



Updating MOVES with Instrumented Heavy-duty Truck Activity Data

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Heavy-duty Truck Activity

- Commercial heavy-duty vehicles contribute a significant share of the NO_x and PM emissions
- NO_x emissions from diesel vehicles equipped with selective catalytic reduction (SCR) systems are highly dependent on the duty cycle
- Duty cycles vary considerably across different heavy-duty truck vocations and fleets
- Activity data from commercial heavy-duty diesel vehicles are more limited than light-duty vehicles



Instrumented Truck Data

SourceType	Description	Vehicle Test Populations	
		Fleet DNA (NREL)	HD SCR (CE-CERT)
41	Other Bus	0	5
42	Transit Bus	16	11
43	School Bus	7	0
51	Refuse Truck	37	6
52	Single Unit Short-Haul	119	32 ^b
61	Combination Short-Haul	105	36
62	Combination Long-Haul	131	b
Total Vehicles		415 ^a	90
Instrumented Days		14,682	7,778
Average Instrumented Days/Vehicle		35	86

^a Only used conventional technology vehicles from FLEET DNA

^b While CE-CERT classifies some vehicles as “long-haul,” EPA found the activity did not include the multi-day trips expected from long-haul vehicles and will reclassify them as “short-haul” in the future analysis

Instrumented Truck Data

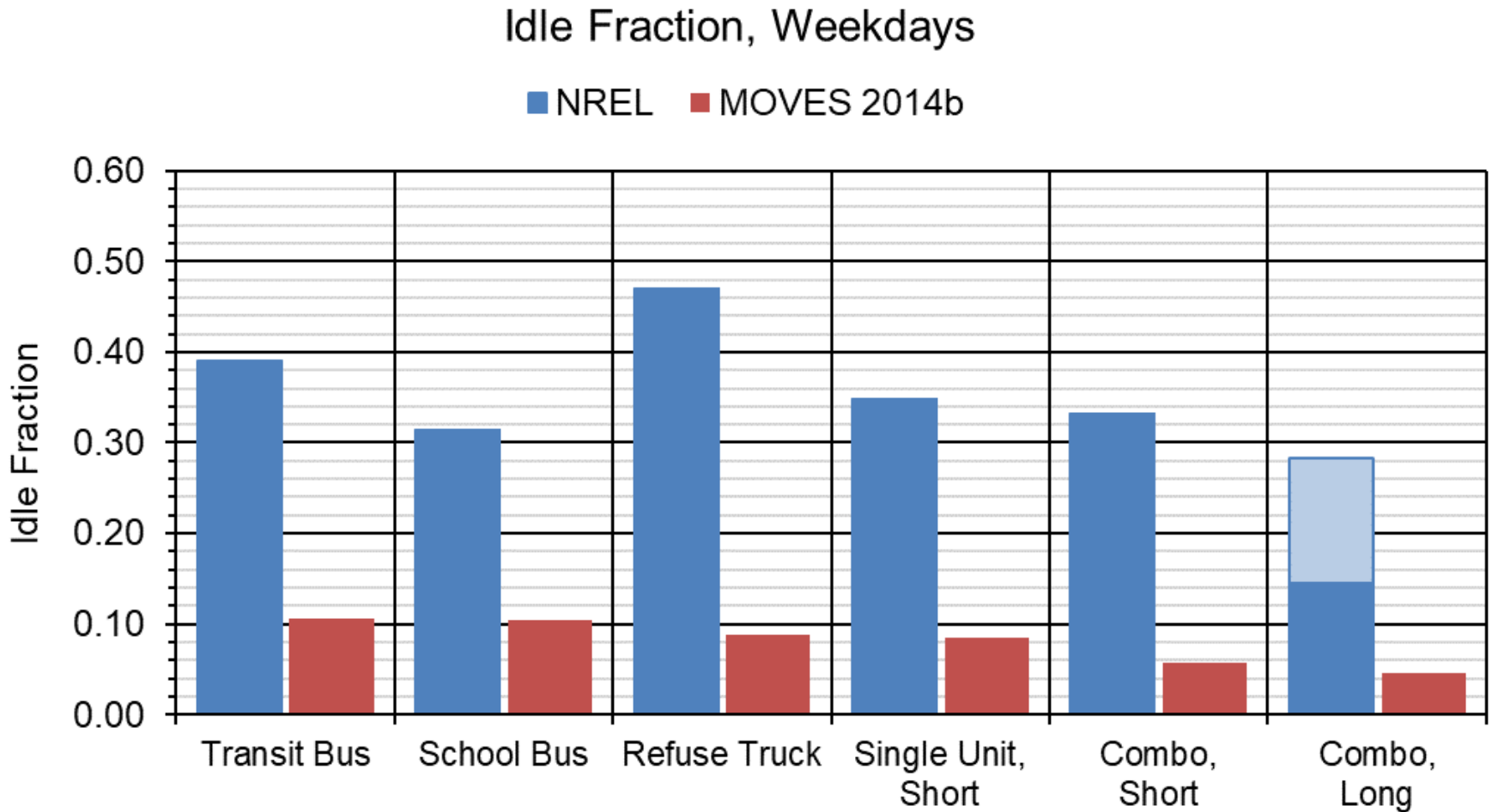
SourceType	Description	Vehicle Test Populations	
		Fleet DNA (NREL)	HD SCR (CE-CERT)
<p>Efforts to combine the Fleet DNA and HD SCR CE-CERT data in progress</p> <p>Preliminary results based on just the Fleet DNA dataset</p>			
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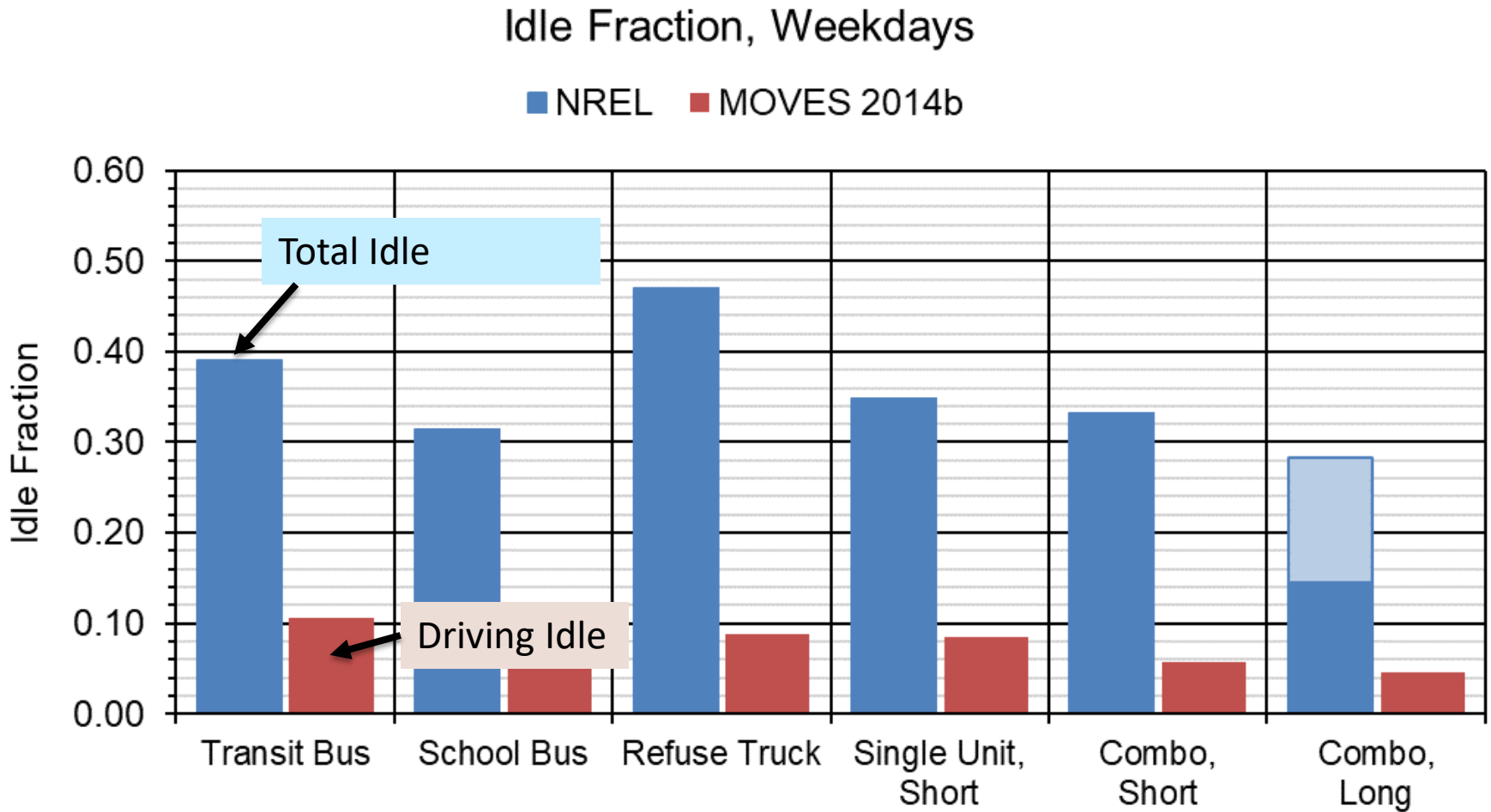
Idle Fraction

