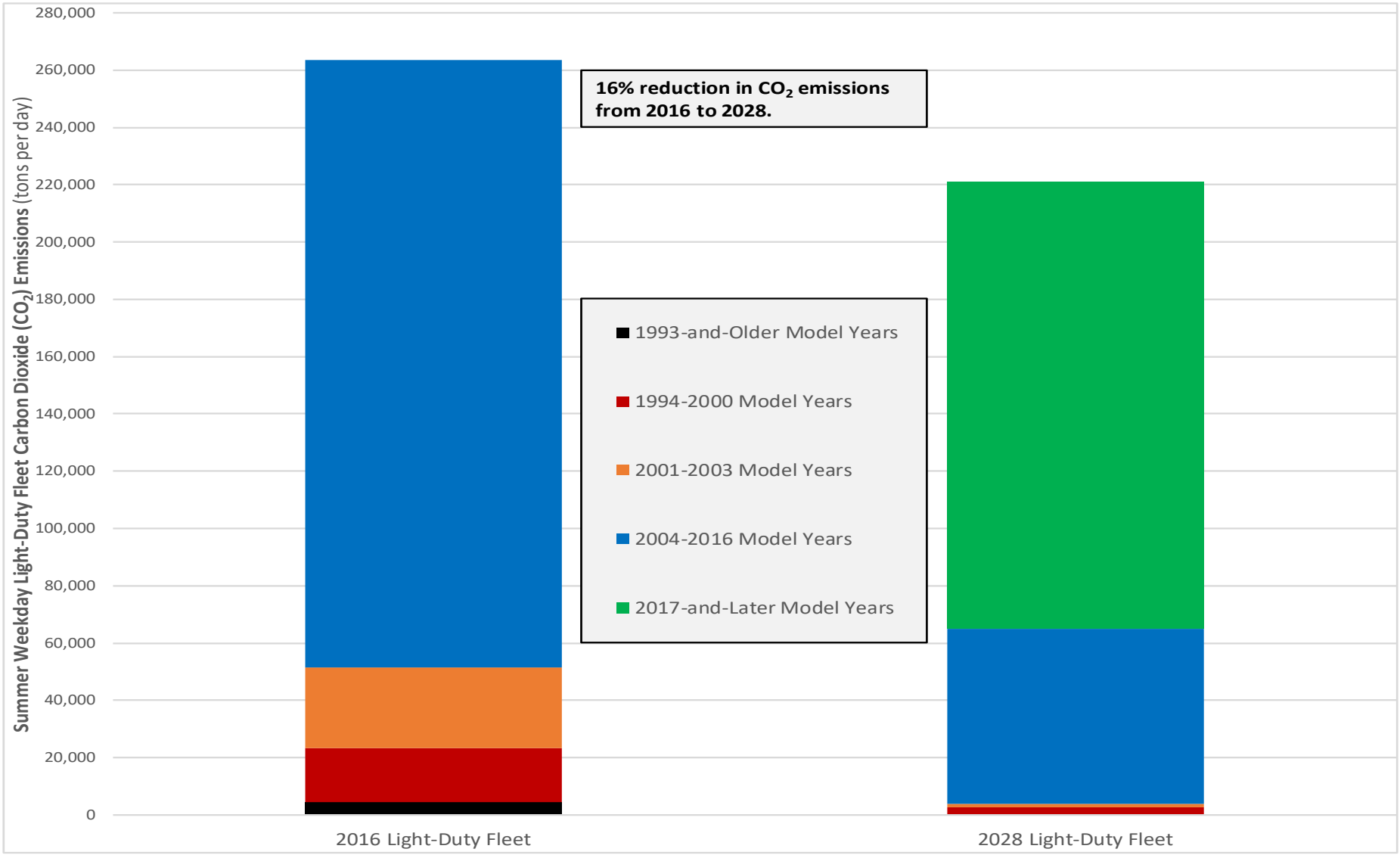
Composition of Texas of Light-Duty Fleets in 2016 and 2028 by Tailpipe Emissions Standard



NO_X and VOC Emissions of Texas Light-Duty Fleets in 2016 and 2028 by Tailpipe Standard



CO_2 Emissions of Texas Light-Duty Fleets in 2016 and 2028 by Model Year Groups



Federal Light-Duty Tailpipe Emissions Standards: Tier 2 (2004-to-2016) and Tier 3 (2017-and-Later)

