Evaluations of 1997 Fuel Consumption Patterns of Heavy Duty Trucks

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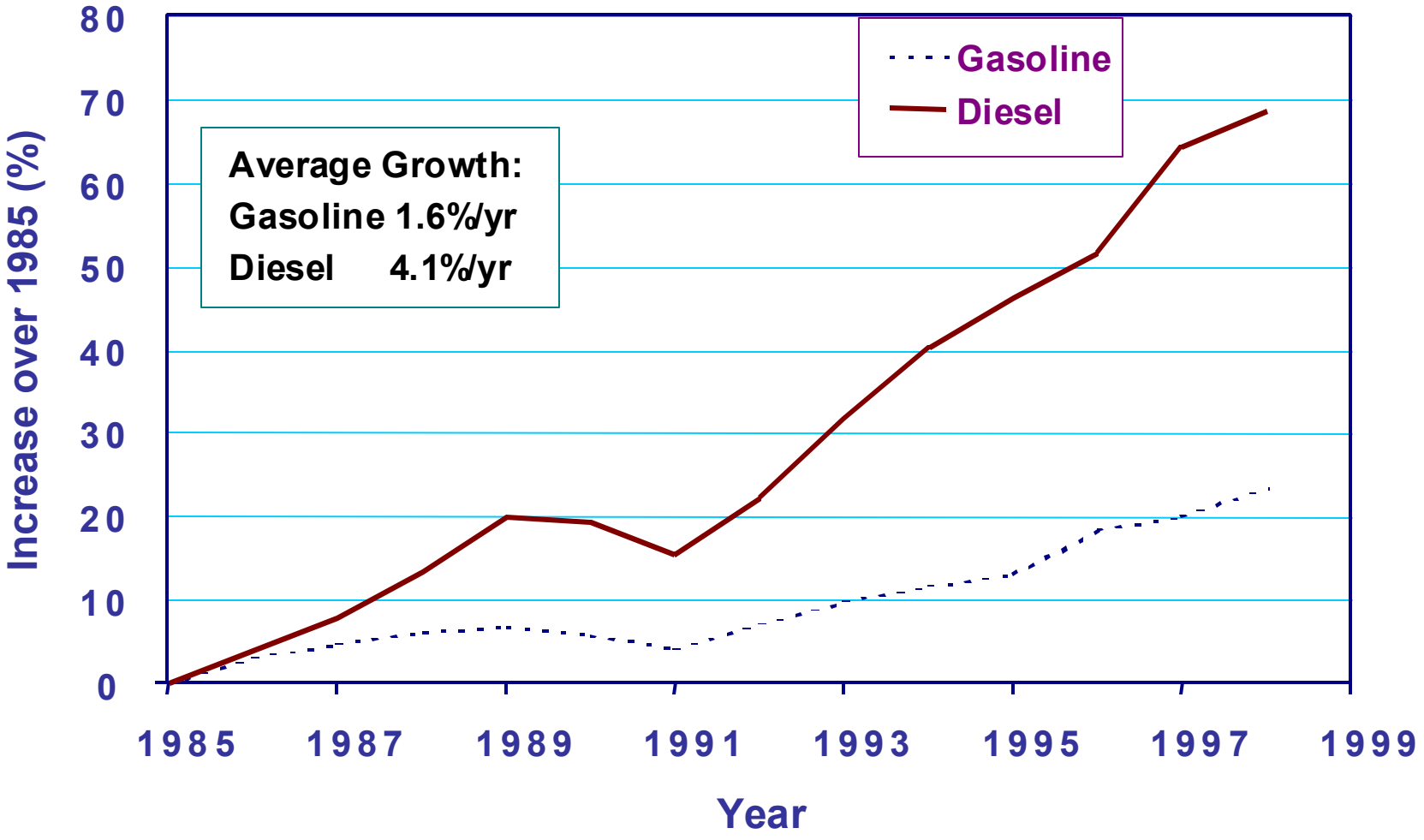
Diesel Fuel Consumption is Rising at a Faster Rate Than Gasoline Consumption



Gross Vehicle Weight Class Analysis

- The 1997 VIUS contains two fields for GVW class
  1. Based on vehicle registration (used in this analysis)
  2. Based on respondent reported average vehicle weight
- Class 2B trucks are difficult to classify
  1. All trucks in class 2 bunched together
  2. Average weight data not available for all

Class 2B Trucks' Gasoline and Diesel Consumption Required More Judgment

- **Class 2B trucks classification difficulty addressed**

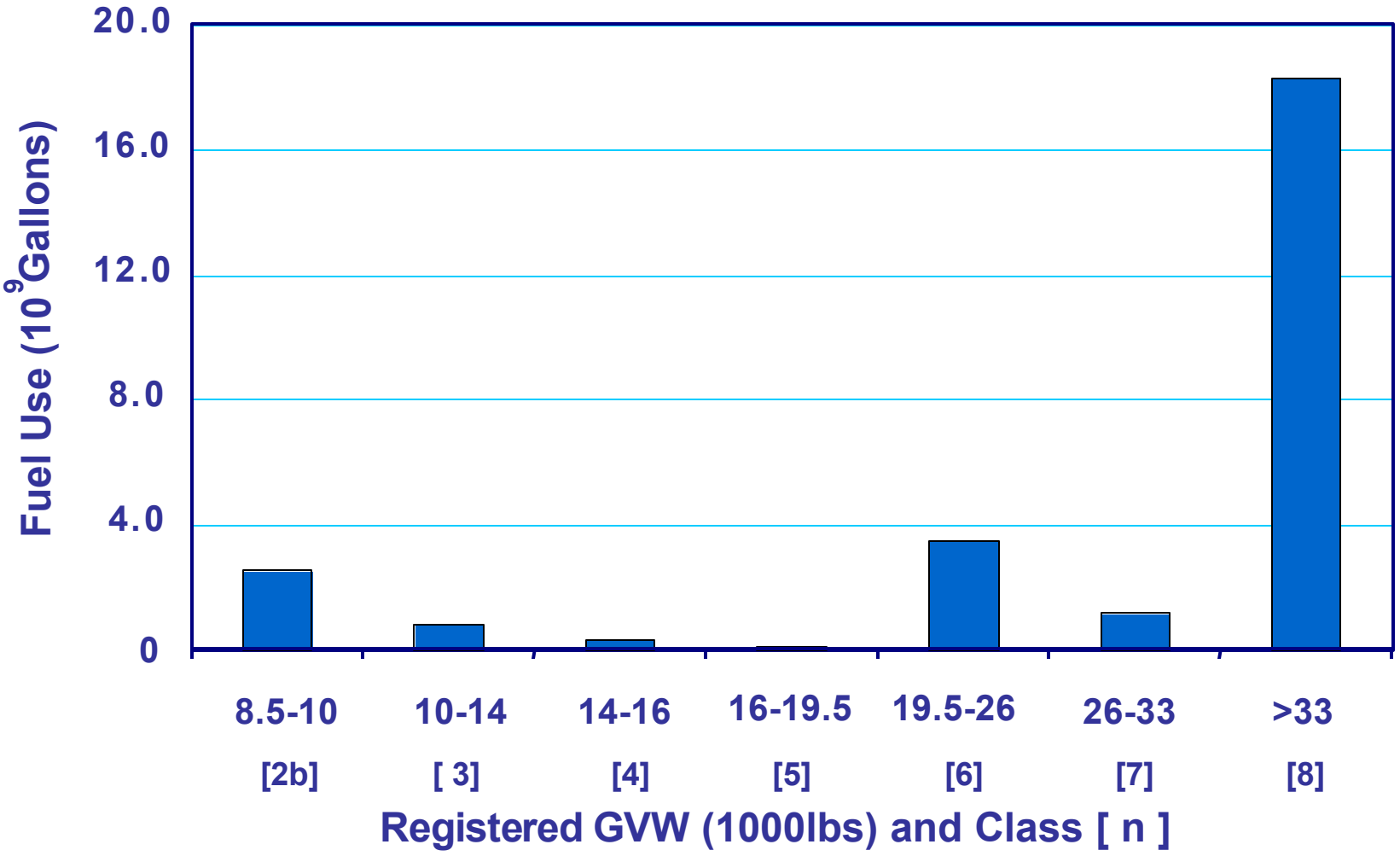
  Following assumptions were made:

