Texas A&M Transportation Institute

MOVES3 versus MOVES5 Sensitivity

TWG Quarterly Meeting

December 2025

History of the EPA's MOVES Models

The Environmental Protection Agency (EPA) released the MOVES (Motor Vehicle Emissions Simulator) to replace the MOBILE model in March 2010 (MOVES2010). Since then, many versions of MOVES have been released:

MOVES2014

- Released in 07/2014
- Conformity grace period ending on 10/7/2016.

MOVES3

- Released in 11/2020
- Conformity grace period ending on 11/4/2022.

MOVES4

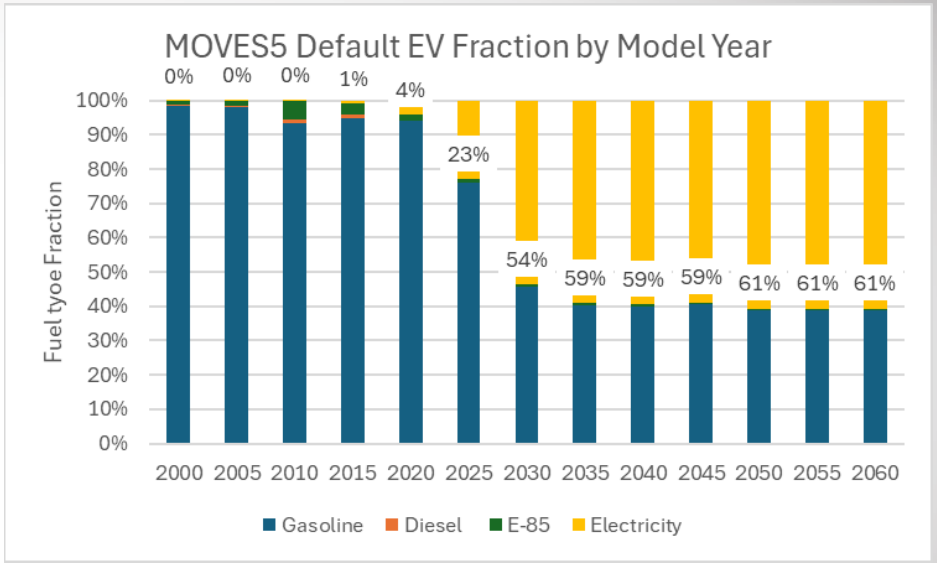
- Released in 09/2023
- Conformity grace period ending on 9/12/2025.

MOVES5

- Released in 11/2024
- Conformity grace period ending on 12/11/2026.

EV in MOVES

- EPA has updated the EV modeling capabilities of the model since MOVES4.
- Under Tier 3 and light-duty GHG rules, manufacturers can meet emission standards as an average across the fleet; thus, EVs will be used to offset higher emissions from ICE engines.
  - Thus, with increase EV sales, light-duty ICE engine emissions and energy consumptions were expected to increase.



MOVES Version Usage

For State Implementation Plan (SIP) related applications, the latest version of MOVES (in this case, MOVES5) must be used. This includes:

- Attainment Demonstration (AD)
- Reasonable Further Progress (RFP)
- Trends emissions inventory
- Air Emissions Reporting Requirements (AERR)

For Transportation Conformity purposes, the MOVES version still within grace periods may be used

- As of December 2025, MOVES4 and MOVES5 can both be used.
- Generally, it is better to align MOVES version used with the grace period.

MOVES5 Updates

Updated Emission Rates

- Incorporated new regulatory programs introduced
- Incorporate latest emissions test data

Improved EV Modeling

- Modeling of EVs have been improved since MOVES4.
- EV emission rates are no longer lumped into fleet average rates.

Expanded Vehicle Age

- Vehicle age was expanded from “0 to 30+” to “0 to 40+”.
- As such, emission rate - for years before the new regulations are implemented – tend to be higher
- Age distribution processing methods were updated.