Tier 2 Certification Bin	NO_X (grams per mile)	NMOG* (grams per mile)	NO_X + NMOG (milligrams per mile)	Tier 3 Certification Bin
Bin 1 (Electric Vehicles)	0.000	0.000	0	Bin 0 (Electric Vehicles)
			20	Bin 20
Bin 2	**0.020**	**0.010**	**30**	**Bin 30 (Tier 3 Average)**
			50	Bin 50
			70	Bin 70
Bin 3	0.030	0.055	85	
Bin 4	0.040	0.070	110	
			125	Bin 125
Bin 5 (Tier 2 Average)	**0.070**	**0.090**	**160**	Bin 160 (Tier 3 Maximum)
Bin 6	0.100	0.090	190	
Bin 7	0.150	0.090	240	
Bin 8 (Tier 2 Maximum)	0.200	0.125	325	

* NMOG: Non-methane organic gases, which are VOC plus ethane (or total hydrocarbons minus methane).

Distribution of 2020 Model Year Light-Duty Vehicles by Tier 3 Bin and Fuel Type

Tier 3 Bin	Gasoline	Gasoline/ Electricity	Electricity	Diesel Fuel	Ethanol/ Gasoline	Hydrogen	Total	Distribution
Bin 0			33			4	37	3.1%
Bin 20		1					1	0.1%
Bin 30	207	20					227	18.9%
Bin 50	116	1					117	9.8%
Bin 70	383	3			6		392	32.7%
Bin 125	328	9		5	16		358	29.8%
Bin 160	51			15	2		68	5.7%
Total	1,085	34	33	20	24	4	1,200	100.0%

EPA Tier 3 Rule Excerpts About Stringency of Fleet Average Light-Duty Standards

- "Compliance with the more stringent Tier 3 fleet average standards will require vehicle manufacturers to certify a significant amount of vehicles to bin standards that are below the Bin 30 fleet average standard to offset other vehicles that are certified to bin standards that remain somewhat above the Bin 30 fleet average even after significantly reducing their emissions."

- "There is also very limited ability for vehicle manufacturers to certify vehicles below the stringent Tier 3 fleet average exhaust emissions standard since Bin 20 and Bin 30 standards for individual vehicle certification test groups are approaching the engineering limits of what can be achieved for vehicles using an internal combustion engine and Bin 0 can only be achieved by electric-only vehicle operation."

- "The result is that there is a very limited ability to offset sales of vehicles certified above the 30 milligrams per mile fleet average emission standard."

