SAND2017-13796PE

Heavy-Duty Vehicle Analysis with the Sandia ParaChoice Model

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VTO-Sandia/CA Site Visit, Dec 15th, 2017

Goals of the heavy-duty vehicles analysis

Sandia National Laboratories

Identify the combination(s) of HDV segments and novel technologies that most significantly increase efficiency and/or decrease criteria air pollutants

1. Quantitatively characterize the fleet of HDVs by elucidating the taxonomy of the class 7 & 8 heavy-duty trucks by…
   - Count
   - Annual vehicle miles traveled (VMT)
   - Annual fuel consumption

2. Quantitatively assess alternative energy impacts on fuel use and pollutants
   - Identify bounding cases & technology alternatives
   - Elucidate the drive cycle for each HDV segment (identified above)
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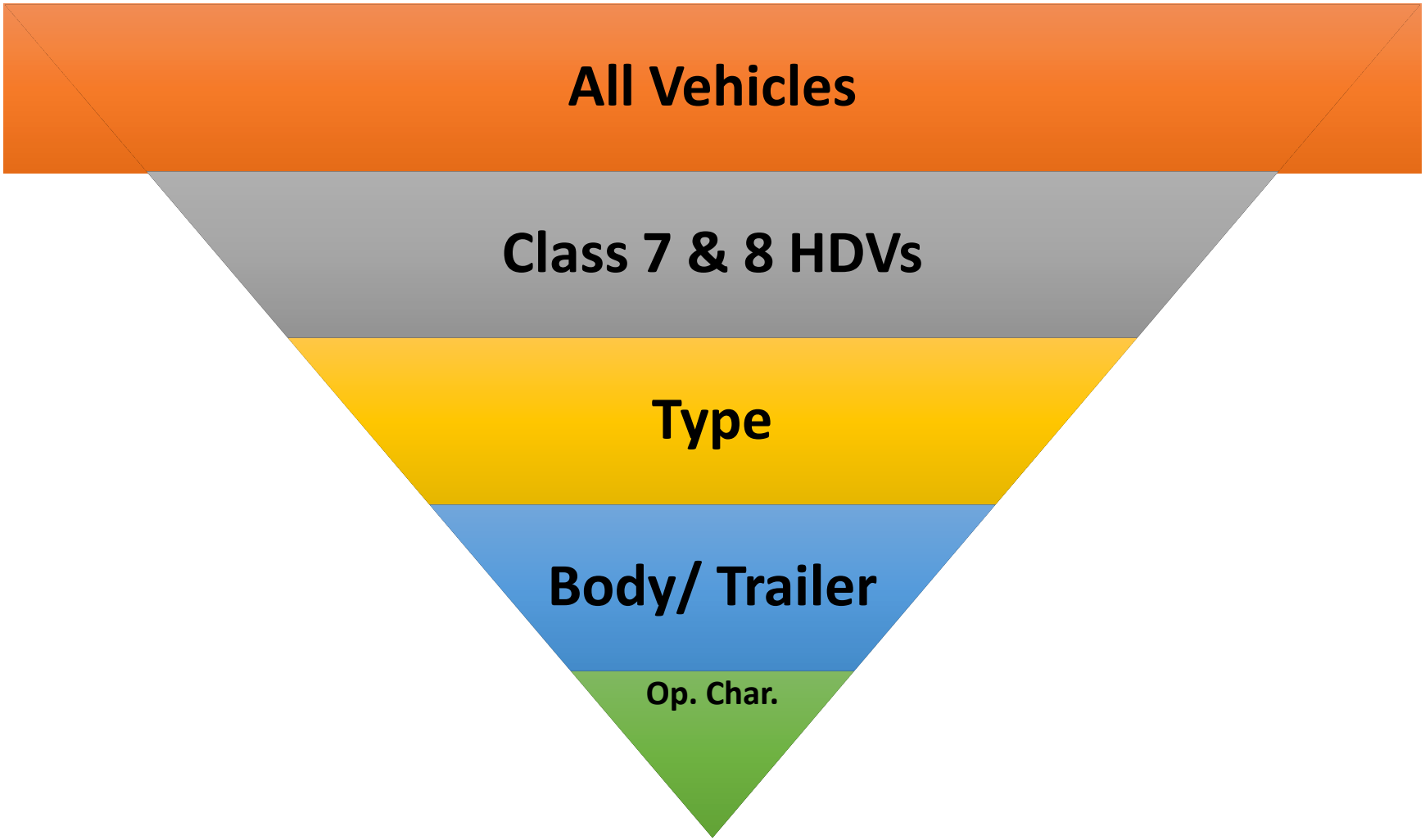
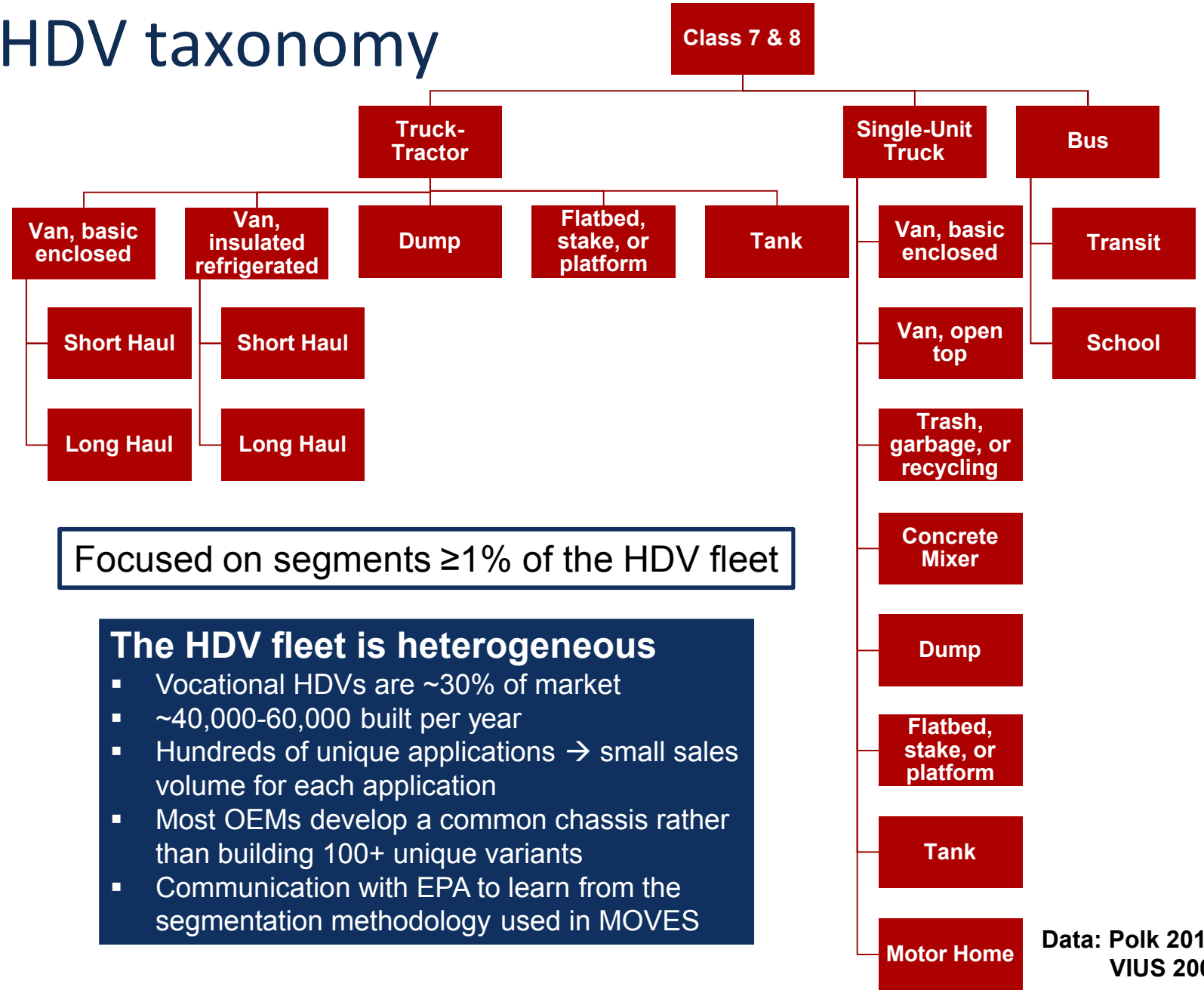
HDV fleet segmentation approach