$$\text{Idle fraction} = \frac{\text{idle hours}}{\text{operating hours}}$$



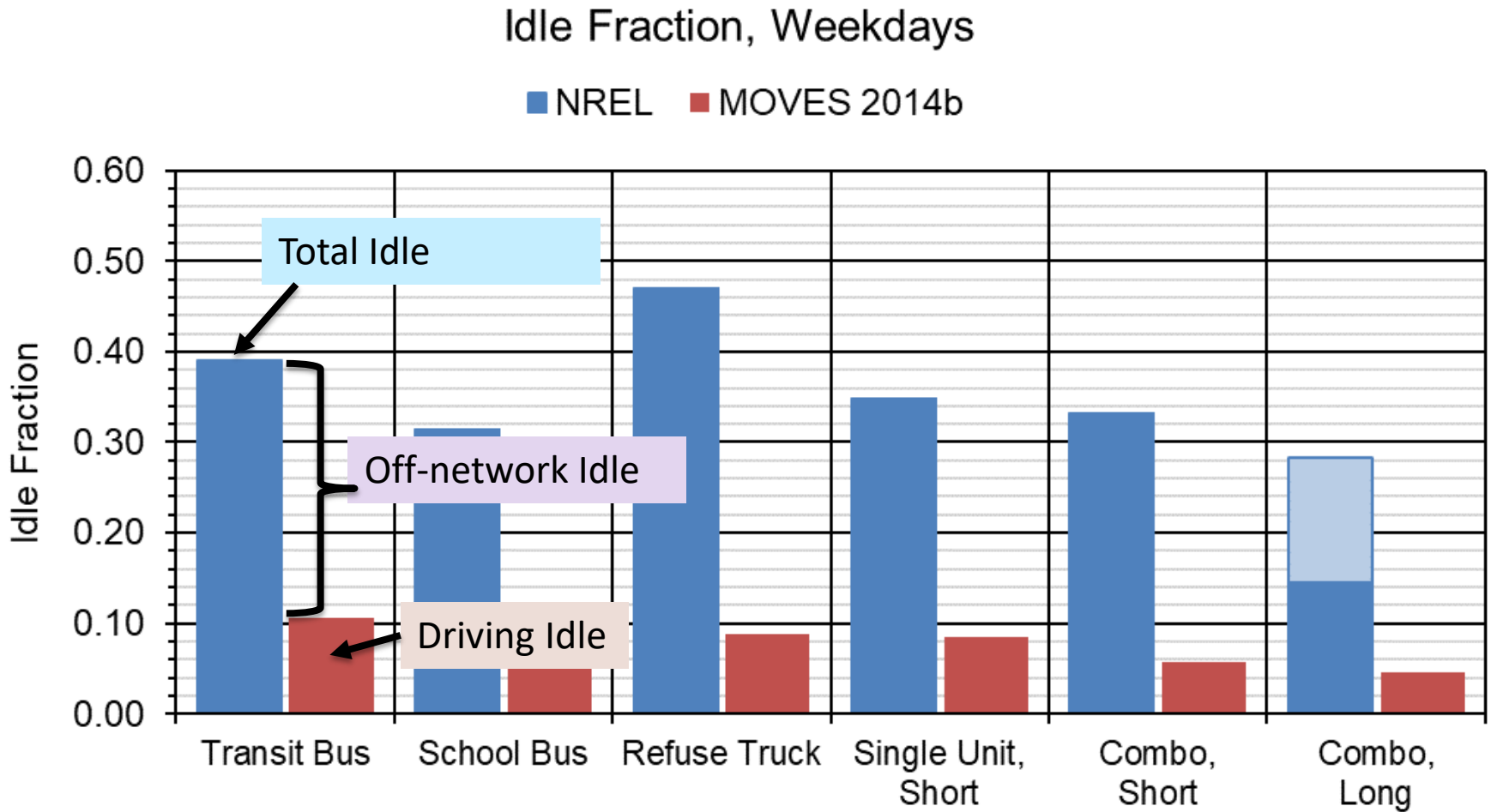
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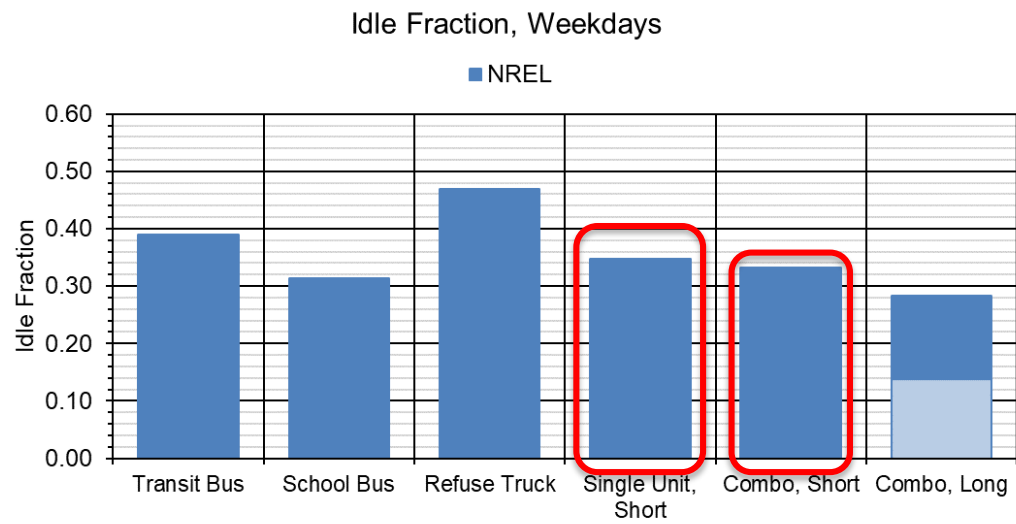
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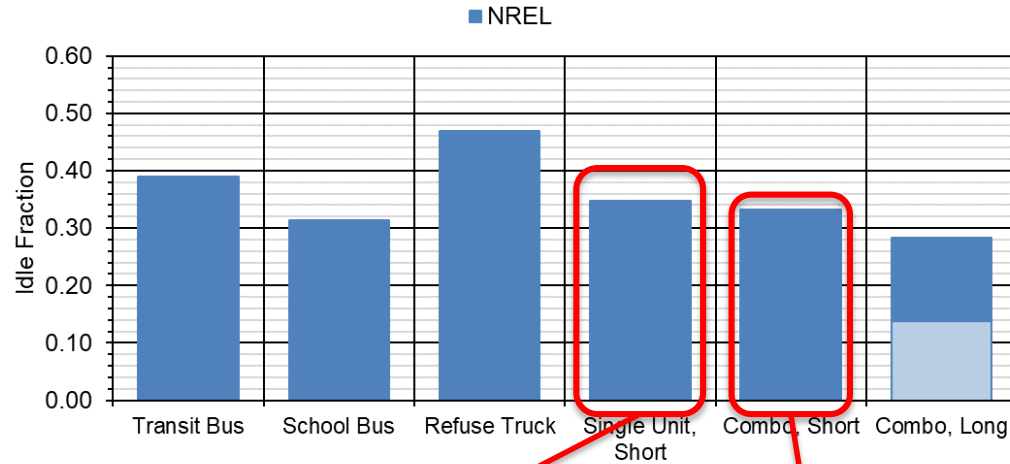
- Updates will increase idle compared to MOVES2014