  All commercial class 2 diesel trucks assumed as class 2B

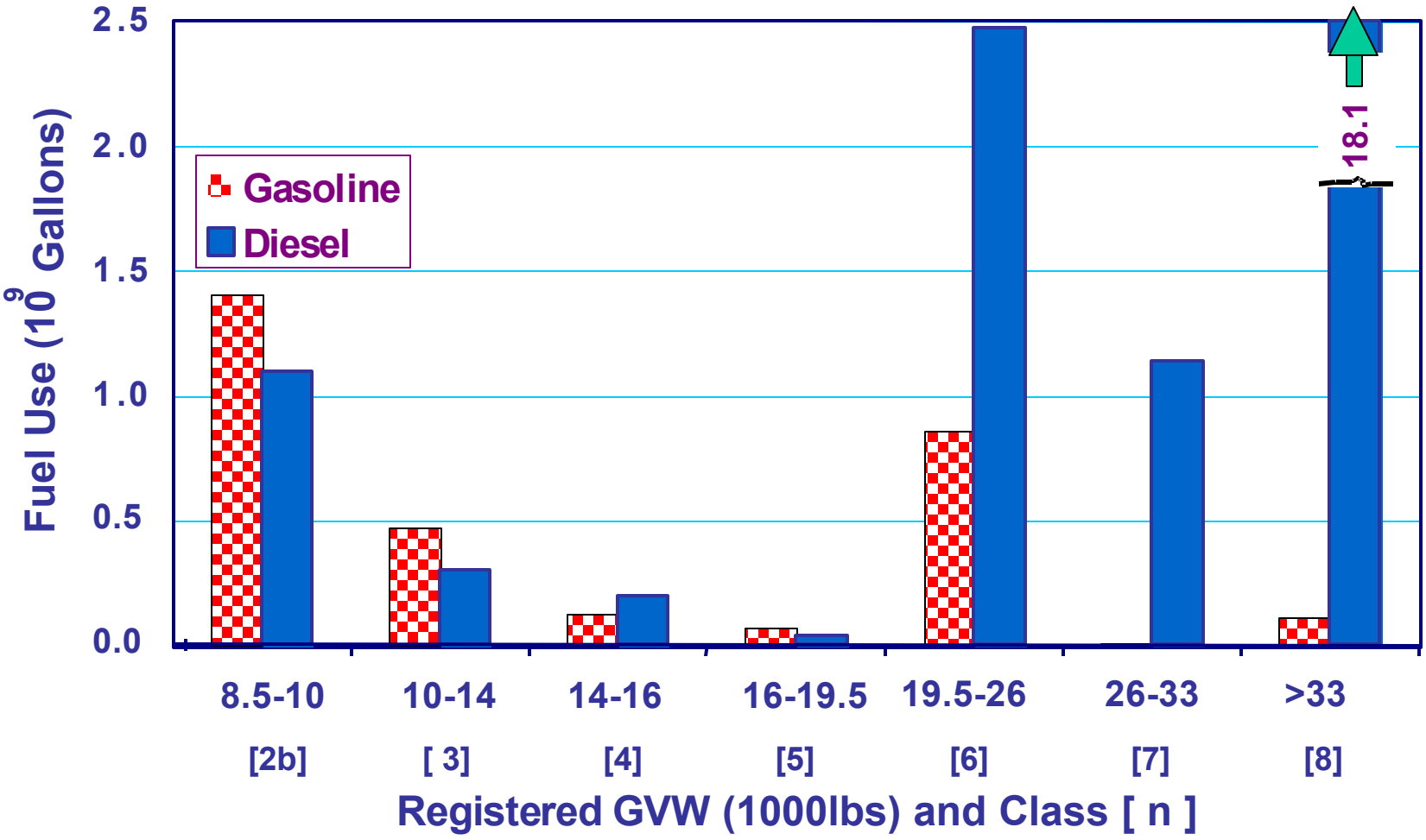
  a) ***Commercial Class 2 gasoline trucks with 6.0L or larger engine assumed as class 2B after cross-checking with "Gasoline truck index" by Truck Index, Inc. (new)***