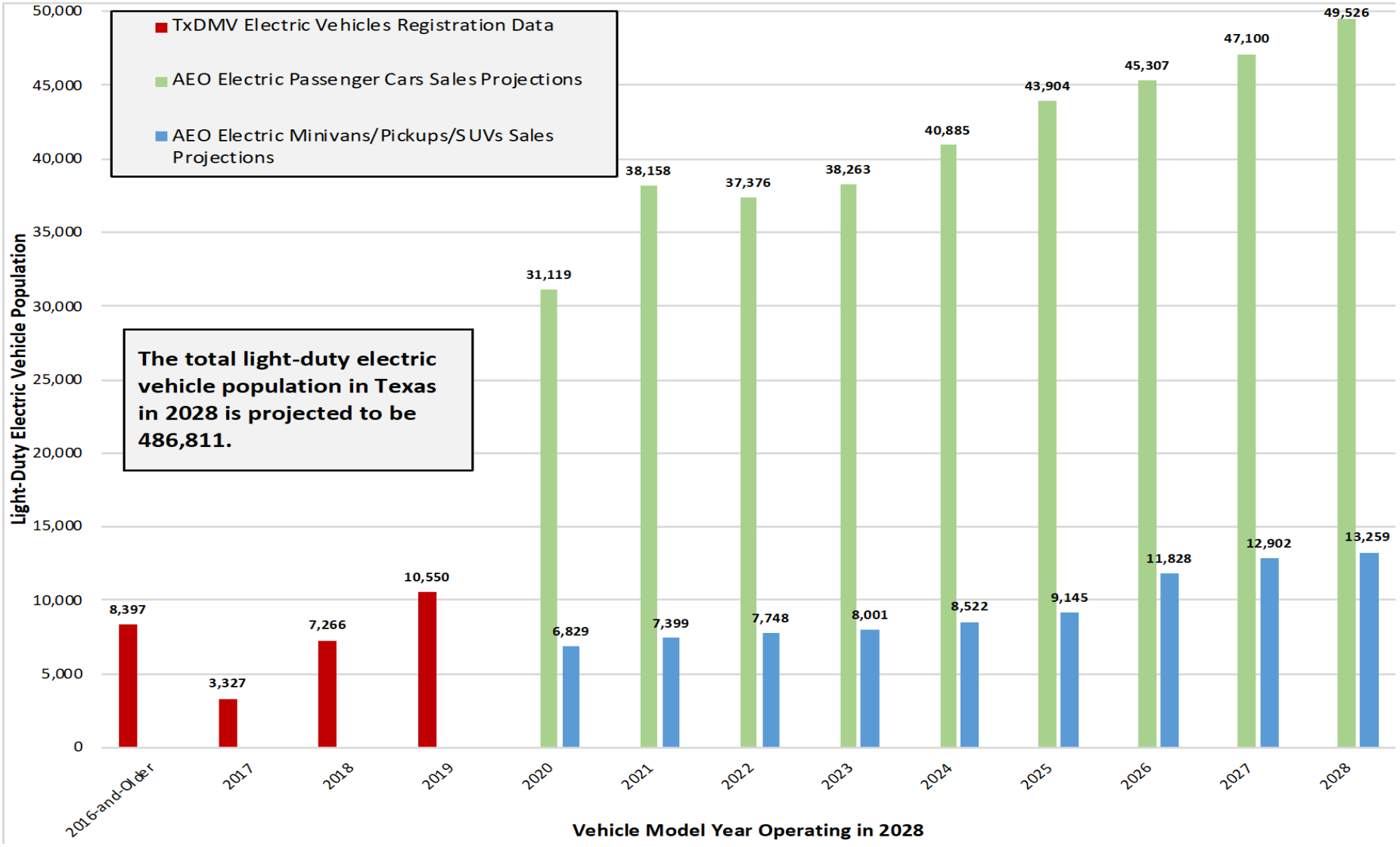
Compliance Options Under Tier 3 Emissions Standards for 2025-and-Later Model Years

Tier 3 Certification Bin	Gasoline Vehicle Sales	Bin 0 Electric Vehicle Sales	Gasoline and Electric Vehicle Sales	Total Emissions (milligrams per mile)	Fleet Average (milligrams per mile)	Gasoline Portion	Electric Portion
Bin 30 (Tier 3 Average)	1	0	1	30	30	100%	0%
Bin 50	3	2	5	150	30	60%	40%
Bin 70	3	4	7	210	30	43%	57%
Bin 125	6	19	25	750	30	24%	76%
Bin 160	3	13	16	480	30	19%	81%

Estimating Maximum Possible Emissions Benefits from Electric Vehicles

- To determine the maximum possible emissions benefits that could be achieved from electric vehicles, a 2028 scenario was modeled that:
  - assumed all new light-duty gasoline and diesel vehicles sold from 2016 through 2028 meet the fleet average requirements per model year (e.g., Bin 30 for 2025-and-later); and
  - assumed all Bin 0 electric vehicles sold are not needed to meet fleet average requirements and are then available for "extra" emissions reduction.
- A projected population of 486,811 light-duty electric vehicles operating in Texas in 2028 was obtained by combining:
  - 2016 through 2019 electric vehicle registrations reported by TxDMV in Appendix E of the *2019 Alternatively Fueled Vehicle Report*; and
  - 2020 through 2028 electric vehicle sales projections for the West-South Central Region from the 2020 Annual Outlook (AEO) published by the U.S. Energy Information Administration (EIA).
- The 2020 AEO projections were chosen because:
  - estimates were provided for each model year;
  - estimates were provided separately for passenger cars and passenger trucks; and
  - the Texas portion of the West-South Central Region (also includes Arkansas, Louisiana, and Oklahoma) could be obtained by applying a 69.6% contribution based on the 2019 *Highway Statistics Series* published by the U.S. Federal Highway Administration (FHWA).