Regulations Incorporated since MOVES3

- Heavy-Duty Engine and Vehicle Standards (HD2027)
- Revised 2023 and Later Model Year Light-Duty Vehicle GHG Standards (LDGHG 2023)
- Heavy-Duty GHG Phase 2 Standards (HDGHG2)
- Light- & Medium-Duty Multi-pollutant Rule (LMDV)
- GHG Emission Standards for Heavy-Duty Vehicles – Phase 3 (HGP3)

Texas Trends Emissions Inventory

TTI developed a trends emissions inventory (EI) using the EPA's MOVES5 model:

- For all 254 counties in Texas
- For the years 1990, 1999-2060.

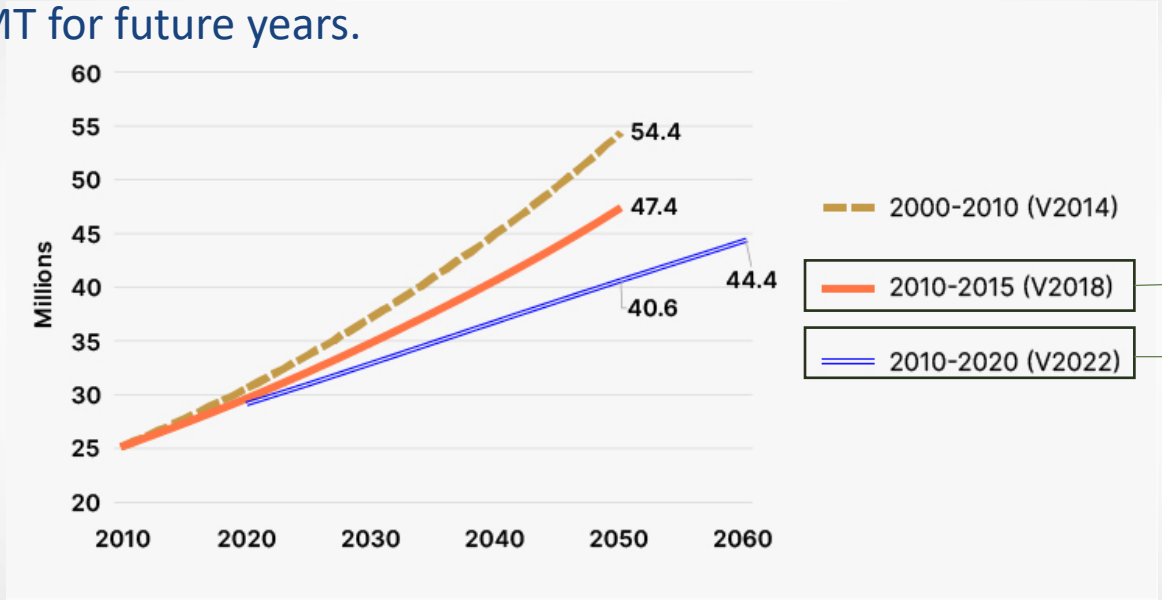
Latest available data was utilized:

- 2023 midyear DMV registration with VIN
- 2014-2023 ATR data.
- Updated population projections, meteorology, fuel (including 2023 summer fuel field study), MOVES5 I/M compliance factors were utilized.

The previously available trend EI in Texas: MOVES3 Trend EI.

Update in Population Projection

- Population projections, along with linear regression of historic data, were used to project VMT for future years.



- The v2022 0.5 Migration Scenario Projections from the Texas Demographic Center were utilized. This was the latest available projection with county-level distribution at the time.