HDV taxonomy



Focused on segments ≥1% of the HDV fleet

The HDV fleet is heterogeneous

- Vocational HDVs are ~30% of market
- ~40,000-60,000 built per year
- Hundreds of unique applications → small sales volume for each application
- Most OEMs develop a common chassis rather than building 100+ unique variants
- Communication with EPA to learn from the segmentation methodology used in MOVES

Data: Polk 2011
VIUS 2002

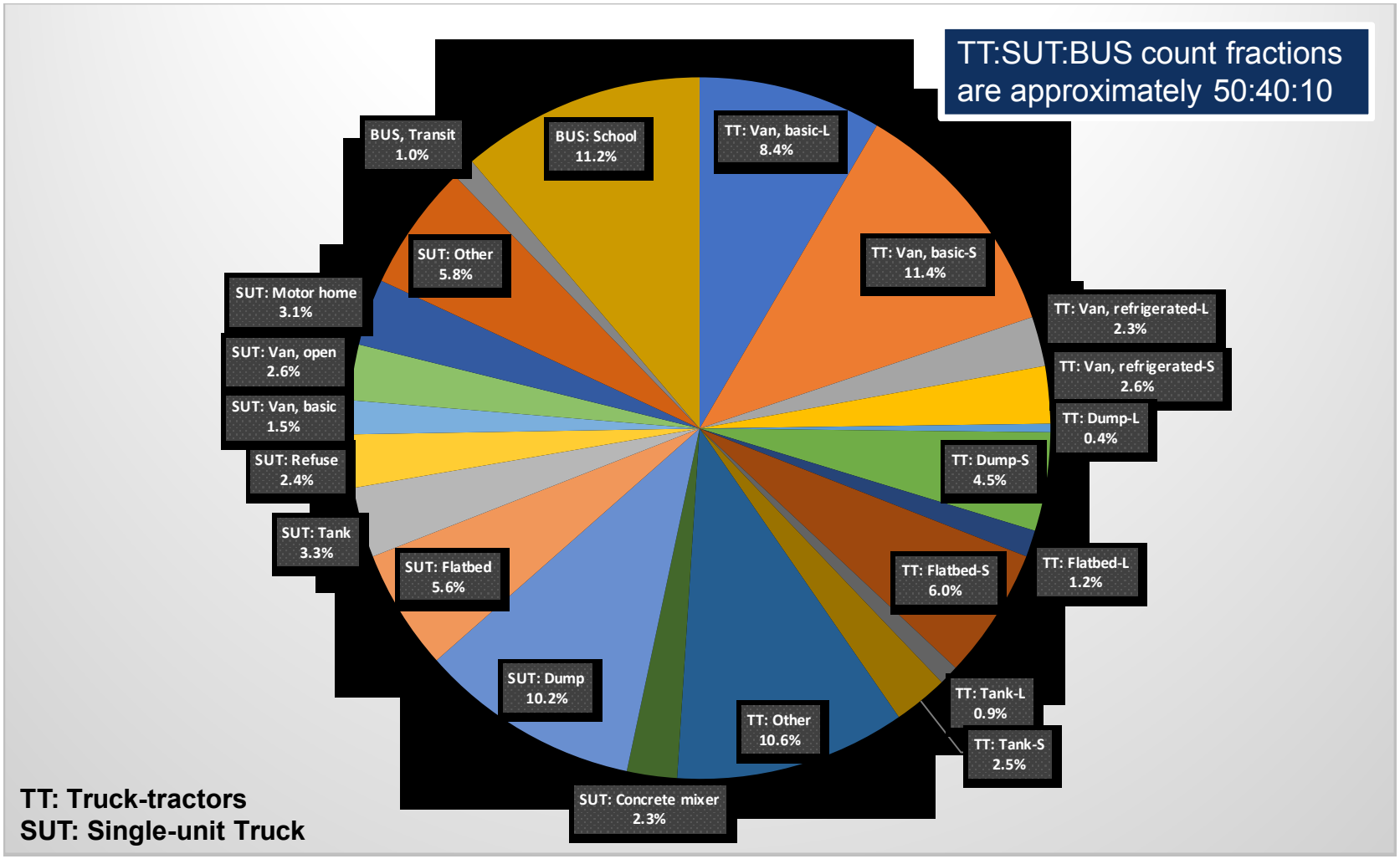
Quantitative segmentation methodology