- **Only commercial use trucks are analyzed**

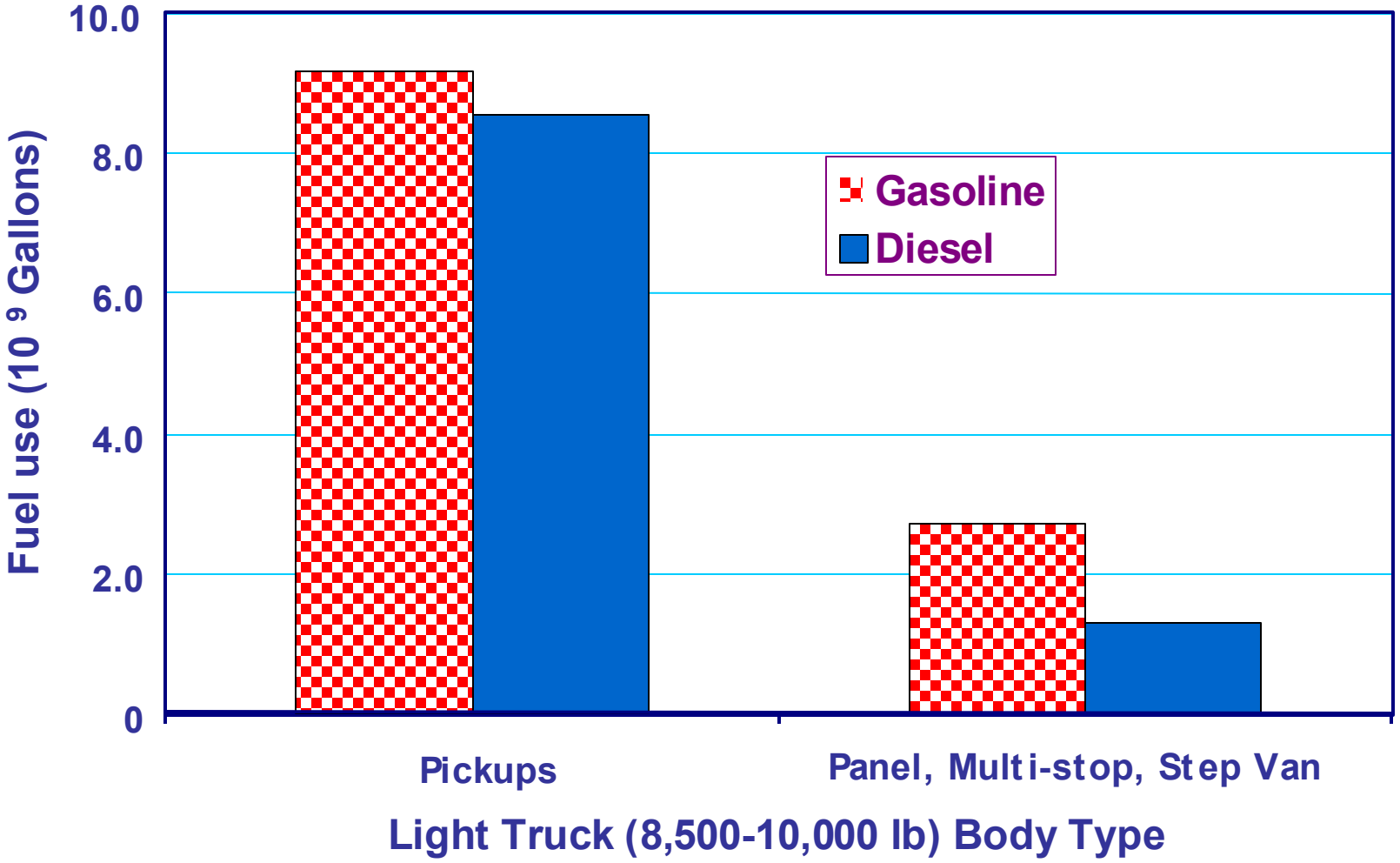
For Commercial Trucks, Class 8 was Estimated to Dominate Total Fuel Consumption



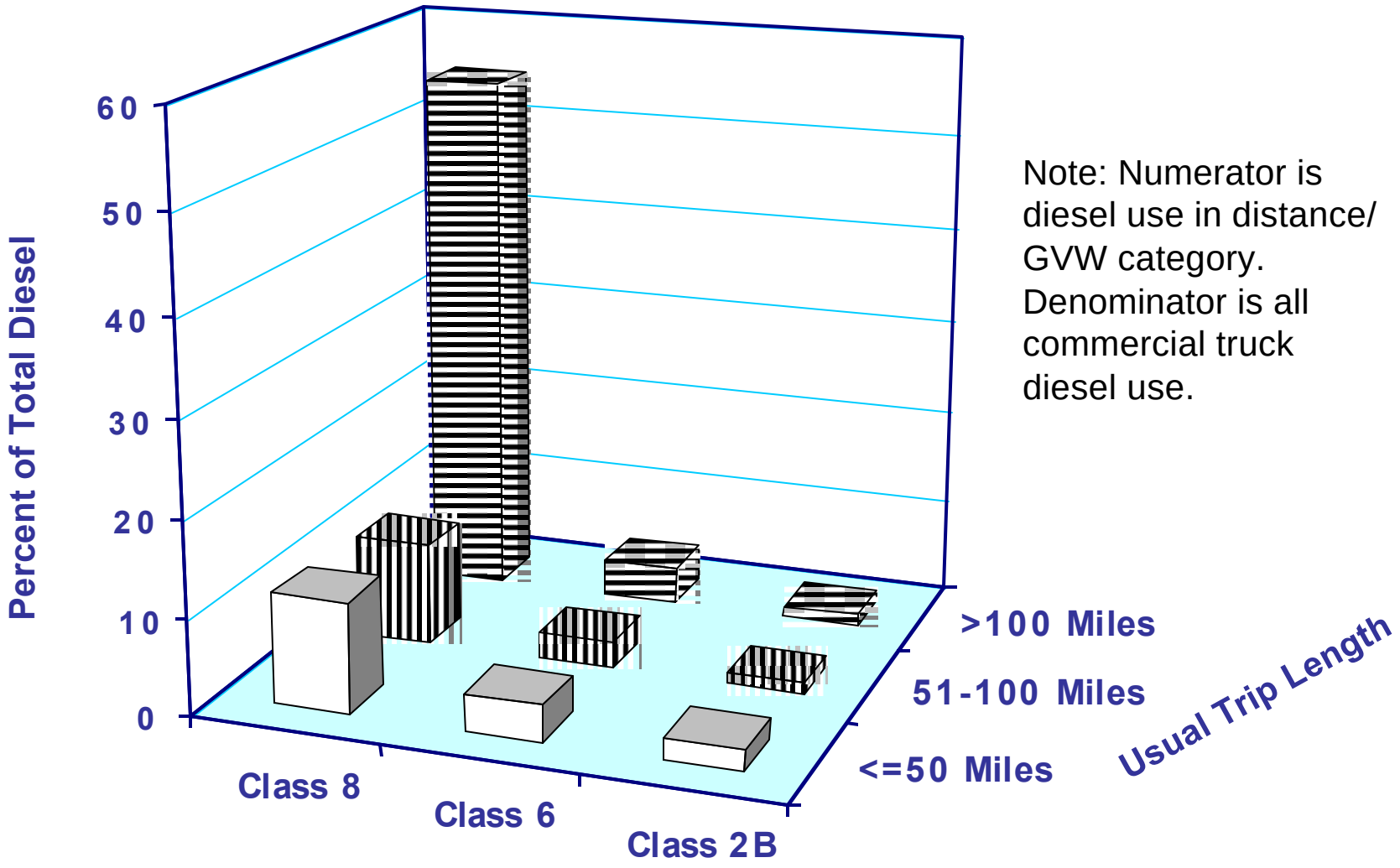
Gasoline? The Highest Proportional Use Is In 2B-5, the Highest Amount in 2B