Trends EI Scenario Comparisons

MOVES3 Trends EI:

- Uses MOVES3 emission factors
- Registration data: end of 2018
- ATR counts: 2013–2020
- HPMS VMT: 2020
- Includes gasoline and diesel vehicles

MOVES5 Trends EI:

- Uses MOVES5 emission factors
- Registration data: mid-2023
- ATR counts: 2014–2023
- HPMS VMT: 2023
- Includes gasoline, diesel, and electric vehicles
  - EV adjustment factor applied based on 2023 registration data

MOVES5 with Adjusted EV Adoption:

- Same as MOVES5 Trends EI, but EV adoption for combination trucks (both SUT 61 and 62) is set to zero (less aggressive EV uptake for those trucks)

New Versus Old Registration Processing

- Registration processing method was revised as the new data contained VIN
- Registration processing method also accounted for expanding of vehicle ages (age 30+ to 40+)

Used in MOVES3 Trends EI

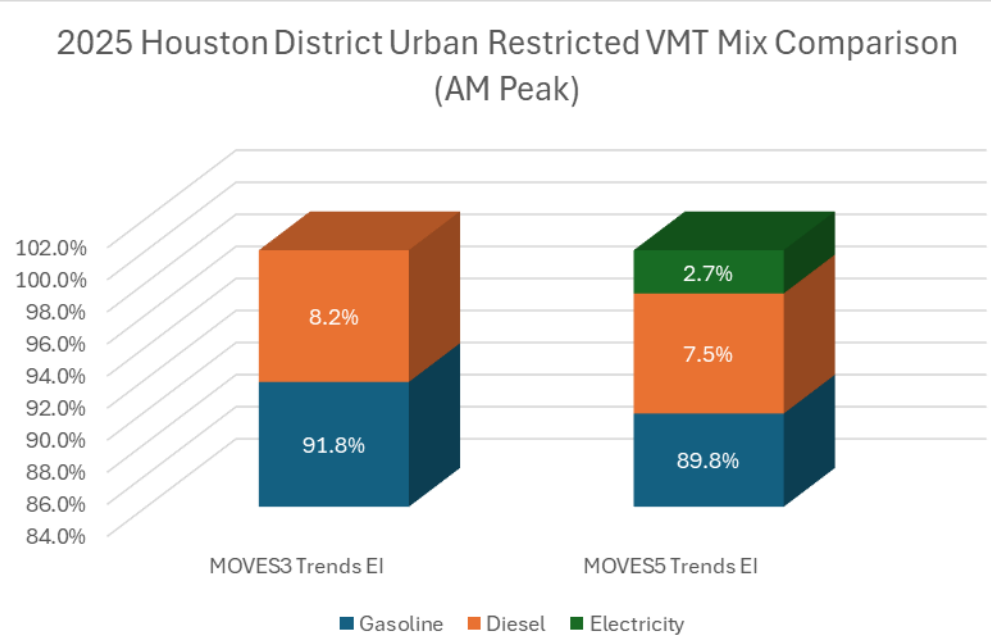
Vehicle Registration[1] Aggregation	MOVES SUT and Fuel Type (Vehicle Type)
Motorcycles	MC_Gas
Passenger Cars	PC_Gas; PC_Diesel
Trucks <= 8.5 K gross vehicle weight rating (GVWR: pounds)	PT_Gas; PT_Diesel; LCT_Gas; LCT_Diesel
Trucks > 8.5 and <= 19.5 K GVWR	RT_Gas; RT_Diesel SUShT_Gas; SUShT_Diesel MH_Gas; MH_Diesel Obus_Gas; Obus_Diesel TBus_Gas; TBus_Diesel SBus_Gas; SBus_Diesel
Trucks > 19.5 K GVWR	CShT_Gas; CShT_Diesel
NA[1]	SULhT_Gas; SULhT_Diesel CLhT_Gas; CLhT_Diesel

[1] The four long-haul SUT/fuel type populations are estimated using a long-haul-to-short-haul weekday SUT VMT mix ratio applied to the short-haul SUT population estimate.