- Number of registered [class 7 & 8] vehicles for each truck type comes from the Polk 2011 data set (TT, SUT, motor home) or 2011 FHWA Table MV-10 (buses)

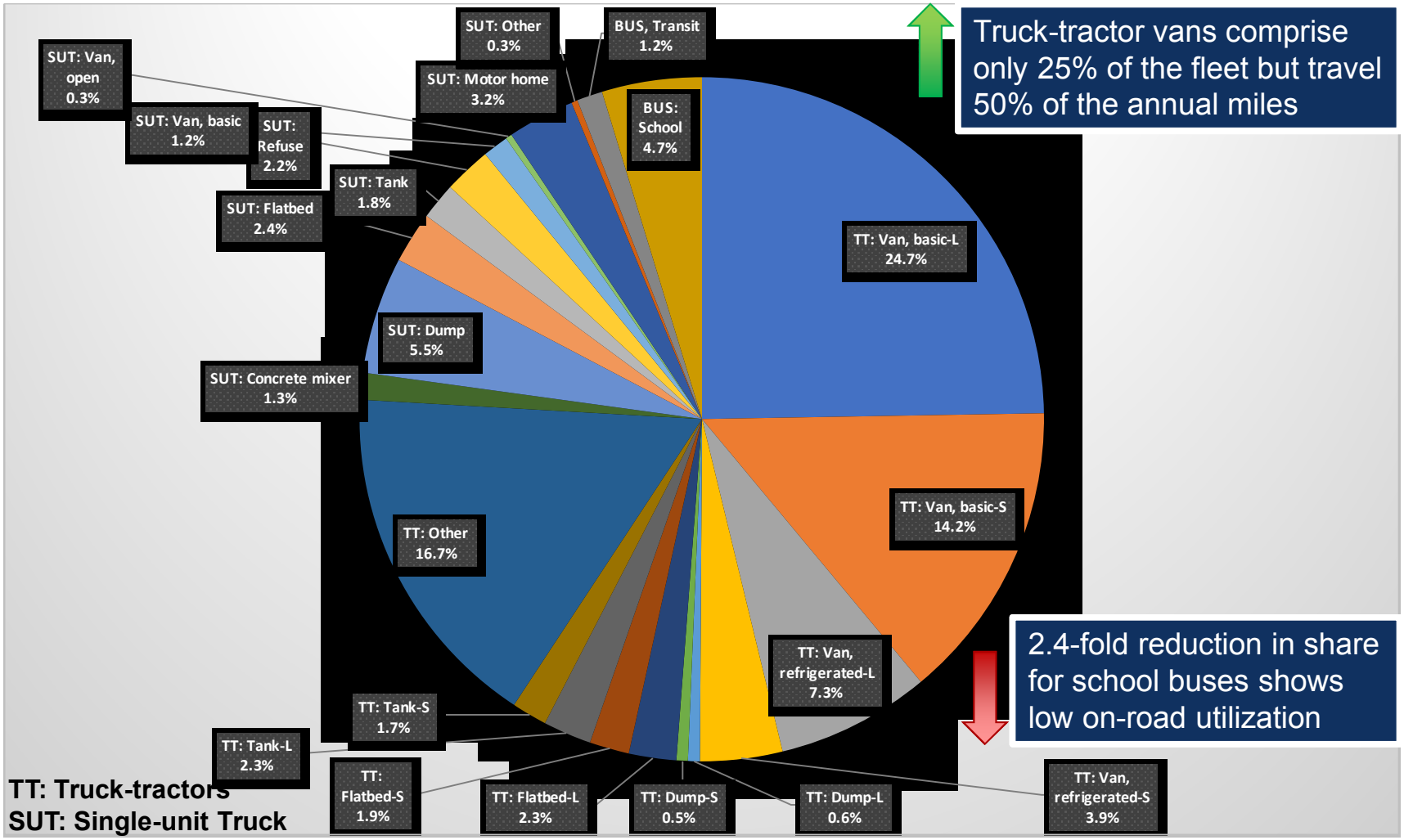
	Polk 2011	NTD	FHWA MV-10	Use	% of Fleet
Truck-Tractor	2,561,984			2,561,984	50.5%
Single-Unit Truck	1,692,818			1,692,818	33.4%
School Bus	450,845		583,439	583,439	11.5%
Transit Bus		72,087	82,625	72,087	1.4%
Touring Bus				10,538	0.2%
Motor Home	152,400			152,400	3.0%
				5,073,266	100.0%