Idle

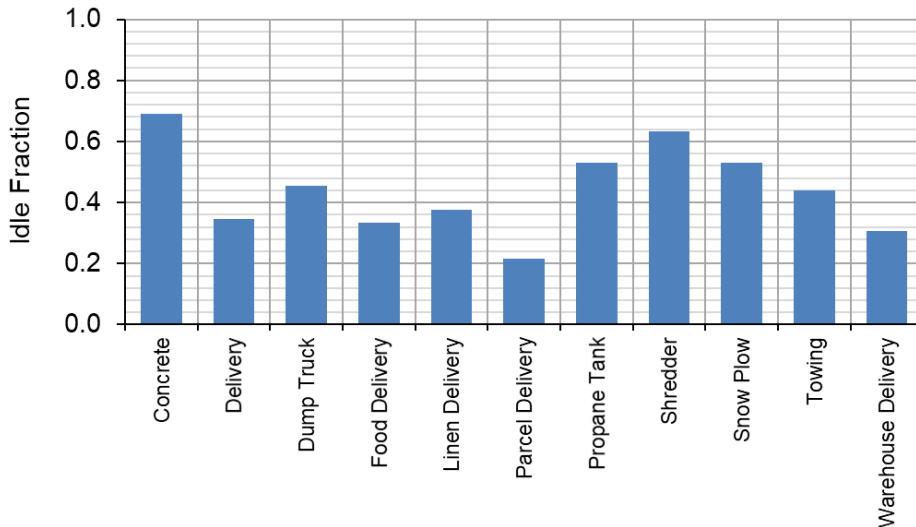


Idle

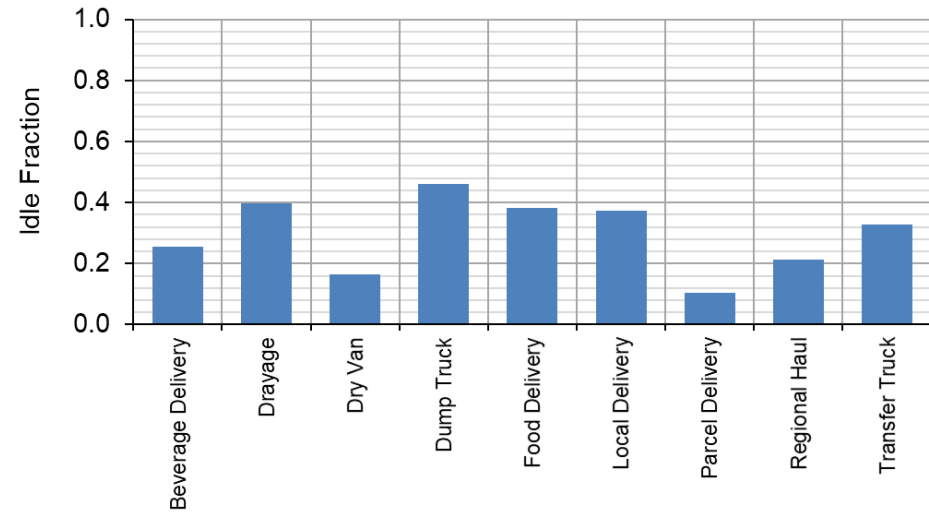
Idle Fraction, Weekdays



Idle Fractions by NREL-Defined Vocation
Single Unit Short-Haul Trucks, Weekdays

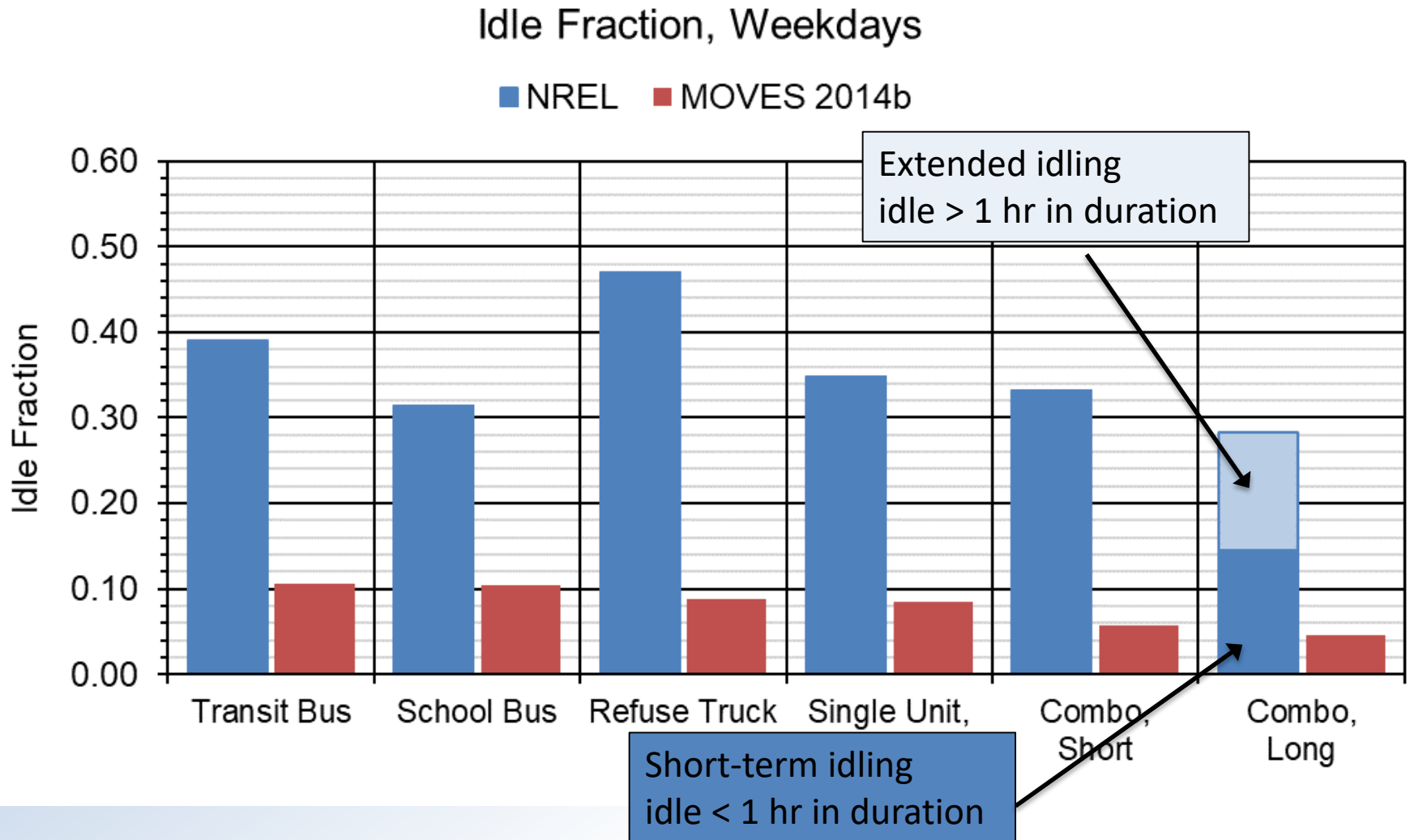


Idle Fractions by NREL-Defined Vocation
Combination Short-Haul Trucks, Weekdays



- Large variation among vocation trucks within short-haul source types

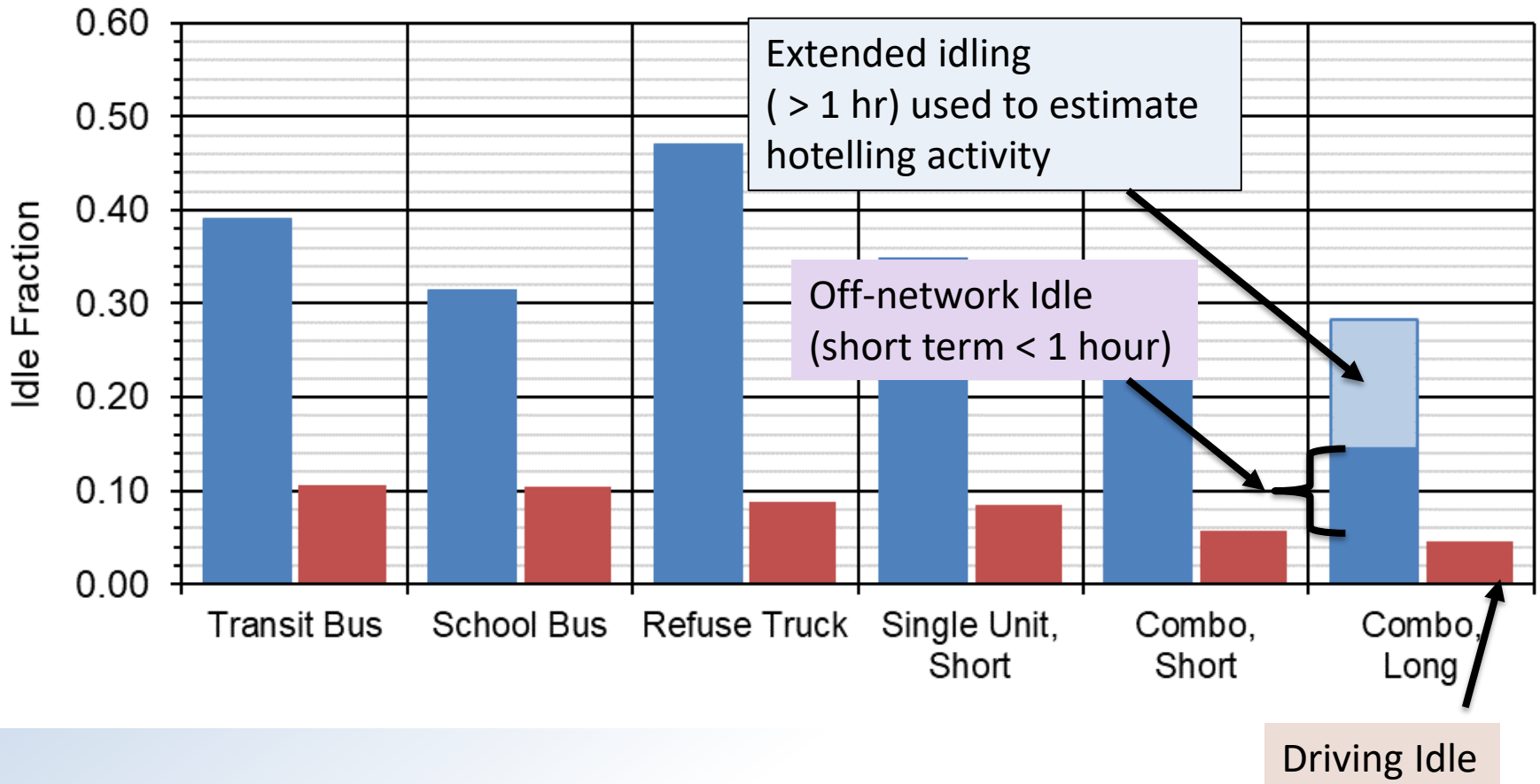
Idle Fraction: Combination Long-Haul



Idle Fraction: Combination Long-Haul