Used in MOVES5 Trends EI

Registration Data Aggregation	Associated Vehicle Type
Motorcycles	MC_Gas
Passenger Cars	PC_Gas; PC_Diesel; PC_Electricity
Multipurpose Passenger Vehicle (MPV) and Truck<=10,000 lbs	PT_Gas; PT_Diesel; PT_Electricity LCT_Gas; LCT_Diesel; LCT_Electricity
Bus other than School Bus	Obus_Gas; Obus_Diesel; Obus_Electricity TBus_Gas; TBus_Diesel; TBus_Electricity
School Bus	SBus_Gas; SBus_Diesel; SBus_Electricity
10,000<Truck<=19,500 other than Motorhome & 19,500<Truck<33,000 other than Truck-Tractor and Motorhome and no sleeping cab	RT_Gas; RT_Diesel; RT_Electricity SUShT_Gas; SUShT_Diesel; SUShT_Electricity
19,500<Truck<33,000 other than Truck-Tractor and Motorhome, and with sleeping cab	SULhT_Gas; SULhT_Diesel; SULhT_Electricity
Motorhome	MH_Gas; MH_Diesel; MH_Electricity
19,500<Truck-Tractor with no sleeping cab	CShT_Gas; CShT_Diesel; CShT_Electricity
19,500<Truck-Tractor and body type is Truck-Tractor with sleeping cab	CLhT_Diesel; CLhT_Electricity

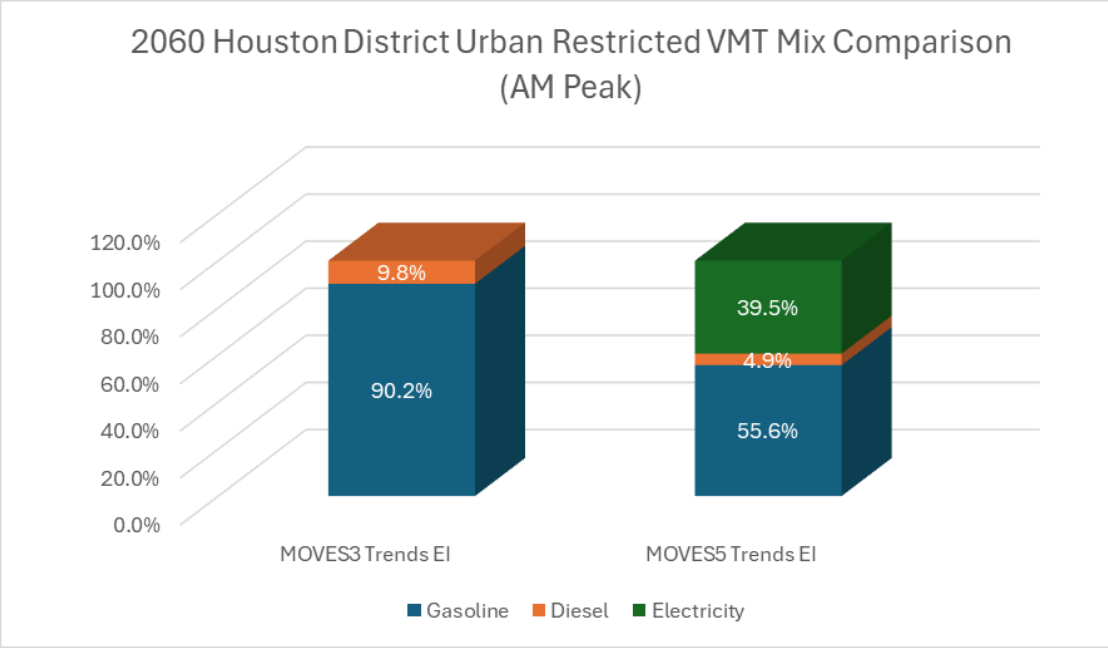
Difference in VMT Mix
On-network



Proportionately, the composition of gasoline vehicles fell by about 2% while diesel vehicles fell by about 9%.