- Body/trailer breakdowns for each type come from VIUS 2002 where the body/trailer represents ≥5% of the total for each truck type; else, it was grouped into “Other"
- The short- vs. long-haul split fraction is achieved by applying a mileage threshold (100k) to the annual miles (MILES_ANNL) from VIUS 2002
  - Long-haulers travel 110,000 miles annually[1]
  - Short-hauling “daycabs” travel ~80,000 miles annually[1]

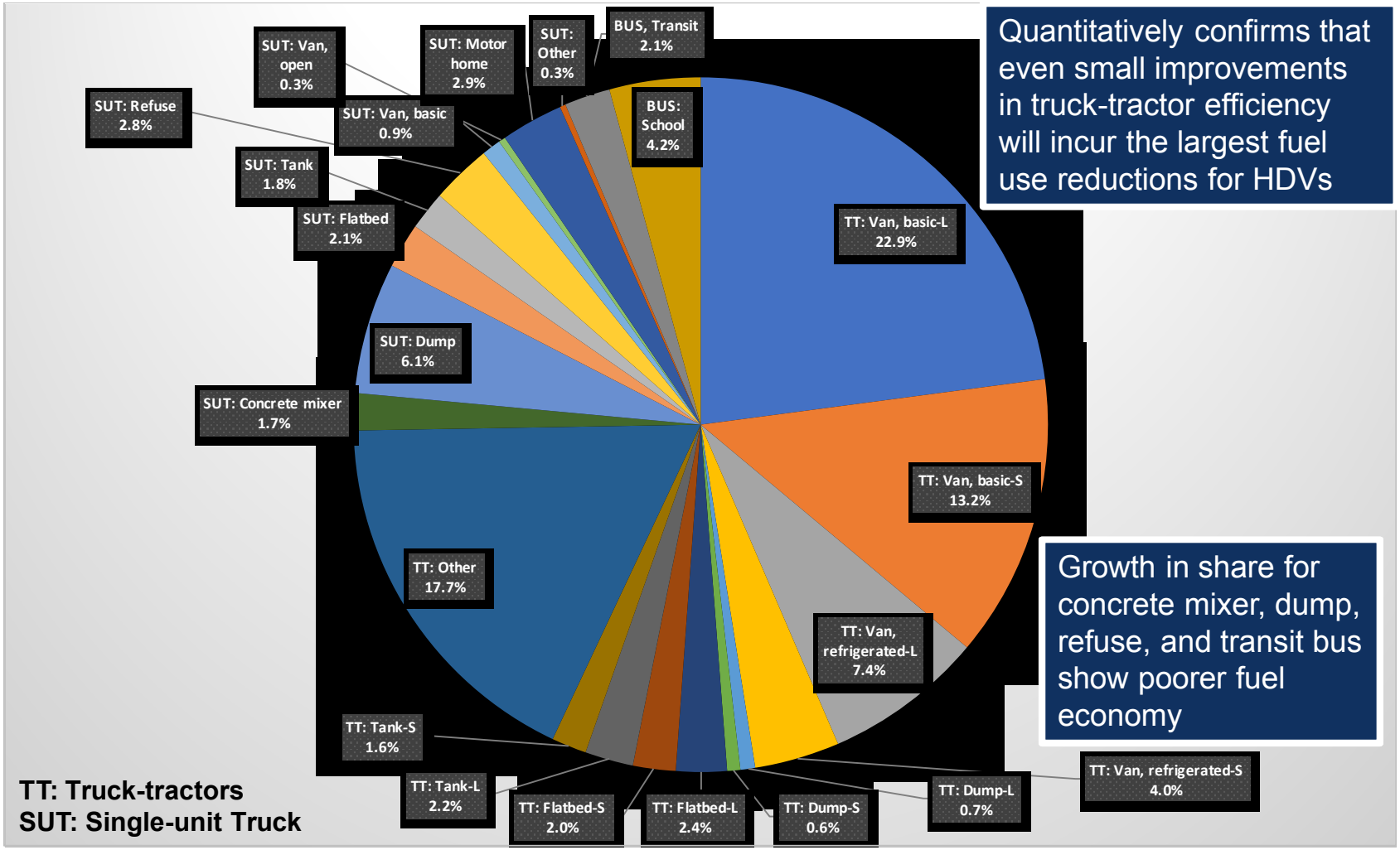