Idle Fraction, Weekdays

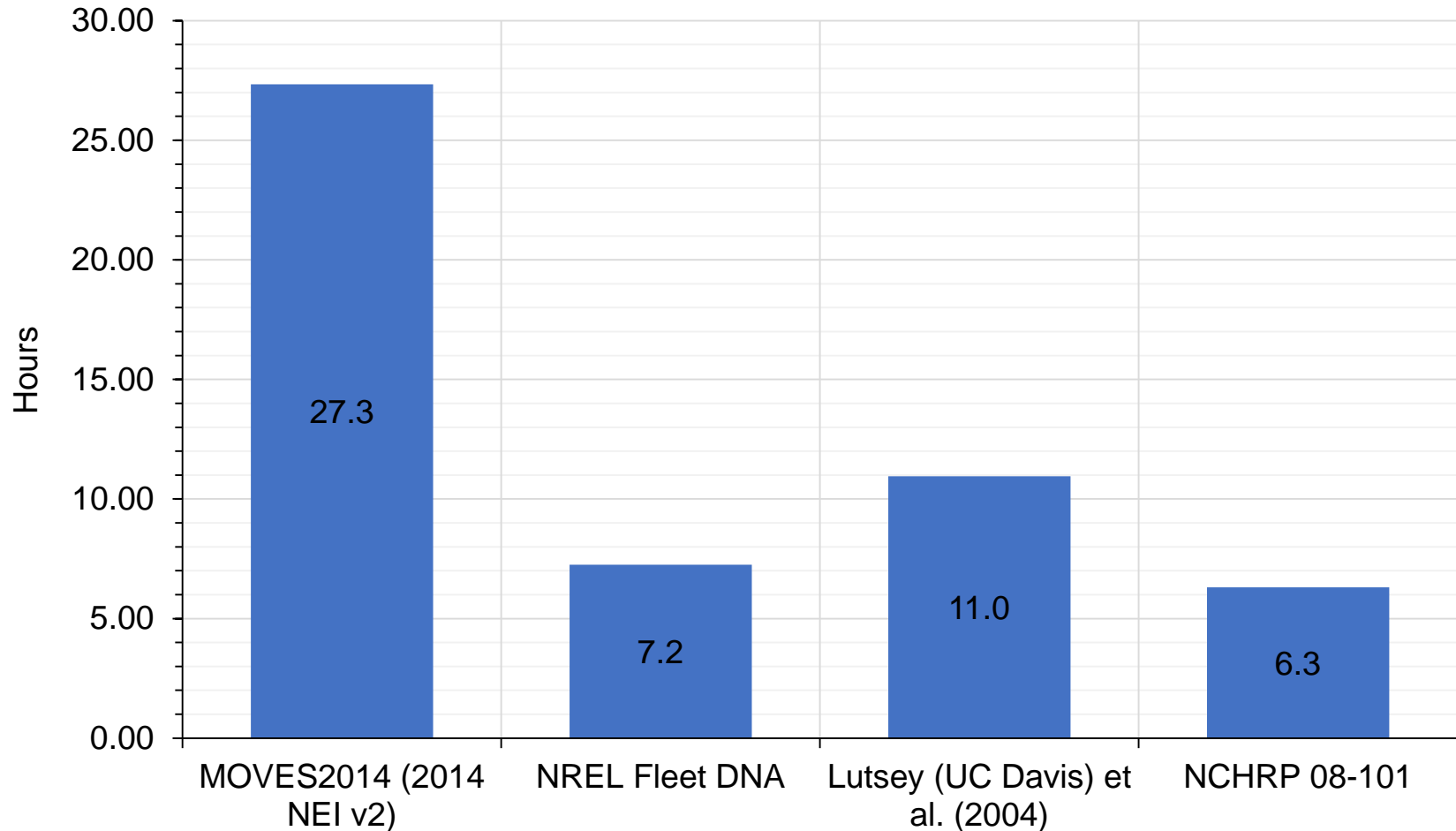
■ NREL ■ MOVES 2014b



Hotelling Activity

Hotelling = using the truck as a resting place for long-haul trucks drivers

Hotelling hours per 1000 miles driven on freeways
(restricted access roadways)

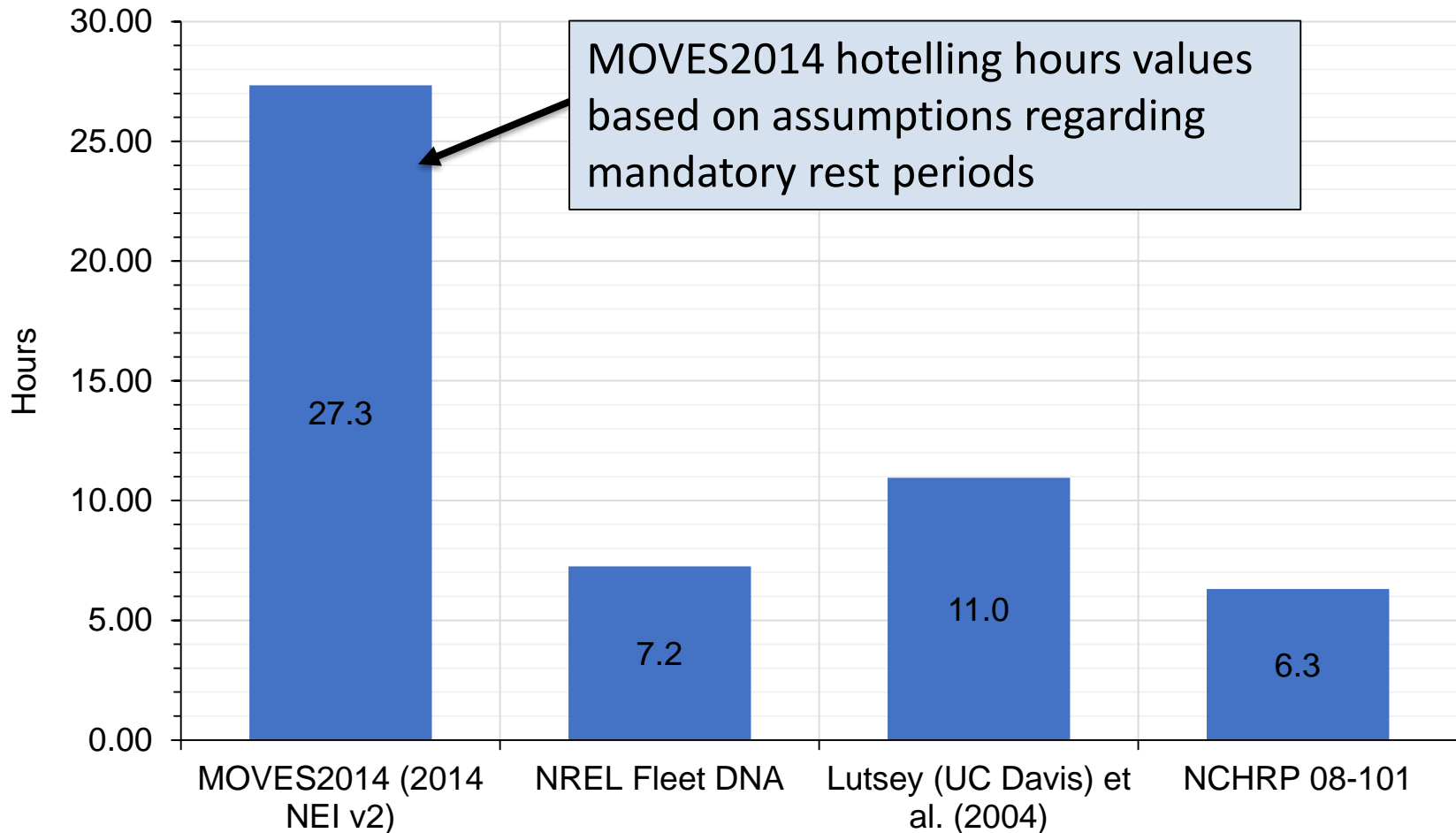


Note: MOVES data on VMT distribution on restricted access roadways, and % of hotelling time spent in extended idle are used to estimate hotelling from extended idling data recorded in the NREL, Lutsey, and NCHRP studies