Within Class 2, Pickup Trucks Use Gasoline and Diesel Nearly Equally, While Closed Body Light Trucks Use More Gasoline



Class 8 Trucks on Trips >100 Miles Use More Than Half of Commercial Truck Diesel Fuel



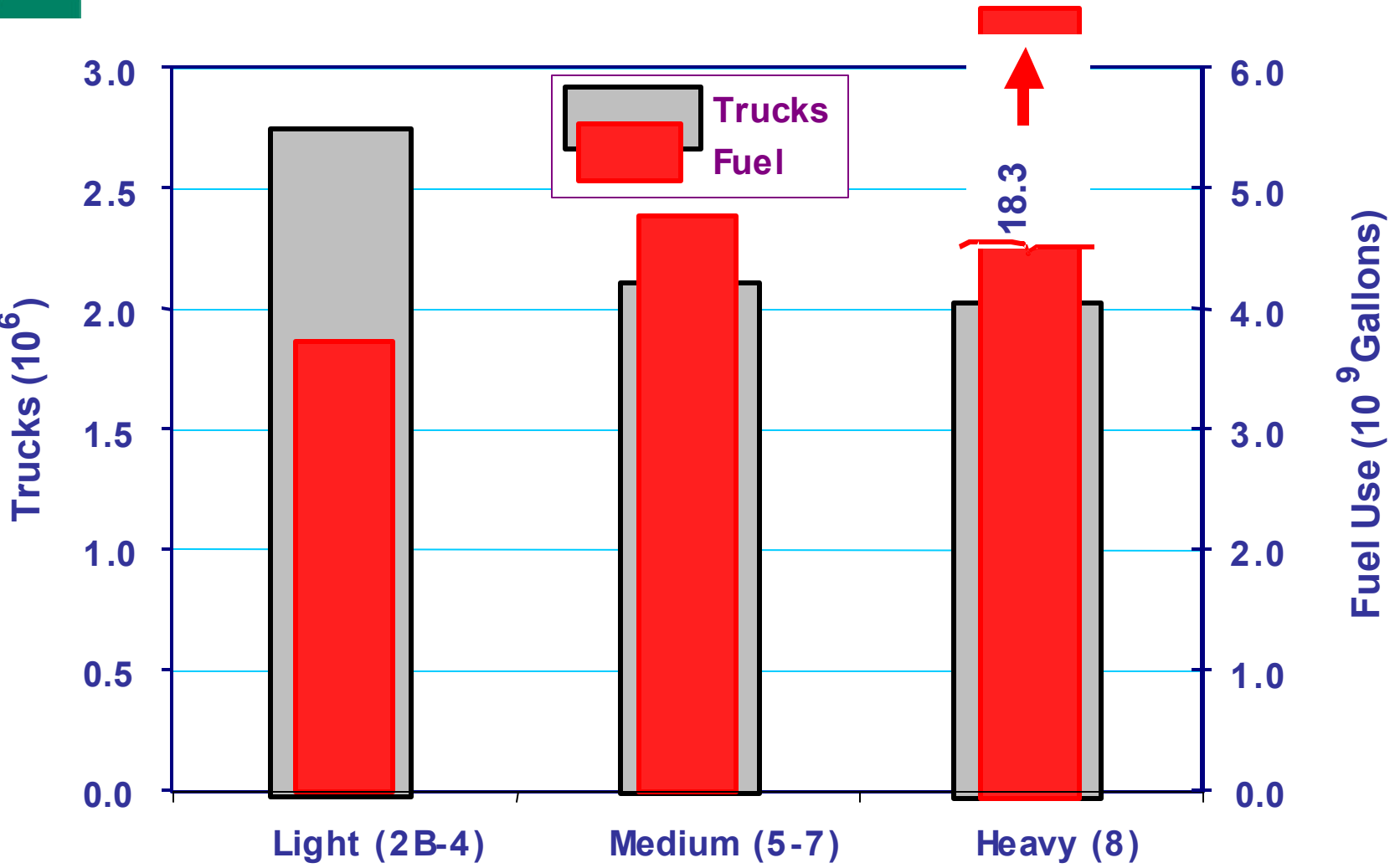
Note: Numerator is diesel use in distance/ GVW category. Denominator is all commercial truck diesel use.

Analysis by Truck Groups

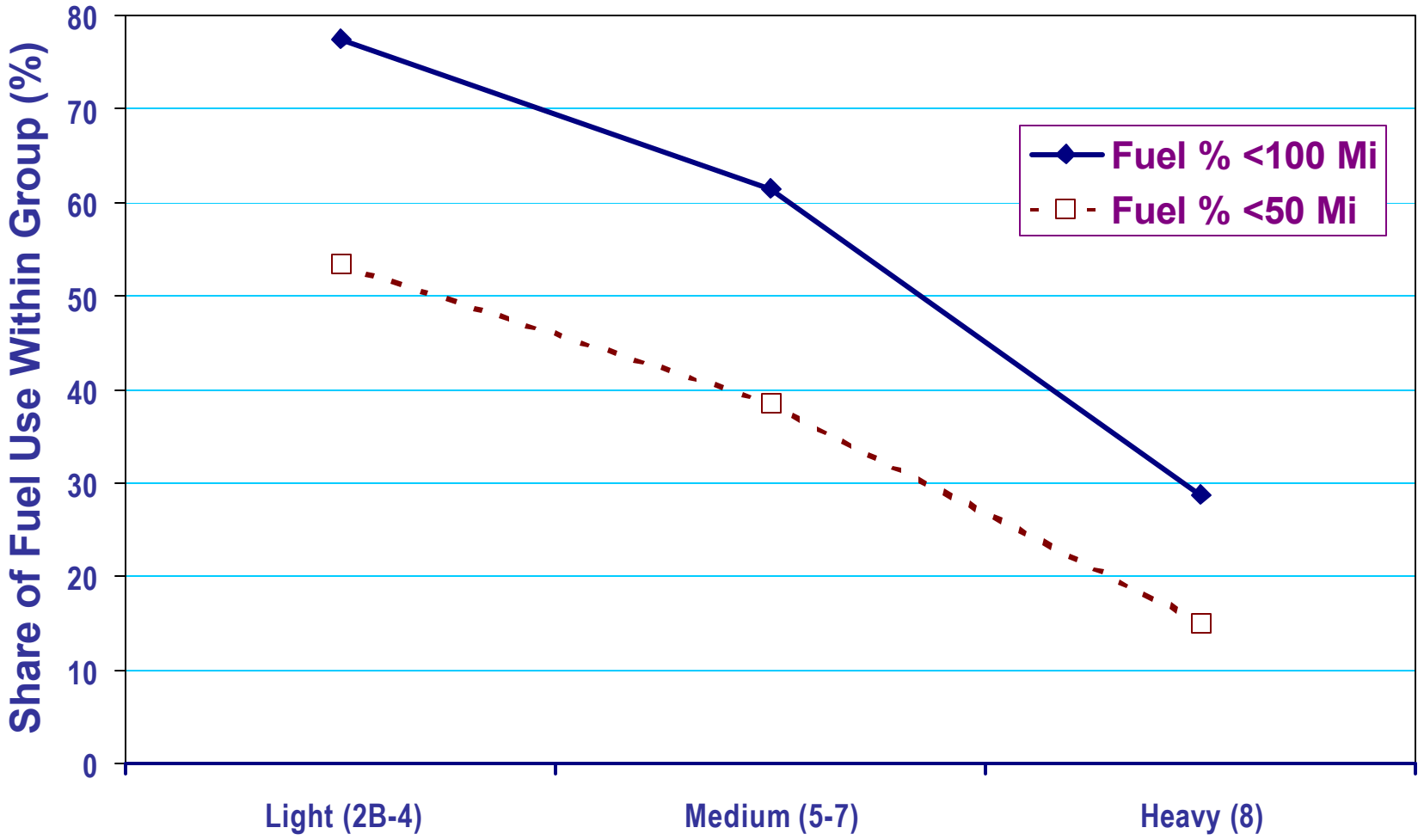
- Three groups are created for aggregation, and simplification:
  1. Light, representing 8,500-16,000 lbs classes
  2. Medium, representing 16,000-33,000 lbs classes
  3. Heavy, representing >33,000 lbs class