HDV fleet segmentation by **COUNT**



HDV fleet segmentation by **VMT**



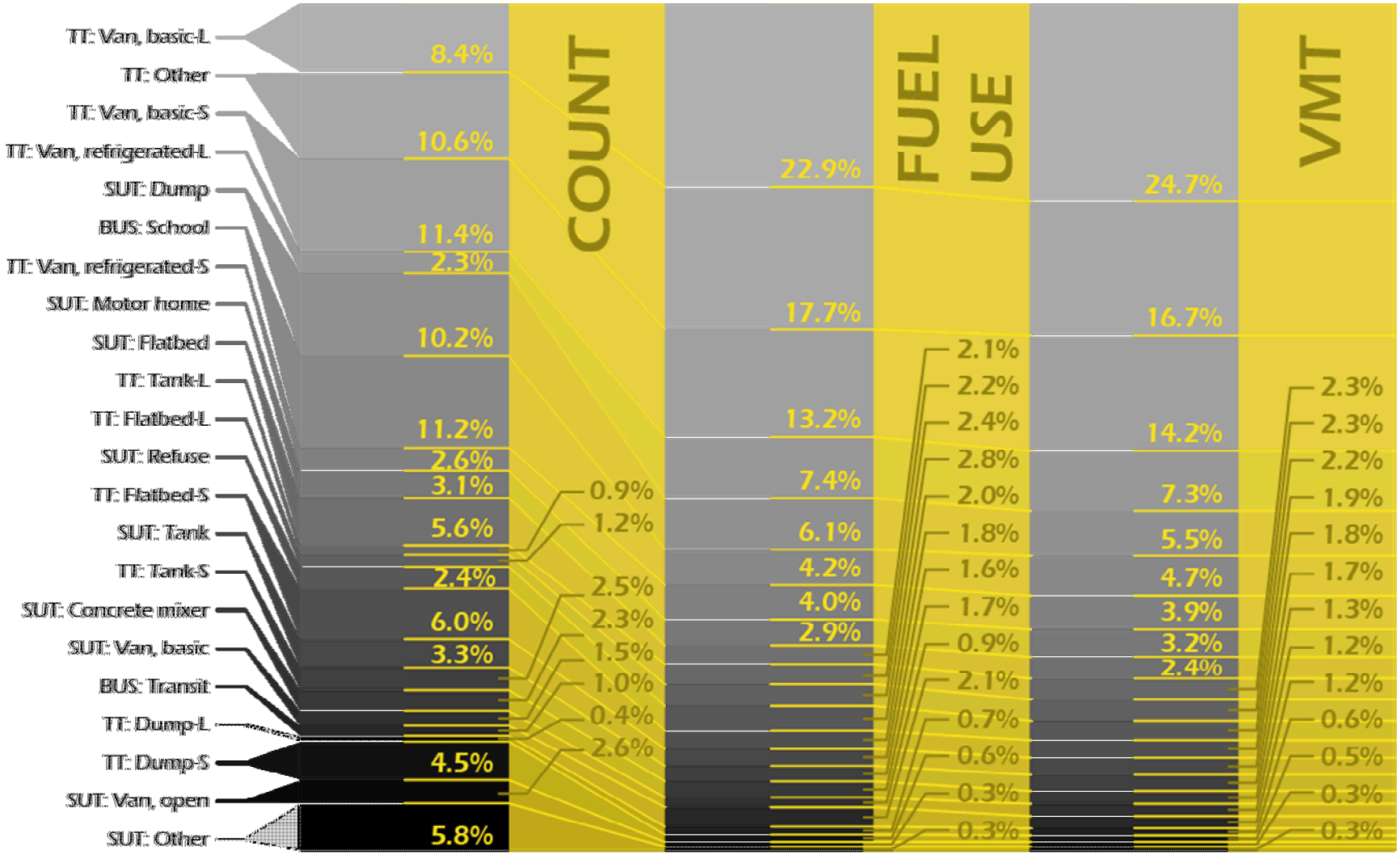
HDV fleet segmentation by **FUEL USE**



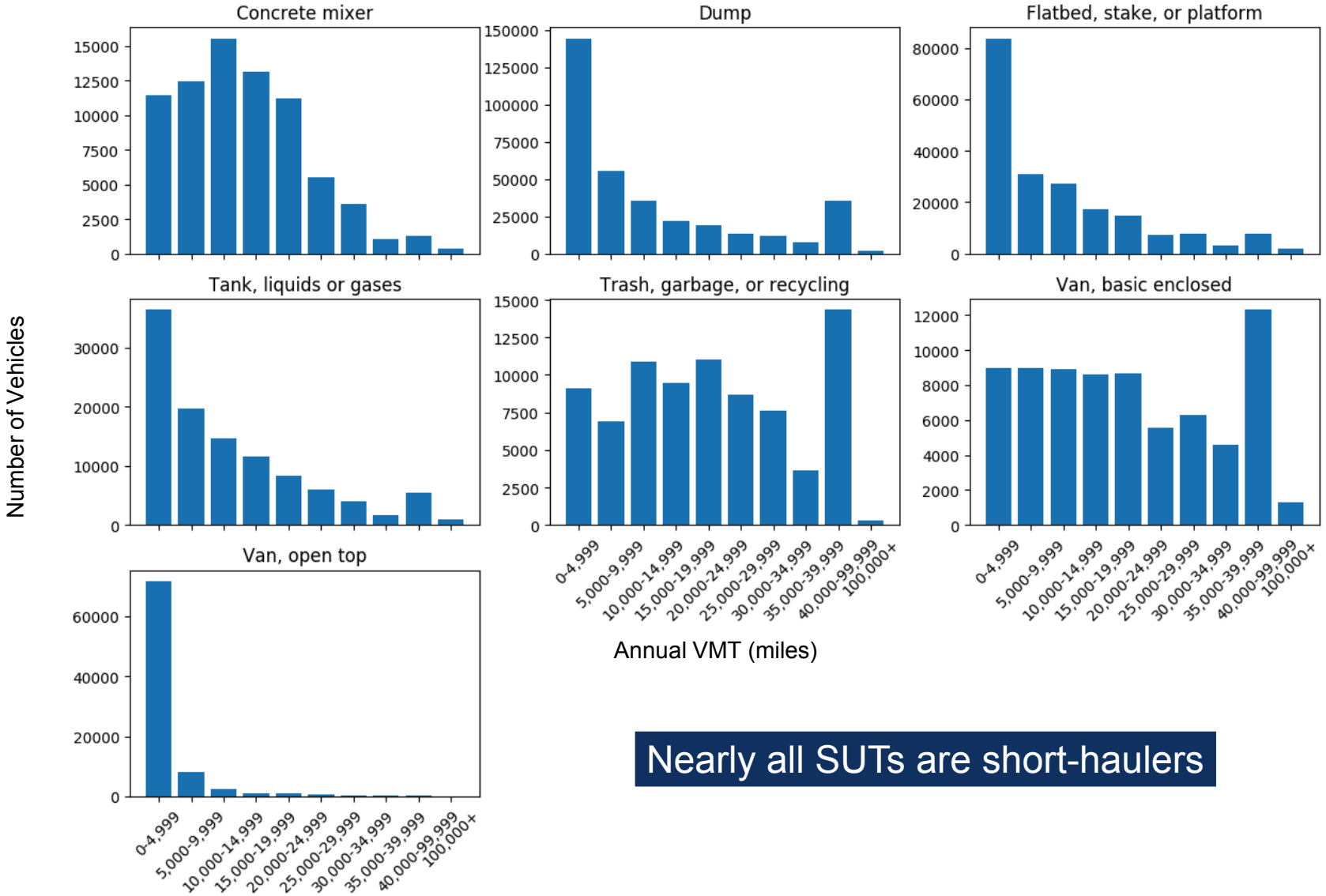
Quantitatively confirms that even small improvements in truck-tractor efficiency will incur the largest fuel use reductions for HDVs

Growth in share for concrete mixer, dump, refuse, and transit bus show poorer fuel economy