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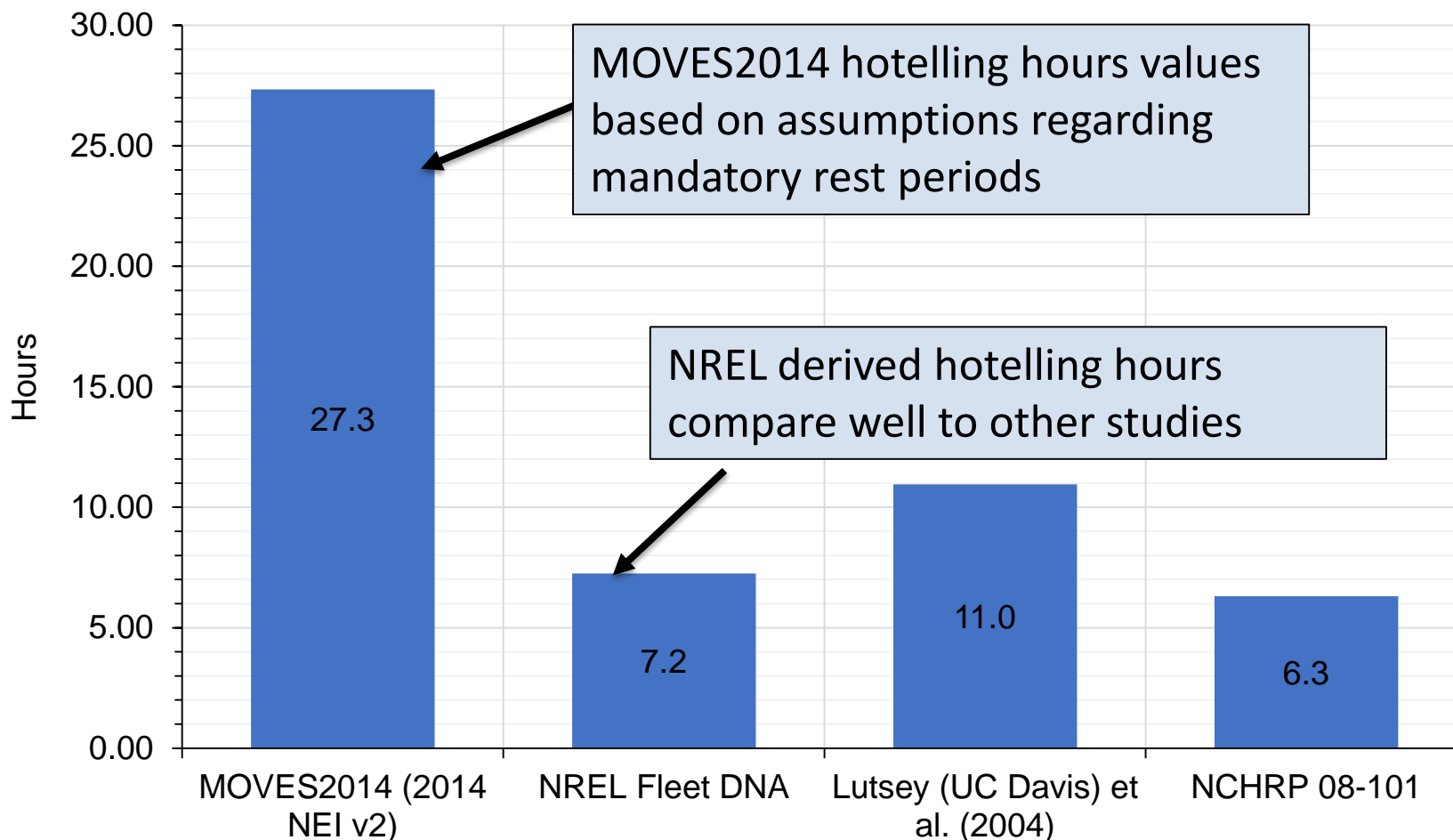


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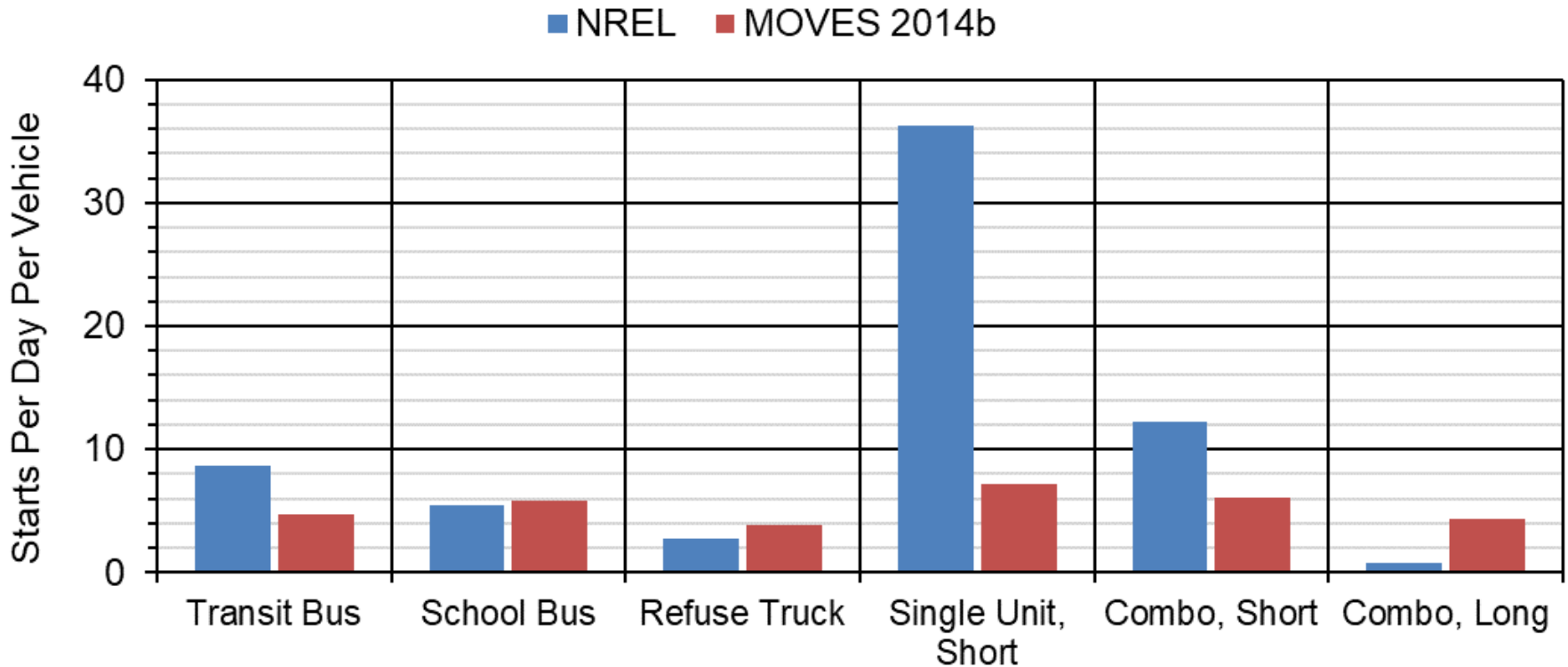
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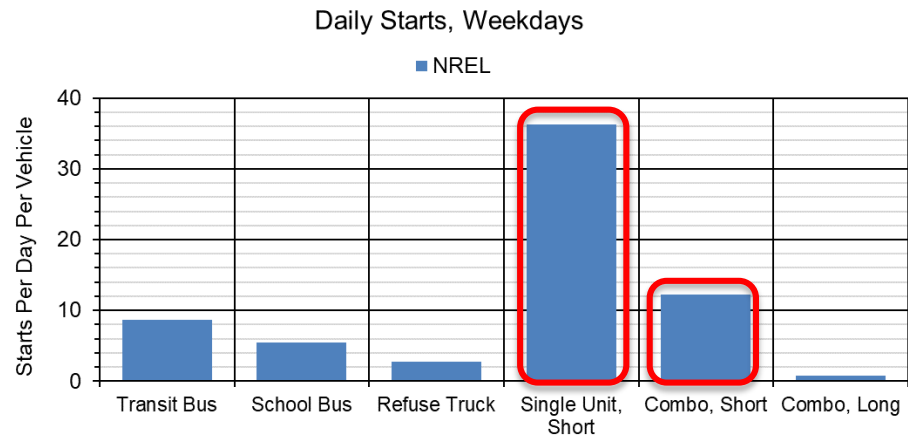
Starts

Daily Starts, Weekdays



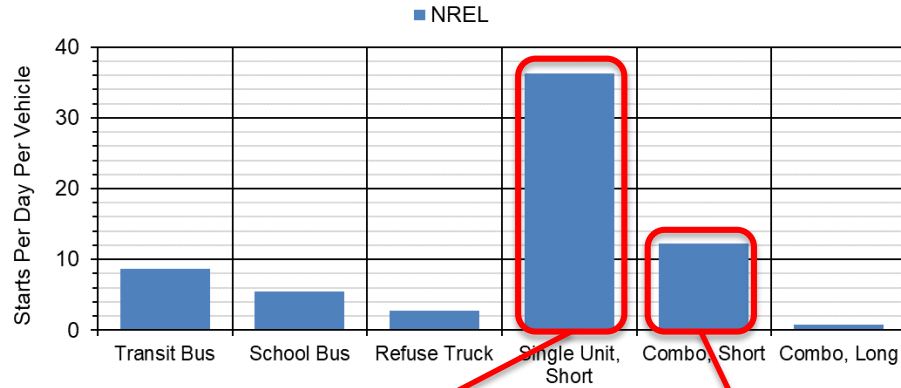
- More starts per day in Fleet DNA compared to MOVES2014b
- For transit buses, single-unit long-haul and combination short-haul