sourceTypeID	fuelTypeID	MOVES3 Trends EI VMT Mix	MOVES5 Trends EI VMT Mix
Motorcycle	Gasoline	0.0010	0.0007
Passenger Car	Gasoline	0.6873	0.6536
	Diesel	0.0057	0.0012
	Electricity	0.0000	0.0223
Passenger Truck	Gasoline	0.1950	0.2112
	Diesel	0.0107	0.0064
	Electricity	0.0000	0.0041
Light Commercial Trucks	Gasoline	0.0268	0.0235
	Diesel	0.0020	0.0009
	Electricity	0.0000	0.0004
Other Buses	Gasoline	0.0003	0.0003
	Diesel	0.0017	0.0011
	Electricity	0.0000	0.0000
Transit Buses	Gasoline	0.0001	0.0001
	Diesel	0.0006	0.0004
	Electricity	0.0000	0.0000
School Bus	Gasoline	0.0000	0.0001
	Diesel	0.0009	0.0006
	Electricity	0.0000	0.0000
Refuse Truck	Gasoline	0.0000	0.0000
	Diesel	0.0003	0.0002
	Electricity	0.0000	0.0000
Single Unit Short-Haul Truck	Gasoline	0.0056	0.0065
	Diesel	0.0190	0.0207
	Electricity	0.0000	0.0001
Single Unit Long-Haul Truck	Gasoline	0.0011	0.0014
	Diesel	0.0034	0.0035
	Electricity	0.0000	0.0000
Motor Home	Gasoline	0.0006	0.0007
	Diesel	0.0004	0.0003
	Electricity	0.0000	0.0000
Combination Short-Haul Truck	Gasoline	0.0000	0.0000
	Diesel	0.0138	0.0145
	Electricity	0.0000	0.0000
Combination Long-Haul Truck	Diesel	0.0238	0.0250
	Electricity	0.0000	0.0000
SUM		1.00000	1.00000

Difference in VMT Mix
On-network (Continue)



Proportionately, the composition of gasoline vehicles fell by about 38% while diesel vehicles fell by about 50%.

sourceTypeID	fuelTypeID	MOVES3 Trends EI VMT Mix	MOVES5 Trends EI VMT Mix
Motorcycle	Gasoline	0.0010	0.0007
Passenger Car	Gasoline	0.6775	0.3908
	Diesel	0.0155	0.0000
	Electricity	0.0000	0.2863
Passenger Truck	Gasoline	0.1900	0.1417
	Diesel	0.0161	0.0028
	Electricity	0.0000	0.0771
Light Commercial Trucks	Gasoline	0.0262	0.0148
	Diesel	0.0022	0.0010
	Electricity	0.0000	0.0091
Other Buses	Gasoline	0.0003	0.0002
	Diesel	0.0017	0.0007
	Electricity	0.0000	0.0007
Transit Buses	Gasoline	0.0001	0.0001
	Diesel	0.0006	0.0002
	Electricity	0.0000	0.0003
School Bus	Gasoline	0.0000	0.0000
	Diesel	0.0009	0.0002
	Electricity	0.0000	0.0004
Refuse Truck	Gasoline	0.0000	0.0000
	Diesel	0.0003	0.0002
	Electricity	0.0000	0.0000
Single Unit Short-Haul Truck	Gasoline	0.0052	0.0060
	Diesel	0.0195	0.0143
	Electricity	0.0000	0.0069
Single Unit Long-Haul Truck	Gasoline	0.0009	0.0012
	Diesel	0.0035	0.0027
	Electricity	0.0000	0.0010
Motor Home	Gasoline	0.0006	0.0006
	Diesel	0.0004	0.0003
	Electricity	0.0000	0.0001
Combination Short-Haul Truck	Gasoline	0.0000	0.0000
	Diesel	0.0138	0.0081
	Electricity	0.0000	0.0064
Combination Long-Haul Truck	Diesel	0.0238	0.0183
	Electricity	0.0000	0.0067
SUM		1.00000	1.00000