HDV fleet segmentation comparison

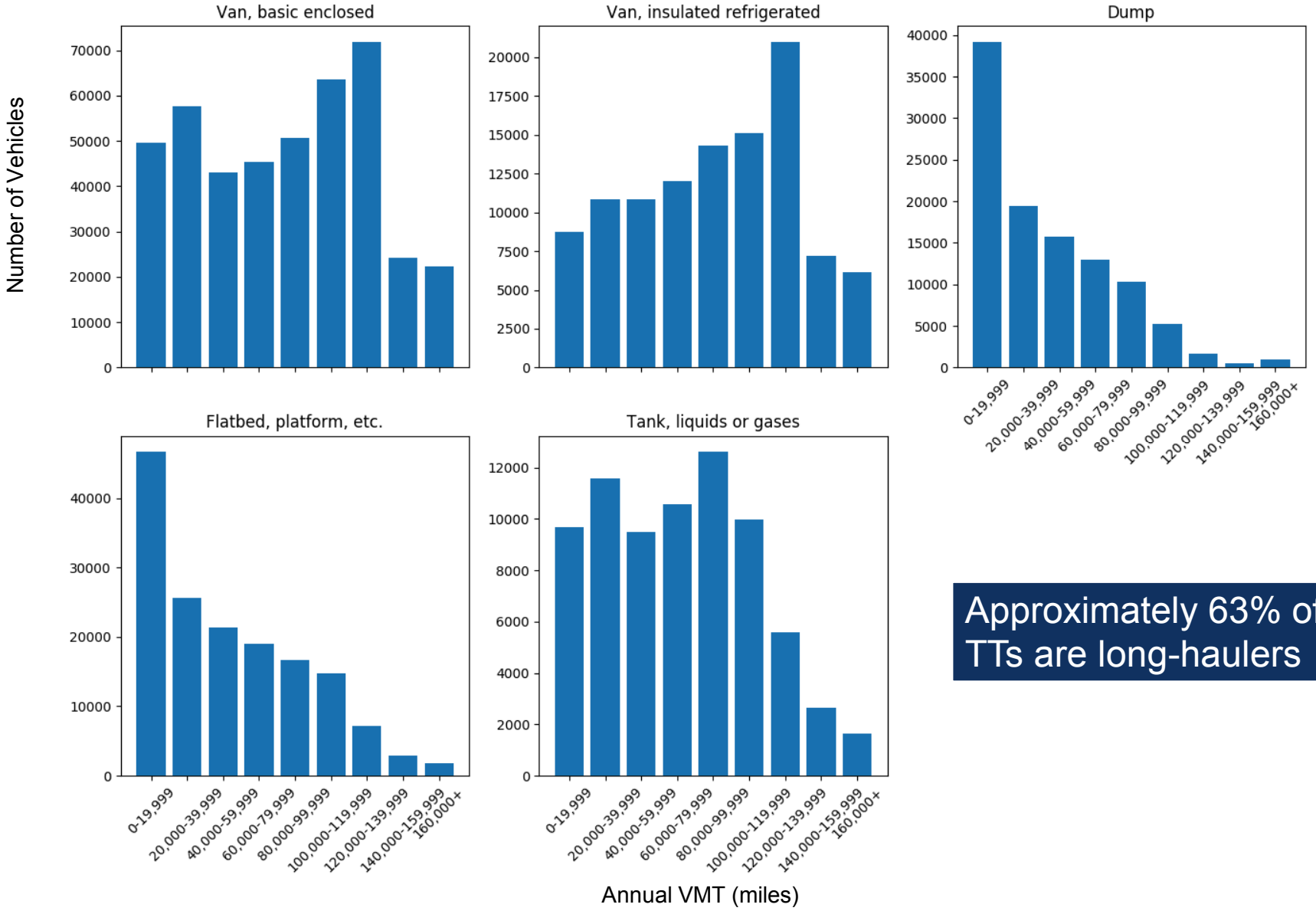


Annual VMT for single-unit trucks (SUTs)



Nearly all SUTs are short-haulers

Annual VMT for truck-tractors (TTs)



Approximately 63% of TTs are long-haulers

Segmentation takeaways

- HDV segmentation by count looks quite different than by annual VMT or fuel use
  - Truck-tractors account for only half of class 7 & 8 HDVs but travel three-quarters of the total annual miles and consume three-quarters of fuel