Starts

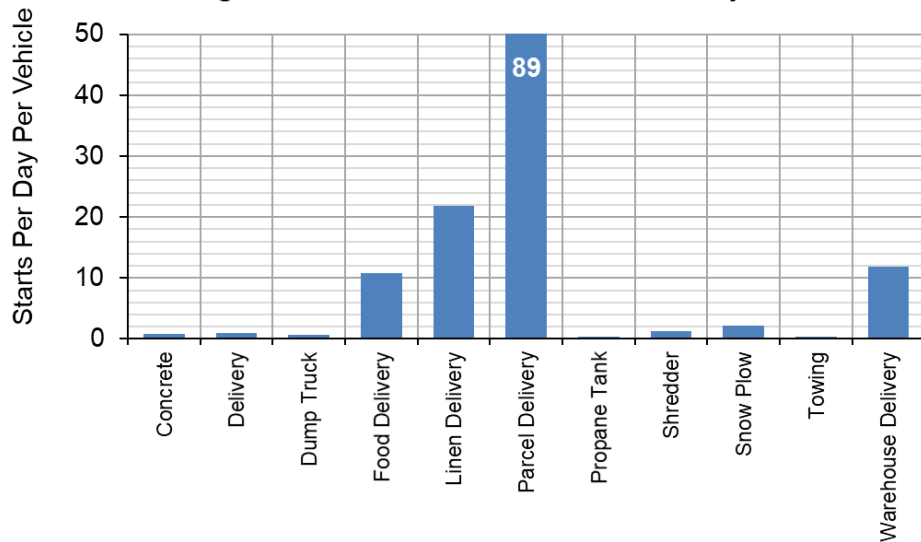


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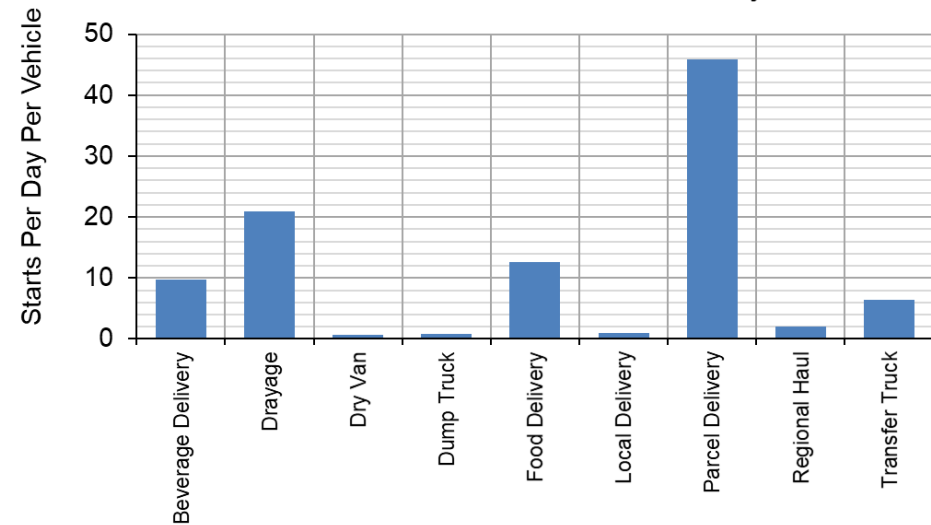
Daily Starts, Weekdays



Daily Starts by NREL-Defined Vocation
Single Unit Short-Haul Trucks, Weekdays

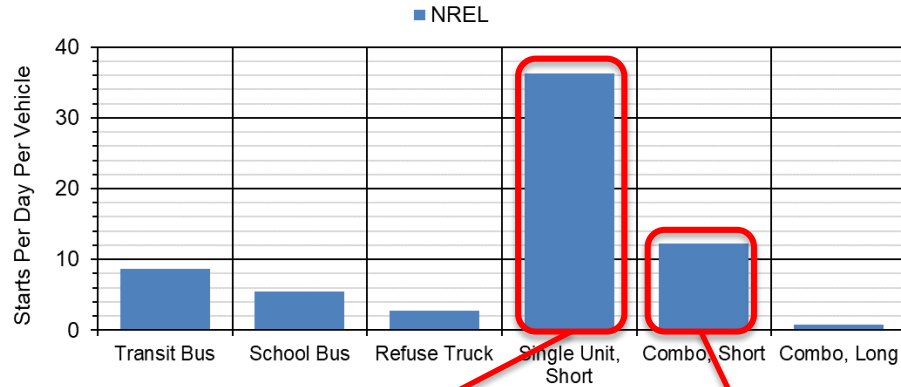


Daily Starts by NREL-Defined Vocation
Combination Short Haul Trucks, Weekdays

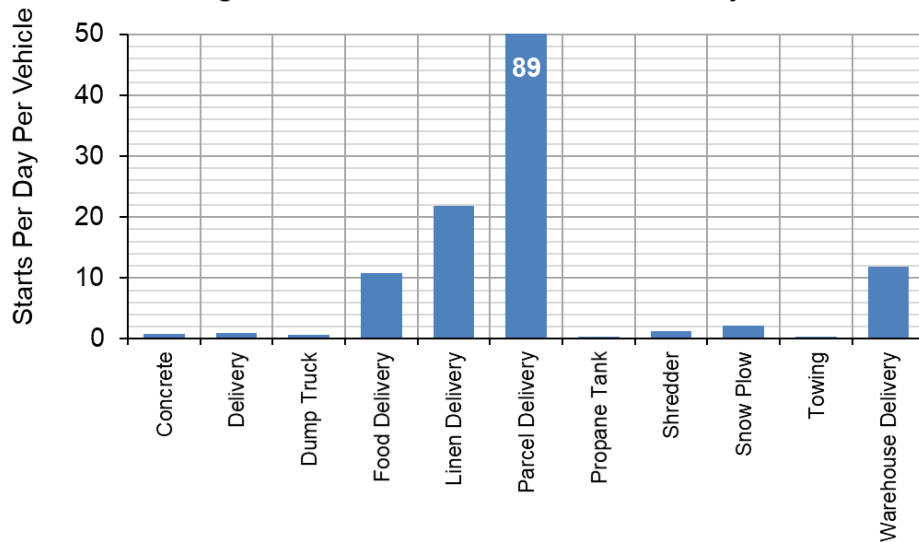


Starts

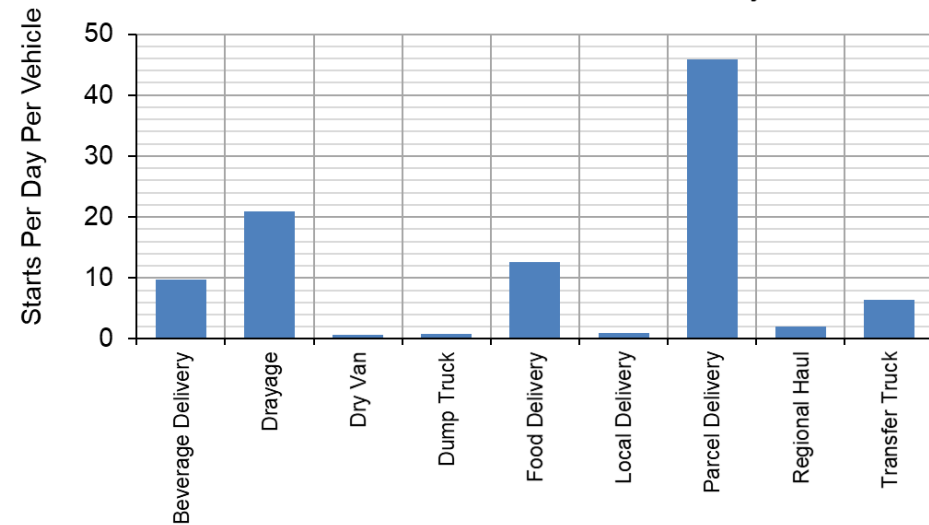
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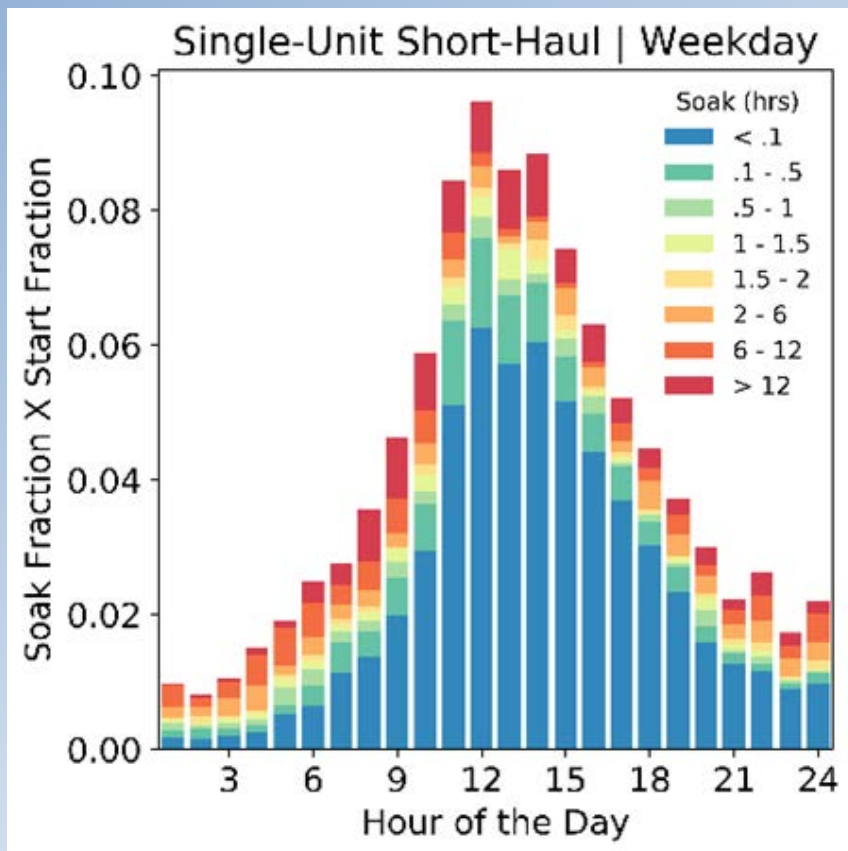
Daily Starts by NREL-Defined Vocation
Combination Short Haul Trucks, Weekdays