Texas Electric Vehicle Population Projections by Model Year Operating in 2028



2028 Maximum Daily Emissions Benefits from Light-Duty Electric Vehicles

Pollutant or Vehicle Data	2028 Light-Duty Fleet Totals	2028 Maximum Electric Vehicle Impacts	2028 Maximum Electric Vehicle Impact Portion
Vehicle Population	21,844,307	486,811	2.2%
Daily Vehicle Miles Traveled	737,198,139	18,945,921	2.6%
NO_X (tons per day)	77.65	0.63	0.8%
VOC from Vehicles (tons per day)	122.67	0.95	0.8%
CO (tons per day)	1,811.19	19.70	1.1%
CO_2 (tons per day)	220,966.51	4,945.73	2.2%
SO_2 (tons per day)	1.47	0.03	2.2%
NH_3 (tons per day)	15.71	0.35	2.2%
$PM_{2.5}$ (tons per day)	2.72	0.03	1.3%
PM_{10} (tons per day)	3.07	0.04	1.3%
VOC from Refueling (tons per day)	8.14	0.15	1.9%
Fuel Consumption (gallons per day)	23,457,278	525,093	2.2%

2028 Maximum Annual Emissions Benefits from Light-Duty Electric Vehicles

Pollutant or Vehicle Data	2028 Light-Duty Fleet Totals	2028 Maximum Electric Vehicle Impacts	2028 Maximum Electric Vehicle Impact Portion
Vehicle Population	21,844,307	486,811	2.2%
Annual Vehicle Miles Traveled	266,935,091,907	6,859,346,184	2.6%
NO_X (tons per year)	29,354.43	238.11	0.8%
VOC from Vehicles (tons per year)	41,671.52	324.65	0.8%
CO (tons per year)	566,668.22	6,175.61	1.1%
CO_2 (tons per year)	76,572,720.80	1,713,238.74	2.2%
SO_2 (tons per year)	507.83	11.36	2.2%
NH_3 (tons per year)	5,692.66	125.73	2.2%
$PM_{2.5}$ (tons per year)	1,004.20	12.78	1.3%
PM_{10} (tons per year)	1,134.20	14.44	1.3%
VOC from Refueling (tons per year)	2,796.75	52.79	1.9%
Fuel Consumption (gallons per year)	8,128,923,443	181,899,225	2.2%

Additional Resources for SB604 Environmental Benefit Analysis

- Full SB604 report is available on the TxDMV *Reports and Data* web page at https://www.txdmv.gov/reports-and-data/.
- Most recent U.S. EPA MOVES model is available at https://www.epa.gov/moves/.
- MOVES2014a and Excel spreadsheet files used by TCEQ in the SB604 analysis are available at ftp://amdaftp.tceq.texas.gov/EI/onroad/sb604/.
- Most recent U.S. EPA tailpipe regulations for light-duty vehicles are available:
  - Tier 2 for 2004-to-2016 model years at https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-new-motor-vehicles-tier/; and
  - Tier 3 for 2017-and-later model years at https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-motor-vehicles-tier-3/.
- Most recent U.S. National Highway Transportation Safety Administration (NHTSA) fuel economy regulations are available at https://www.nhtsa.gov/corporate-average-fuel-economy/safe/.
- 2019 *Highway Statistics Series* from U.S. FHWA is available at https://www.fhwa.dot.gov/policyinformation/statistics/2019/.
- 2020 AEO from the U.S. EIA is available at https://www.eia.gov/outlooks/aeo/.
- 2020 *Green Vehicle Guide* from the U.S. EPA and Department of Energy (DOE) is available at https://www.fueleconomy.gov/feg/download.shtml/.

Questions?

air modeling data analysis

Chris Kite

chris.kite@tceq.texas.gov

512-239-1959

Texas Electric Vehicle Registrations and AEO Electric Vehicle Sales Projections

Texas Statewide Electric Vehicle Registrations	2016-and-Older	2017	2018	2019
Texas Registrations by Fiscal Year	8,397	11,724	18,990	29,540
Percent Increase in Registrations		39.6%	62.0%	56.0%
Incremental Model Year Assignment	8,397	3,327	7,266	10,550

2020 Annual Energy Outlook Passenger Car Projections	2020	2021	2022	2023	2024	2025	2026	2027	2028
Battery Electric Vehicles	36,408	47,854	47,711	49,346	53,393	58,569	60,409	62,605	65,585
Plug-In Gasoline Hybrids	8,318	6,989	6,008	5,648	5,369	4,533	4,710	5,090	5,596
West-South Central Total	44,726	54,843	53,719	54,994	58,762	63,102	65,118	67,695	71,181
Texas Portion (69.6%)	31,119	38,158	37,376	38,263	40,885	43,904	45,307	47,100	49,526