Patterns in Activity and Emission

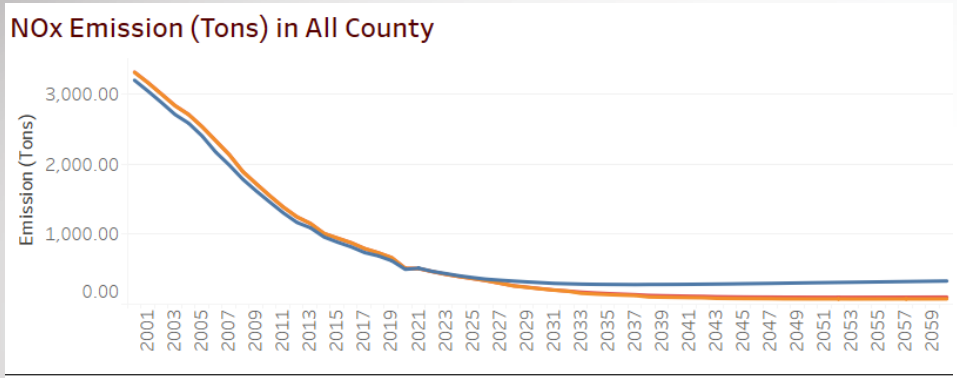
As EVs become more dominant as year progresses:

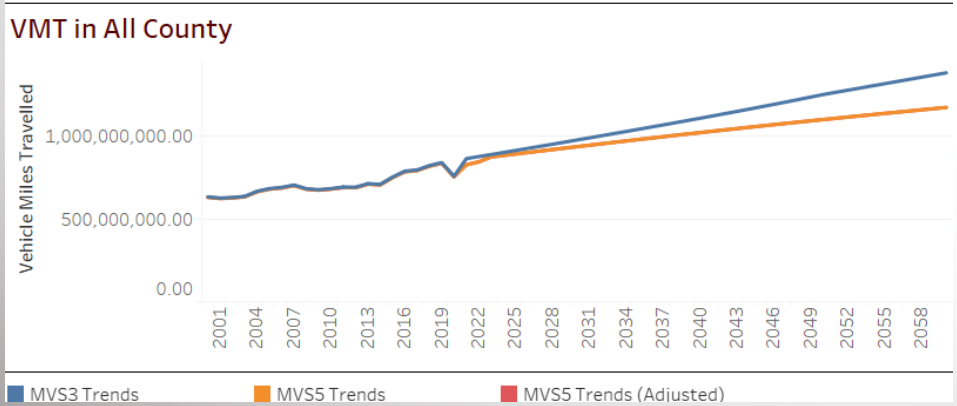
- Portion of on-network activity (i.e., exhaust emissions) that contributes to emission (i.e., from ICE) decreases,
- Portion of off-network activities that contribute to emission (i.e., starts, off-network idling [ONI], source hours parked [SHP], source hours extended idling [SHEI], and auxiliary power unit exhaust [APU] hours) decreases.

This is coupled with lower heavy-duty vehicle emission rates (compared to MOVES3) post-2026 from regulation updates.

1990, 1999-2060 NO_X Trends (Tons)