- Very large variation in starts per day among different vocations within short-haul trucks

How you average matters: Start Activity Example

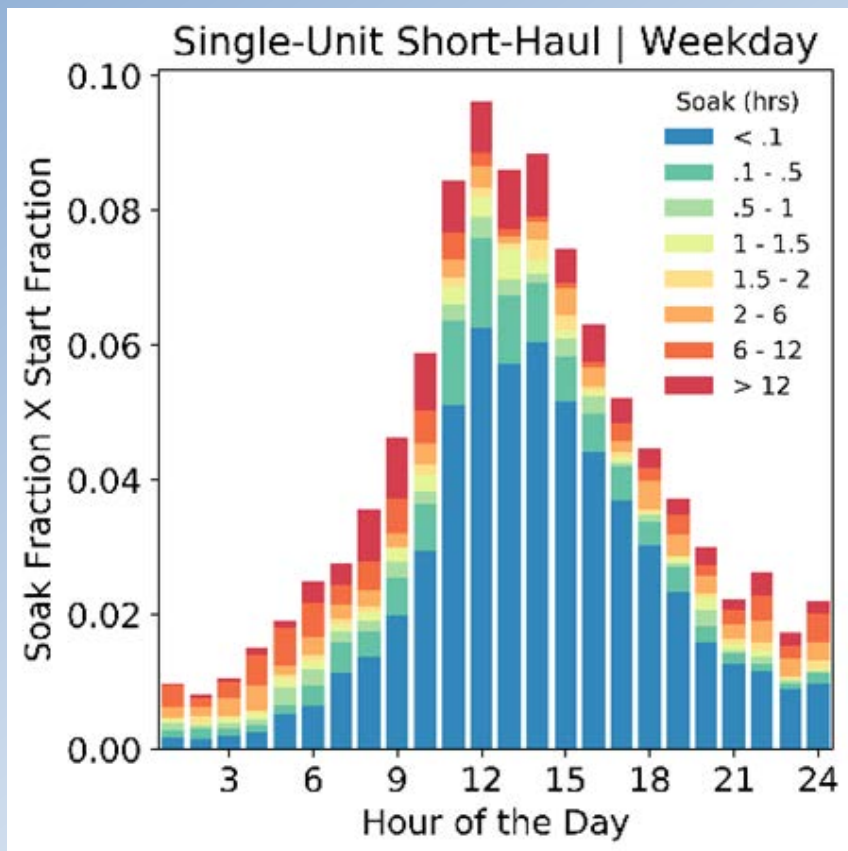
Initial Average: Each vehicle is
weighted equally



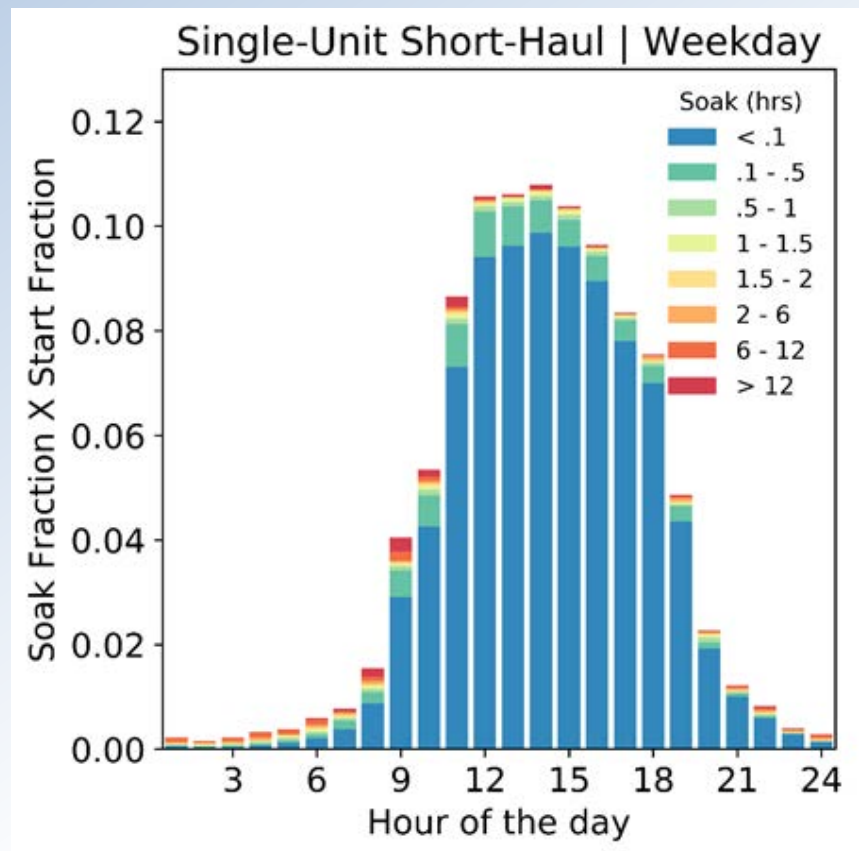
Additional details in Final Report (Kotz et al. 2019)

How you average matters: Start Activity Example

Initial Average: Each vehicle is weighted equally



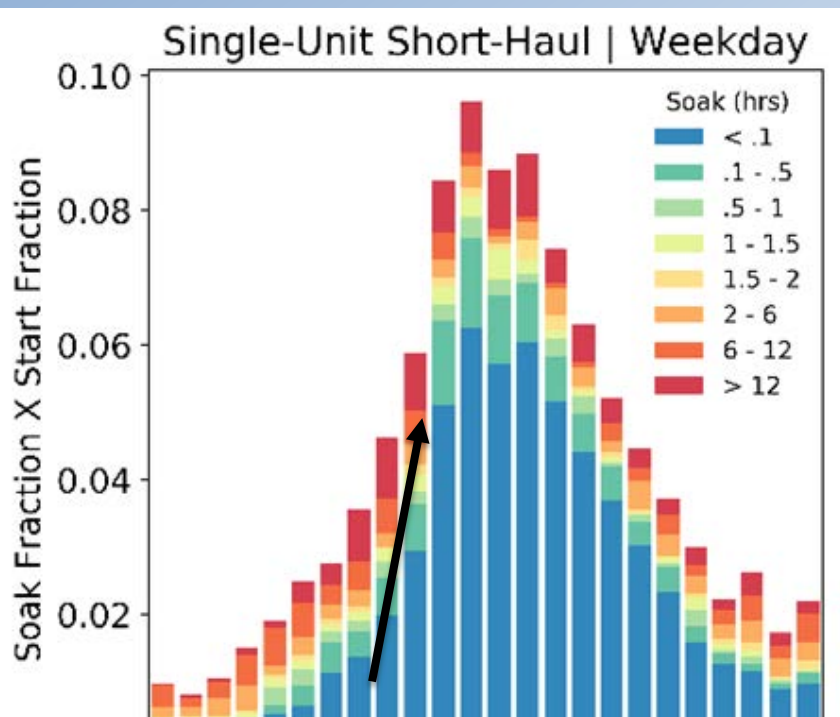
Final Average: Each vehicle is weighted to the daily starts



Equations in Appendix slides and in Kotz et al. (2019)