2020 Annual Energy Outlook Minivan/Pickup/SUV Projections	2020	2021	2022	2023	2024	2025	2026	2027	2028
Battery Electric Vehicles	6,475	7,256	7,983	8,515	9,383	9,695	9,812	10,050	10,462
Plug-In Gasoline Hybrids	3,340	3,379	3,153	2,985	2,866	3,449	7,188	8,494	8,594
West-South Central Total	9,815	10,635	11,136	11,500	12,249	13,144	17,001	18,544	19,056
Texas Portion (69.6%)	6,829	7,399	7,748	8,001	8,522	9,145	11,828	12,902	13,259

2028 Summer Weekday Activity and MOVES2014a Emission Rates by Model Year for Maximum Electric Vehicle Benefits Scenario: Passenger Cars

Inventory Parameter	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total/ Average
Electric Vehicle Miles Traveled	254,209	104,711	237,255	356,935	1,087,383	1,377,945	1,391,800	1,464,688	1,610,083	1,775,132	1,875,066	1,988,781	2,115,847	15,639,834
Electric Vehicle Population	8,397	3,327	7,266	10,550	31,119	38,158	37,376	38,263	40,885	43,904	45,307	47,100	49,526	401,178
Daily Accumulation (miles per vehicle)	30.3	31.5	32.7	33.8	34.9	36.1	37.2	38.3	39.4	40.4	41.4	42.2	42.7	39.0
NO_X (grams per mile)	0.1228	0.0852	0.0783	0.0617	0.0560	0.0420	0.0378	0.0281	0.0252	0.0142	0.0140	0.0141	0.0140	0.0283
VOC from Vehicles (grams per mile)	0.2204	0.1597	0.1375	0.0911	0.0760	0.0613	0.0497	0.0406	0.0379	0.0300	0.0294	0.0304	0.0301	0.0465
CO (grams per mile)	4.3413	2.2765	2.1379	1.6225	1.5142	1.3670	1.2720	1.0348	0.9670	0.4958	0.4926	0.5049	0.5028	0.9382
CO_2 (grams per mile)	290.40	273.95	262.16	250.97	240.50	228.92	225.07	219.92	216.06	214.78	212.21	212.21	212.21	221.53
SO_2 (grams per mile)	0.0019	0.0018	0.0017	0.0017	0.0016	0.0015	0.0015	0.0015	0.0014	0.0014	0.0014	0.0014	0.0014	0.0015
NH_3 (grams per mile)	0.0228	0.0228	0.0228	0.0185	0.0185	0.0185	0.0185	0.0152	0.0152	0.0153	0.0152	0.0152	0.0152	0.0164
$PM_{2.5}$ (grams per mile)	0.0049	0.0040	0.0038	0.0027	0.0023	0.0017	0.0017	0.0015	0.0014	0.0012	0.0012	0.0012	0.0012	0.0016
PM_{10} (grams per mile)	0.0056	0.0045	0.0043	0.0031	0.0026	0.0019	0.0019	0.0016	0.0016	0.0013	0.0013	0.0013	0.0013	0.0018
VOC from Refueling (grams per gallon)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.26	0.27	0.27	0.27	0.27	0.26	0.27
Energy Consumption (kilojoules per mile)	4,039	3,811	3,647	3,491	3,345	3,184	3,131	3,059	3,005	2,988	2,952	2,952	2,952	3,081
Fuel Economy (miles per gallon)	29.4	31.2	32.6	34.0	35.5	37.3	37.9	38.8	39.5	39.8	40.2	40.2	40.2	38.5
CO_2 (grams per gallon)	8,538	8,538	8,538	8,538	8,538	8,538	8,538	8,538	8,538	8,538	8,538	8,538	8,538	8,538

2028 Summer Weekday Emissions and Fuel Consumption by Model Year for Maximum Electric Vehicle Benefits Scenario: Passenger Cars