- The next three slides use this grouping:

Although Commercial Fuel Use is Dominated by Class 8 Trucks, Numbers of Lighter Trucks are Far Greater

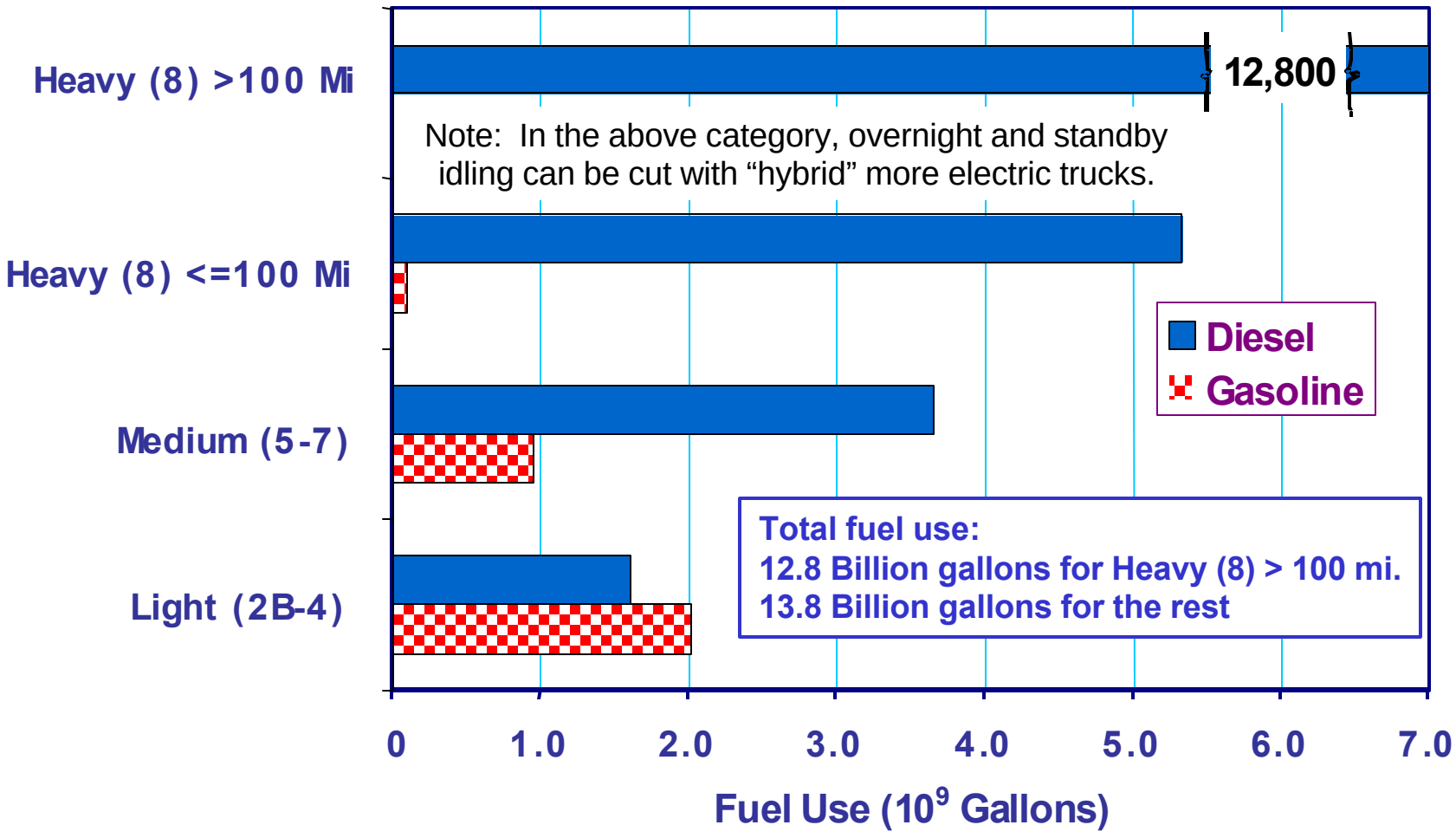


As Truck GVW Decreases, The Share of Fuel for Trip Length Less Than 100 Miles Jumps



A Large Fraction of Commercial Truck Fuel Use Is a Candidate for Reduction Through Hybridization. An Even Higher Proportion of Trucks Would Be Candidates

Assumption: Most Heavy (8) <= 100 Mi, Medium, and Light trucks are suitable for hybridization