Summer Weekday

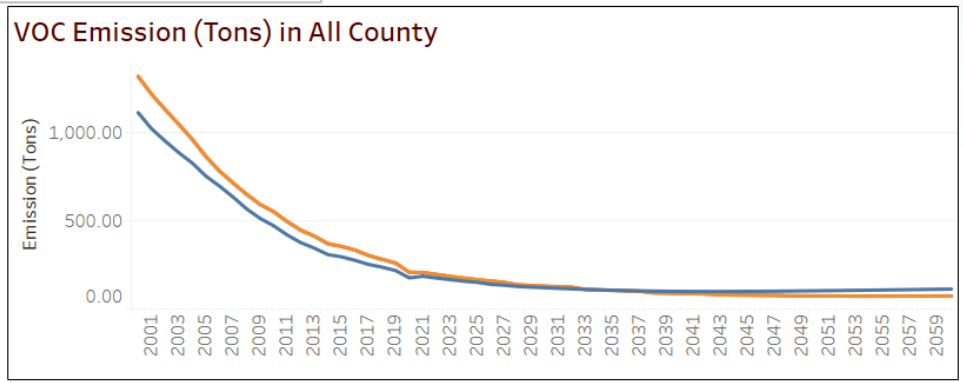


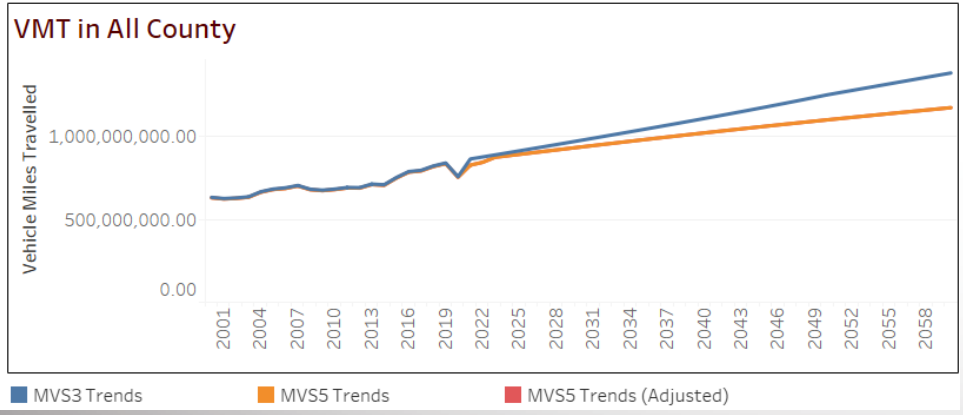


Year	MOVES3 (10^6 VMT)	MOVES5 Trends (10^6 VMT)	MOVES3	MOVES5	MOVES5 Adjusted
2023	888	873	437	427	427
2030	976	936	308	220	222
2040	1,107	1,020	283	94	115
2050	1,250	1,099	306	76	100
2060	1,382	1,173	329	76	102

1990, 1999-2060 VOC Trends (Tons)