    - Of these, the long-haul trucks dominate

- Sectors where alternative energy technologies have been successful are relatively small
  - Refuse (e.g., CNG): 2.2% VMT // 2.8% fuel use
  - Transit buses (e.g., hybrid/electric, CNG/LNG): 1.2% VMT // 2.1% fuel use

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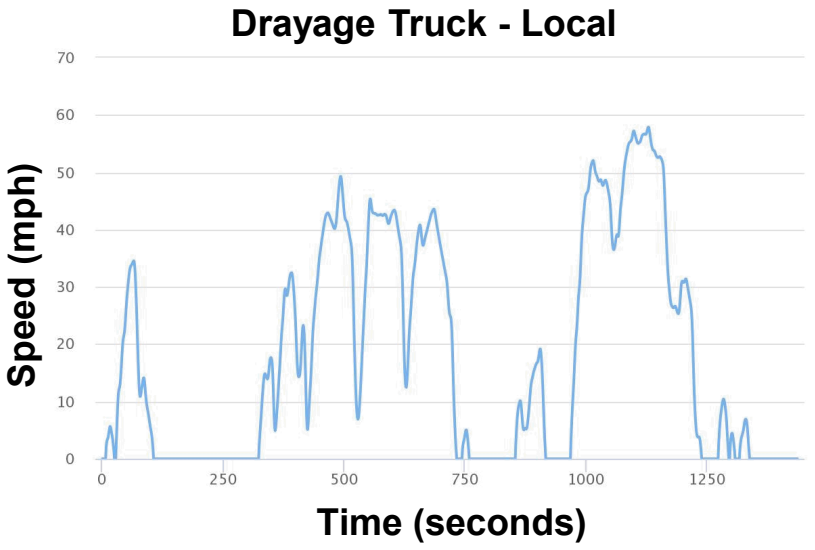
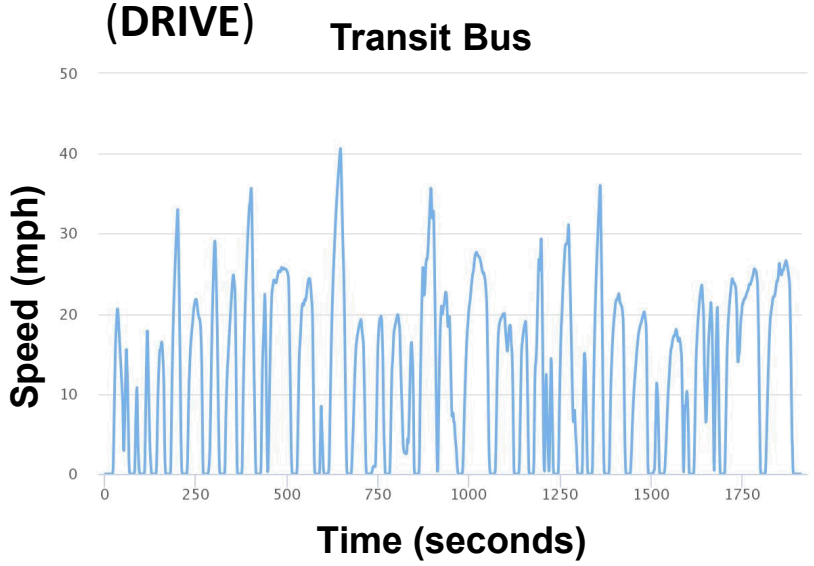
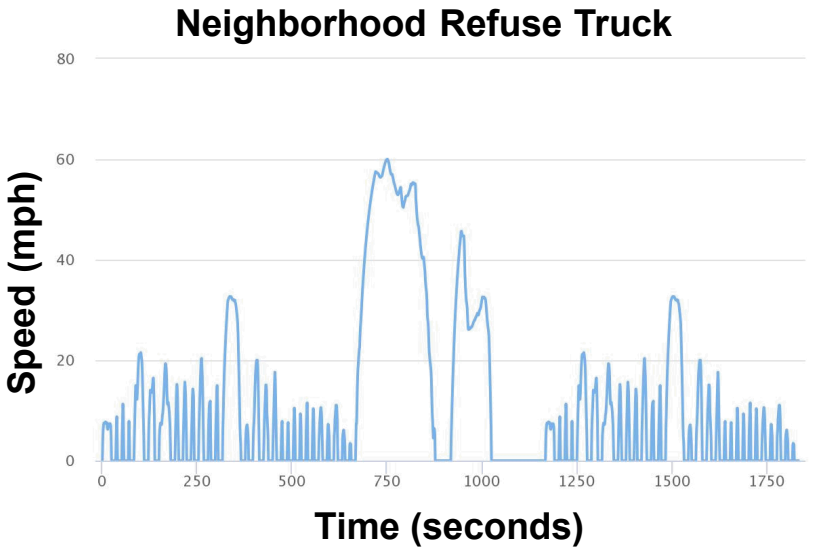
HDV drive cycle characterization