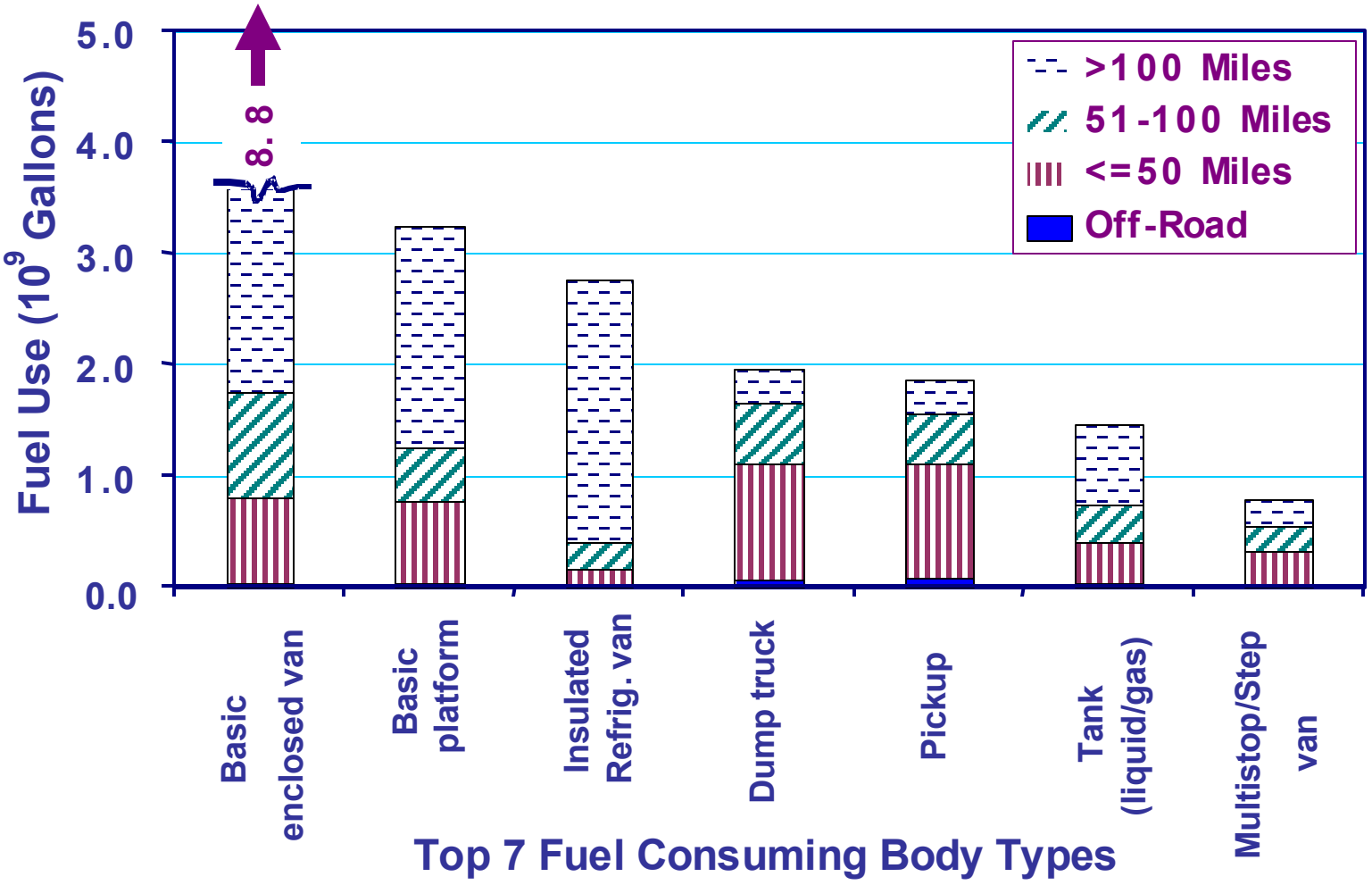


Top Ten Body Types by Truck Population

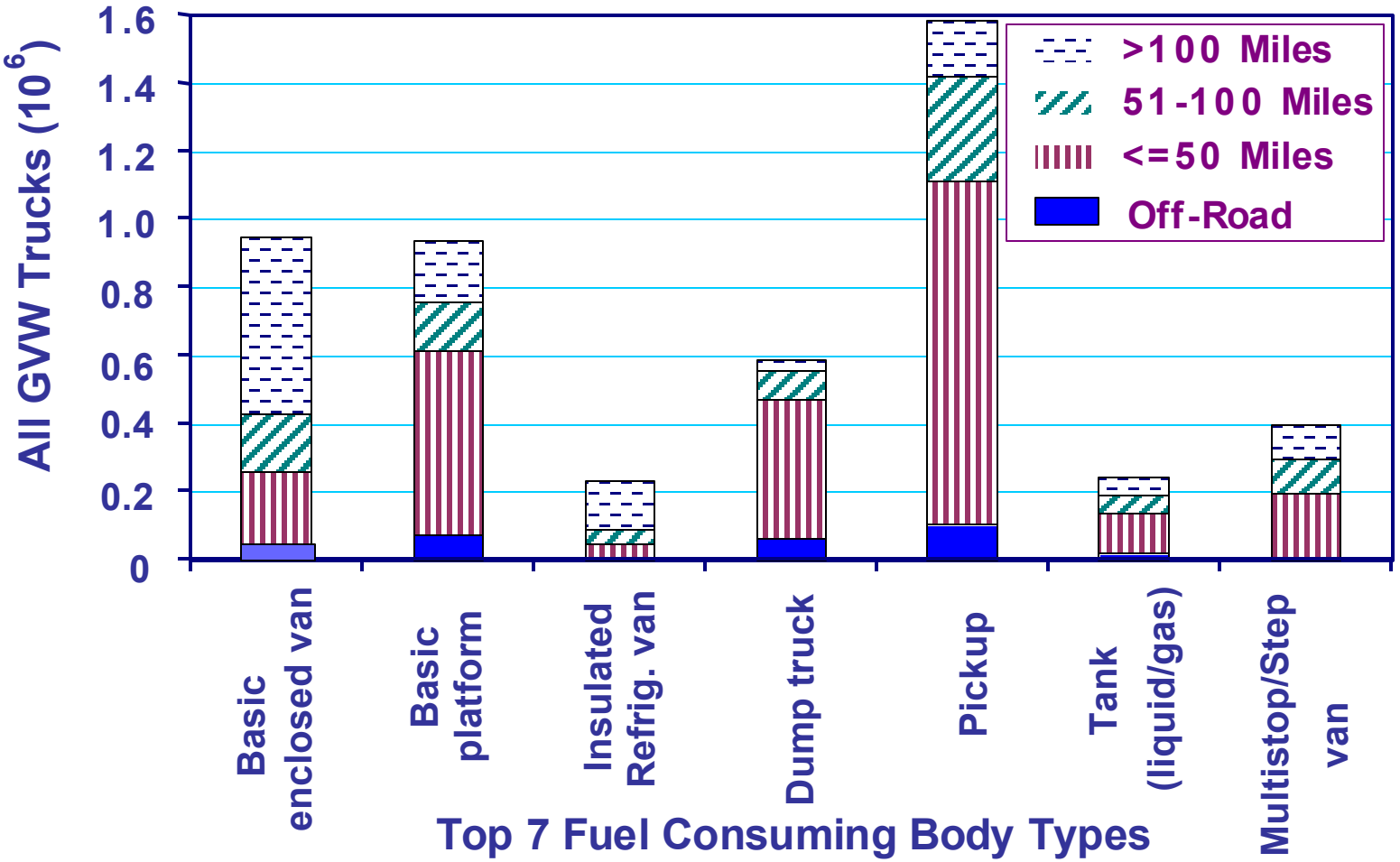
Body Type (commercial trucks only)	Trucks (10^3)	VMT (10^6)	**Fuel (10^6 Gln)**	Avg VMT	Avg Gln/Yr
1. Pickup	1,587	23,663	**1,865***	14,910	1,175
2. Basic enclosed van	949	55,304	**8,786***	58,295	9,260
3. Basic platform	934	21,021	**3,233***	22,435	3,450
4. Dump truck	588	11,066	**1,964***	18,830	3,340
5. Multistop or step van	396	7,251	**788***	18,290	1,990
6. Panel/van (excl minivan)	294	4,377	365	14,910	1,245
7. Grain body	287	2,754	500	9,585	1,740
8. Platform with devices	283	3,551	523	12,545	1,850
9. Tank truck (liquid/gas)	241	8,593	**1,461***	35,665	6,065
10. Insulated refrig. van	230	16,325	**2,767***	70,920	12,020