Summer Weekday

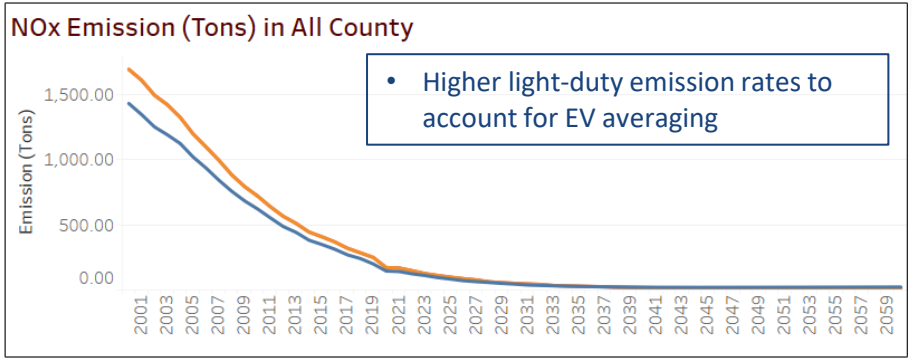


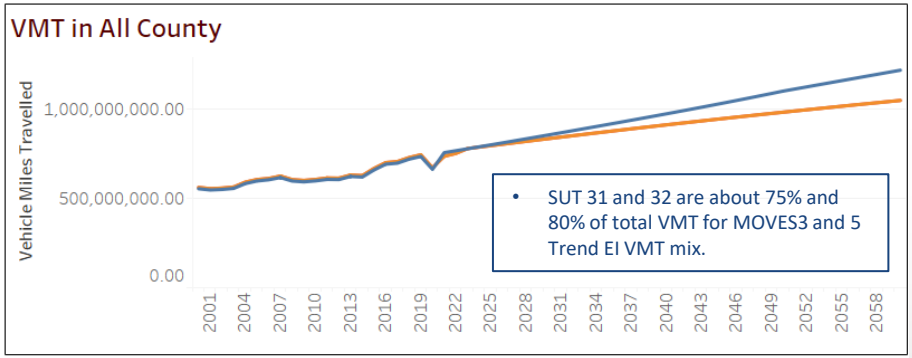


Year	MOVES3 (10^6 VMT)	MOVES5 Trends (10^6 VMT)	MOVES3	MOVES5	MOVES5 Adjusted
2023	888	873	167	185	185
2030	976	936	121	130	130
2040	1,107	1,020	100	88	89
2050	1,250	1,099	103	74	75
2060	1,382	1,173	113	73	74

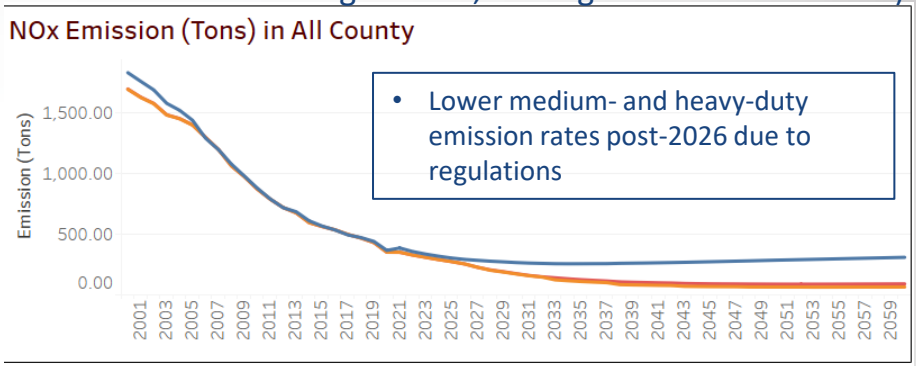
Trends in Light- and Heavy-Duty Vehicles

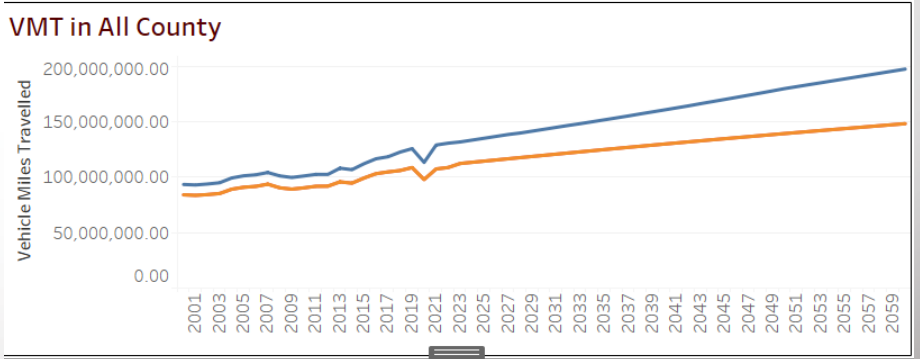
Light-duty (only Motorcycle, Passenger Car, Passenger Truck, and Light Commercial Truck)





Heavy-duty (SUT other than Motorcycle, Passenger Car, Passenger Truck, and Light Commercial Truck)





Summary Findings

MOVES5 emissions before 2026 tend to be higher because of several factors:

- Older vehicles contribute to higher emission rates.
- Increased emission rates for gasoline and diesel light-duty vehicles, reflecting adjustments for the growing share of EVs in the fleet average.

Future year emissions in the MOVES5 Trends analysis are lower than those in MOVES3 Trends for several reasons:

- MOVES5 includes lower emission rates as a result of updated regulations.
- Projected VMT totals are lower in MOVES5.
- There is a shift in the VMT mix toward more light-duty vehicles and well as increased in EV adoption.

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