- Characterize long- vs. short-haul split fraction for each segment
  - Using 2002 VIUS data—**DONE!**
- Determine HDV segment operational characteristics
  - Evaluating NREL's Drive-Cycle Rapid Investigation, Visualization, and Evaluation Analysis Tool (**DRIVE**)



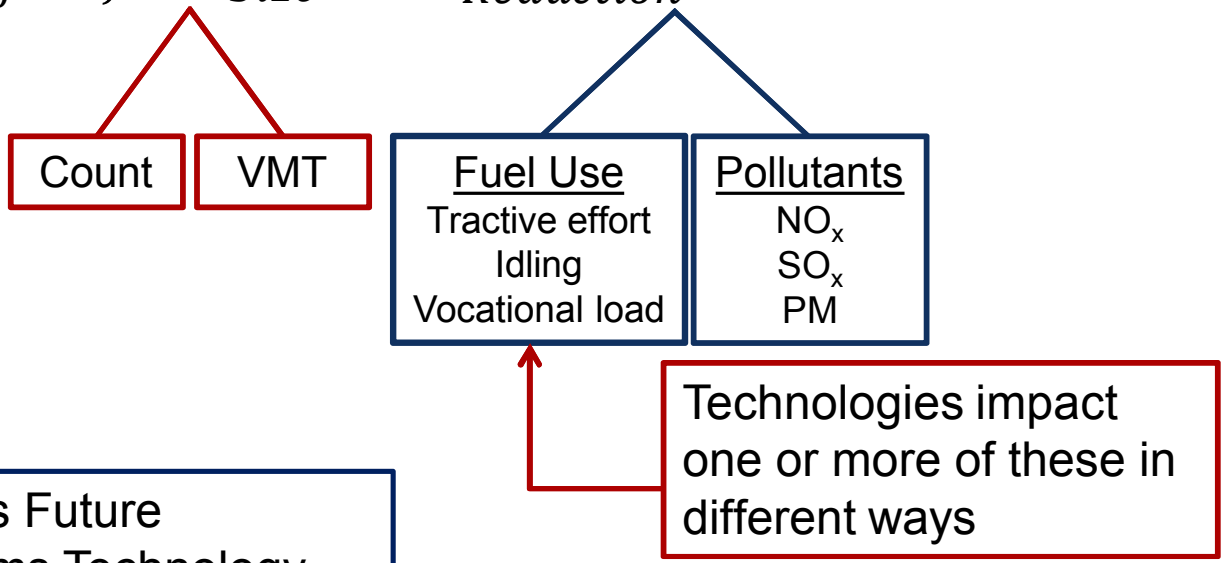




Assessing technology benefits

HDVs are significant contributors to air pollution (e.g., NO_x)

$$\begin{Bmatrix} Technology \\ Benefit \end{Bmatrix} = \begin{Bmatrix} Market \\ Size \end{Bmatrix} \times \begin{Bmatrix} Savings/ \\ Reduction \end{Bmatrix}$$



Evaluating NREL's Future Automotive Systems Technology Simulator (**FASTSim**) to determine savings/reductions from technology

Analysis questions

There are several potential problems that may require different solutions

What technology investment(s) can…

1. Most greatly reduce aggregate fuel consumption?
   - This likely means targeting large HDV fleet segments (i.e., truck-tractors) where gains can be realized over many vehicles
2. Decrease criteria pollutant emissions in sensitive/ populated areas?
   - This likely means targeting short-haul vehicles that operate in these areas all or most of the time (e.g., relatively smaller HDV fleet segments traveling fewer total miles and using less fuel)
3. Have broad impacts across the entire HDV fleet?
   - This involves minimizing a fuel or emissions given the HDV fleet-wide deployment of one or more alternative energy technology
     - Despite traveling fewer miles and using less fuel, OEMs may produce alternative energy vehicles for some segments due to large sales numbers (i.e., count)

Progress and updates

- FY2018Q1 deliverables complete
- FY2018Q2 deliverable status
  - Obtained code for both DRIVE and FASTSim from NREL (thanks to Adam Duran)
  - Preparing to evaluate these tools for suitability to answer our analysis Q's
- CA-VIUS status
  - Caltrans has received preliminary data from Cambridge Systematics but will not be releasing it externally until spring CY2018

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