***In top seven fuel consumers**

Most Long-Haul Truck Fuel Use is in Long Trips, but for Dumps, Pickups, & Multistop/Step Vans Most is in Short Trips



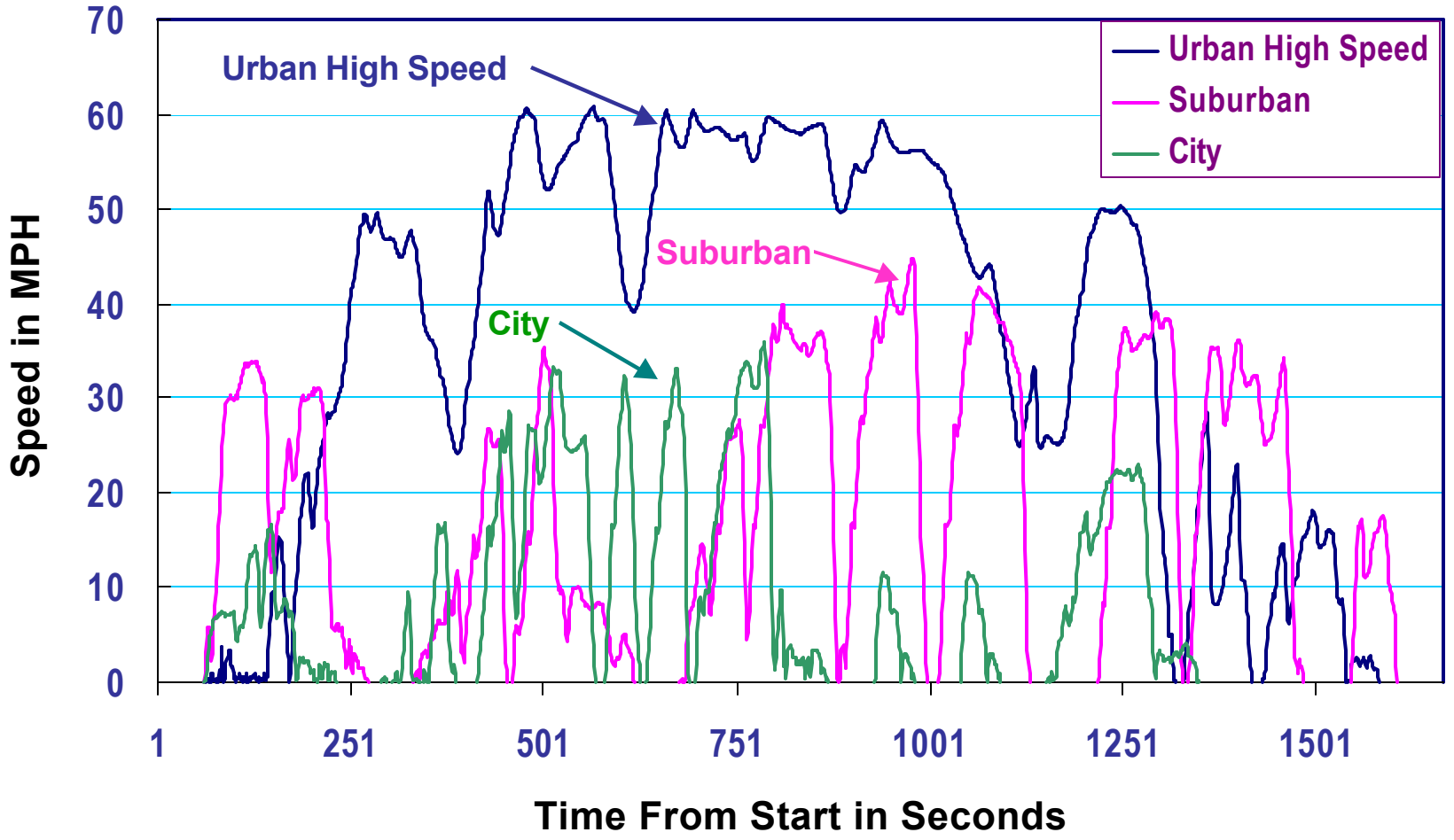
On a Number of Trucks Utilized Basis, Shorter Trips Dominate Intended Use



Estimating Fuel Consumption Through Application of Analytical Tools

- **Determinants of simulated in-use MPG**
  - **Proper vehicle information**
    - **Load carried (total mass)**
    - **Vehicle specifics**
  - **Driving patterns (cycles) of the trucks**
  - **Mix of driving cycles (of those available)**
  - **"Off cycle" idling**
- **Example to illustrate potential:**
  - **Class 8 Aggregate Analysis**

Class 8 Truck Realistic Driving Cycles Have Been Developed by WVU for NREL, by Chasing Trucks