Inventory Parameter	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
NO_X (pounds per day)	69	20	41	49	134	128	116	91	90	55	58	62	65	977
VOC from Vehicles (pounds per day)	124	37	72	72	182	186	152	131	135	118	121	133	140	1,603
CO (pounds per day)	2,433	526	1,118	1,277	3,630	4,153	3,903	3,341	3,433	1,940	2,036	2,214	2,346	32,350
CO_2 (pounds per day)	162,752	63,241	137,126	197,490	576,545	695,442	690,596	710,150	766,949	840,536	877,222	930,422	989,868	7,638,338
SO_2 (pounds per day)	1	0	1	1	4	5	5	5	5	6	6	6	7	51
NH_3 (pounds per day)	13	5	12	15	44	56	57	49	54	60	63	67	71	565
$PM_{2.5}$ (pounds per day)	3	1	2	2	6	5	5	5	5	5	5	5	5	54
PM_{10} (pounds per day)	3	1	2	2	6	6	6	5	6	5	6	6	6	61
VOC from Refueling (pounds per day)	5	2	4	6	18	22	21	22	24	26	27	29	31	237
Fuel Consumption (gallons per day)	8,647	3,360	7,285	10,492	30,631	36,948	36,691	37,729	40,747	44,657	46,606	49,432	52,590	405,816

2028 Summer Weekday Activity and MOVES2014a Emission Rates by Model Year for Maximum Electric Vehicle Benefits Scenario: Passenger Trucks

Inventory Parameter	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total/ Average
Daily Vehicle Miles Traveled					227,108	254,975	277,200	295,474	325,054	359,924	478,435	531,256	556,663	3,306,087
Electric Vehicle Population					6,829	7,399	7,748	8,001	8,522	9,145	11,828	12,902	13,259	85,633
Daily Accumulation (miles per day)					33.3	34.5	35.8	36.9	38.1	39.4	40.4	41.2	42.0	38.6
NO_x (grams per mile)					0.0970	0.0714	0.0615	0.0440	0.0376	0.0221	0.0219	0.0219	0.0218	0.0377
VOC (grams per mile)					0.0864	0.0686	0.0558	0.0441	0.0404	0.0307	0.0300	0.0306	0.0301	0.0415
CO (grams per mile)					1.9703	1.7459	1.5781	1.2623	1.1420	0.5799	0.5772	0.5888	0.5870	0.9675
CO_2 (grams per mile)					336.02	322.23	317.21	313.45	310.94	307.18	300.91	300.91	300.92	309.12
SO_2 (grams per mile)					0.0022	0.0021	0.0021	0.0021	0.0021	0.0020	0.0020	0.0020	0.0020	0.0020
NH_3 (grams per mile)					0.0202	0.0202	0.0202	0.0169	0.0169	0.0169	0.0169	0.0169	0.0169	0.0176
$PM_{2.5}$ (grams per mile)					0.0037	0.0028	0.0028	0.0026	0.0025	0.0017	0.0017	0.0017	0.0017	0.0022
PM_{10} (grams per mile)					0.0041	0.0032	0.0031	0.0029	0.0029	0.0019	0.0019	0.0019	0.0019	0.0024
VOC from Refueling (grams per gallon)					0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Energy Consumption (kilojoules per mile)					4,671	4,479	4,410	4,357	4,323	4,270	4,183	4,183	4,183	4,297
Fuel Economy (miles per gallon)					25.5	26.6	27.0	27.3	27.6	27.9	28.5	28.5	28.5	27.7
CO_2 (grams per gallon)					8,568	8,568	8,568	8,568	8,568	8,568	8,568	8,568	8,568	8,568

2028 Summer Weekday Emissions and Fuel Consumption by Model Year for Maximum Electric Vehicle Benefits Scenario: Passenger Trucks

Inventory Parameter	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
NO_X (pounds per day)					49	40	38	29	27	18	23	26	27	275
VOC (pounds per day)					43	39	34	29	29	24	32	36	37	302
CO (pounds per day)					987	981	964	822	818	460	609	690	720	7,052
CO_2 (pounds per day)					168,240	181,132	193,855	204,185	222,830	243,749	317,394	352,435	369,298	2,253,118
SO_2 (pounds per day)					1	1	1	1	1	2	2	2	2	15
NH_3 (pounds per day)					10	11	12	11	12	13	18	20	21	129
$PM_{2.5}$ (pounds per day)					2	2	2	2	2	1	2	2	2	16
PM_{10} (pounds per day)					2	2	2	2	2	2	2	2	2	18
VOC from Refueling (pounds per day)					5	6	6	6	7	8	10	11	11	70
Fuel Consumption (gallons per day)					8,906	9,589	10,262	10,809	11,796	12,904	16,802	18,657	19,550	119,276