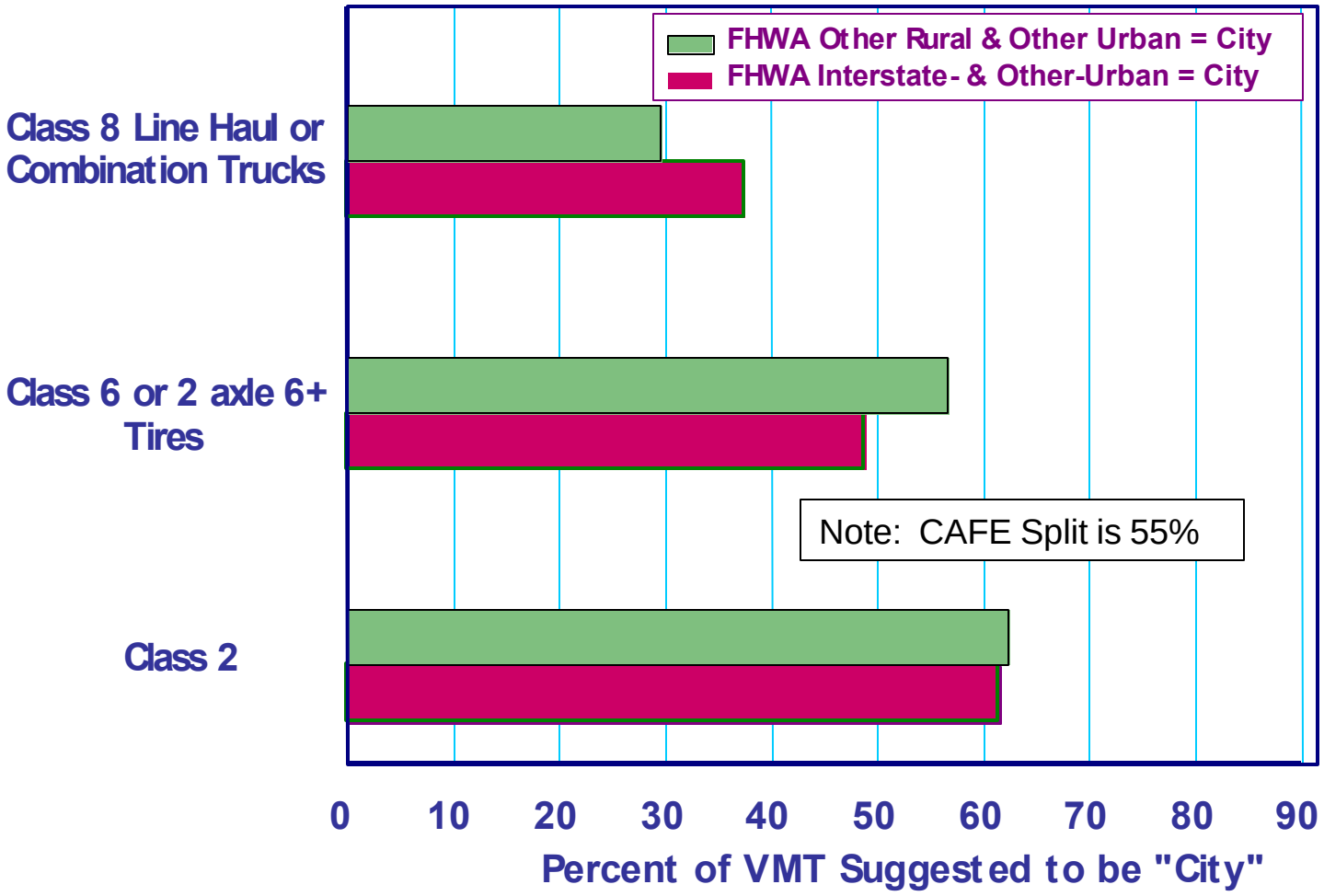


Size of Shortfall of Requested Cycle mph by Modeled Full Class 8 Tractor-Trailer Supports WVU Traces

Driving Cycle	Highest Deviation	2nd Highest Deviation	3rd Highest Deviation	Average Speed
US06	33	32	31	48
WVU "5 Peak"	34	28	23	25
EPA UDDS	6	6	5.5	19
WVU Urban High Speed	5	2.8	1.8	34
WVU Suburban	5	4	3.5	14
WVU Yard (City)	3.4	2.4	2.3	3.3

A 330 kW engine used

Mixed Driving Cycles Are Used by EPA with "City & Highway". What is City & Highway for HD Trucks?



FHWA Categories:
Interstate Rural
Other Arterial Rural
Other Rural
Interstate Urban
Other Urban

Notes:
1. Commercial truck "highway" cycles much more steady in speed than CAFÉ highway.
2. Commercial truck "city" cycle not like CAFÉ city cycle.
3. Class 2 will use CAFÉ cycles.

Vehicle Simulations Imply that Cycle Model Estimates and Field Data Can be Reasonably Reconciled for Class 8, With Plausible "City" (33%) vs. "Highway" Splits.

(Assumes suburban and urban high speed are "city", interstate steady speed is "highway")

<<<<<Percent VMT on Cycle>>>>>

Usual Trip Length	WVU Suburban	WVU Urban High Speed	Interstate 65mph	Interstate 70mph	Simulated mpg	VIUS mpg	Implied Off-Cycle Idling %
<50	28%	57%	15%		**5.65**	**5.61**	0.7%
50-100	25%	53%	23%		**5.74**	**5.68**	1.1%
>100	7%	12%	27%	54%	**6.09**	**5.89**	3.4%
Total	**11%**	**21%**	**25%**	**42%**	**6.00**	**5.83**	2.9%
	"City"		"Highway"				
Model mpg	4.32	6.34	6.72	6.07			

Idling 6% if >500 mi trip

Note: VIUS mpg is an average from the five top fuel consuming class 8 trucks.
MPG values not identical to other estimates herein

Vehicle Simulation (Here Class 8) for Suitable Driving Cycles Could Allow Accurate MPG Gain Estimates

- **Simulation-based estimates (Class 8) - range for multiple cycles**
  - C_d from 0.7 to 0.5…… 0% to 26%
  - C_d from 0.7 to 0.4 …… □ 4% to 41%
  - C_r from 0.0065 to 0.0055…… 2.5% to 6.4%
  - Engine peak efficiency to 50%…… 11-14% on Interstate
  - Increase of average loads on TMT/gal……. Perhaps 5-10%
  - Reduced "off-cycle" idling…… □ 3% (6% long line haul)
- **Judgmental hybridization estimates (all Classes)**
  - Hybridization: …… up to 70% in class 2b-4
    (educated guess for WVU City, Suburban, up to 45% in class 6-7
    and Urban High Speed cycles. up to 20% in class 8
    No gain at steady speed).
  - Reductions of hard accelerations…….. Not estimated
    (driver training, ITS traffic control)

Note: Synthesis of estimates requires industry input.

Conclusion

In conjunction with VIUS, the recently developed vehicle simulation models such as ADVISOR and PSAT make possible a very detailed evaluation of the probable in-use driving behavior of specific types of trucks, and the best mix of fuel saving technologies for a given truck and driving behavior.