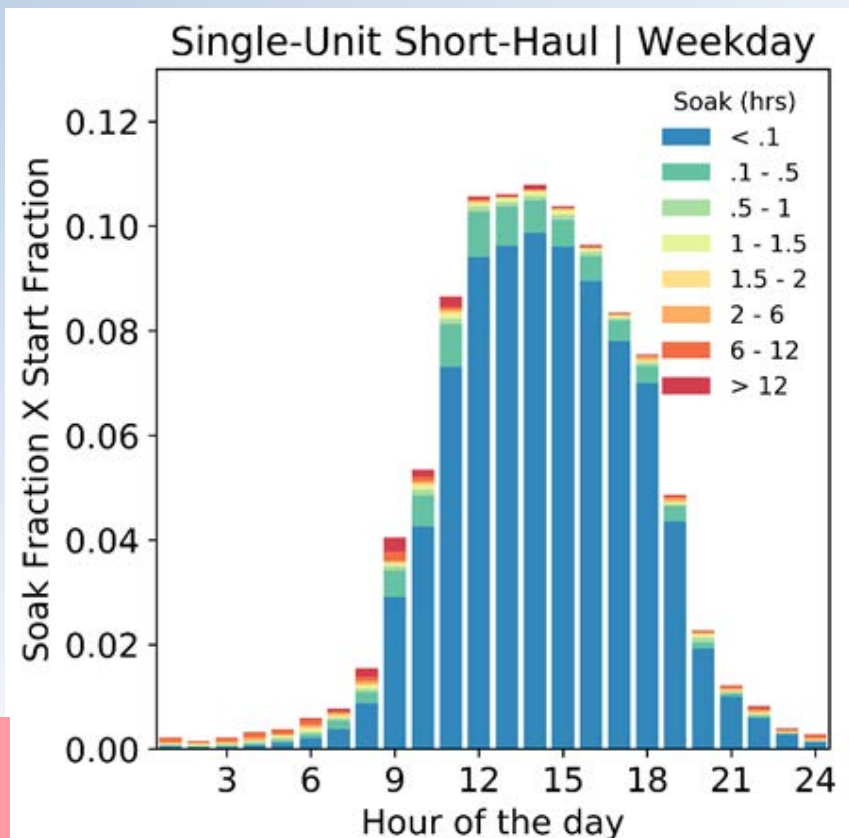
How you average matters: Start Activity Example

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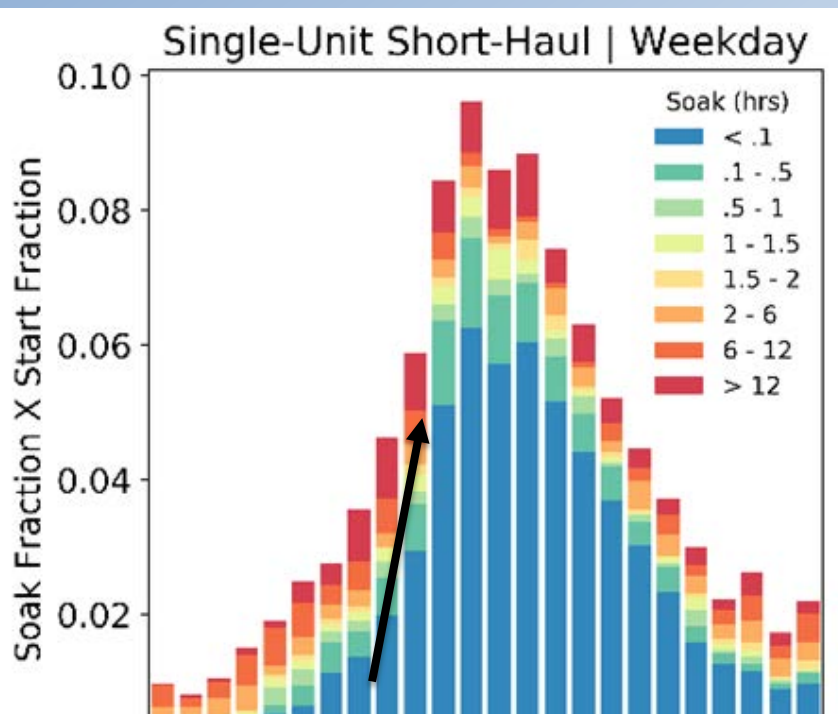
Vehicles with few starts per day (long soak periods, occur throughout the day) are over-represented

Final Average: Each vehicle is weighted to the daily starts



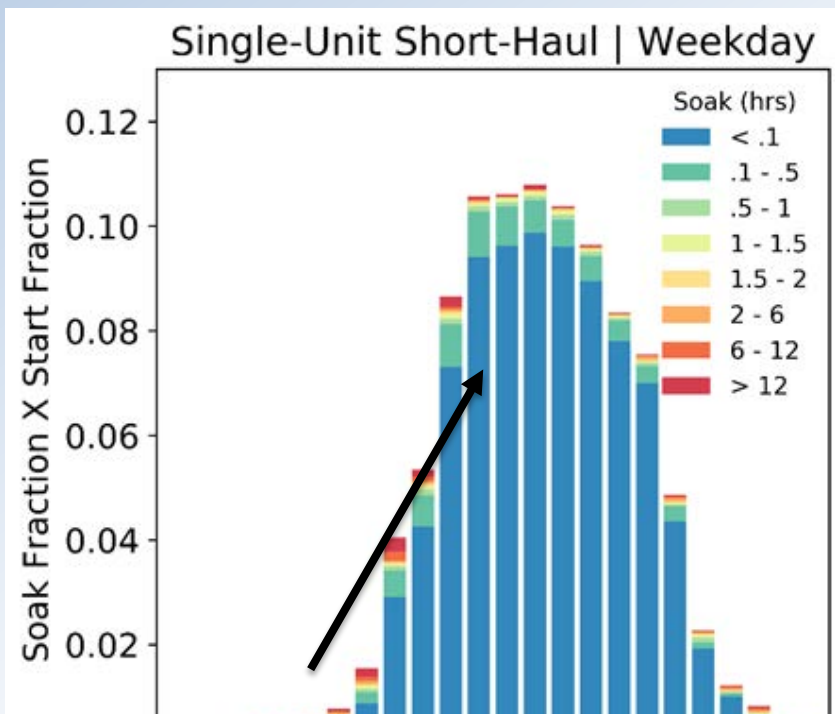
How you average matters: Start Activity Example

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Vehicles with few starts per day (long soak periods, occur throughout the day) are over-represented

Final Average: Each vehicle is weighted to the daily starts



Starts are accurately represented by vehicles with many starts per day (short soak periods, mainly during work-day)

Summary (1)

- Updates to HD vehicle activity based on NREL's Fleet DNA anticipated to significantly improve our understanding of emissions from HD fleet
 - Large **increase** in off-network idle
 - Large **decrease** in hotelling
 - Large **increase** in starts
 - Increased resolution of activity by time of day, day of week, and truck vocation
- Instrumented vehicle activity data also available from CE-CERT
 - In the process of performing combined analysis using consistent methodologies

Summary (2)

- Large variation in truck activity among individual vehicles and vocations
 - **Issue:** How representative are the collected instrumented truck data for national or local emission inventories?
 - **Recommendations:** Weight inputs by daily activity and vocation populations
 - **Data needs:** Instrumented truck data **AND** truck registration data by clearly defined vocations

References

1. Kotz, Andrew and Kenneth Kelly. 2019. *MOVES Activity Updates Using Fleet DNA Data: Interim Report*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5400-70671. <https://www.nrel.gov/docs/fy19osti/70671.pdf>.
2. Boriboonsomsin, K., et al., Collection of Activity Data From On-Road Heavy-Duty Diesel Vehicles available at https://www.arb.ca.gov/research/single-project.php?row_id=65196). 2017.
3. Lutsey, N., C.-J. Brodrick, D. Sperling and C. Oglesby (2004). Heavy-Duty Truck Idling Characteristics: Results from a Nationwide Truck Survey. *Transportation Research Record* 1880(1): 29-38. 10.3141/1880-04.
4. NCHRP 08-101 Report pending (<http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3860>)

Averaging Methods: Idle Example

1 (Initial)	$\text{Idle fraction} = \frac{\sum \text{Idle fraction}_i}{n}$ <p style="text-align: center;">$i = \text{Vehicle ID}$</p>	<ul style="list-style-type: none">• Each vehicle is weighted equally• Average is over-represented by vehicles with little real-world activity
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2	$\text{Idle fraction} = \frac{\sum \text{idle hours}_i}{\sum \text{operating hours}_i}$	<ul style="list-style-type: none">• Average is influenced by the vehicles with the most activity• CE-CERT vehicles would be 2X as influential as the FLEET DNA because of longer instrumentation times

Averaging Methods: Idle Example

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<p>3 (Final)</p>	$\text{Idle fraction} = \frac{\sum (\text{idle hours}_i / \text{days}_i)}{\sum (\text{operating hours}_i / \text{days}_i)}$ <p style="text-align: center;">$\text{days}_i = \# \text{ of days vehicle}_i \text{ is instrumented}$</p>	<ul style="list-style-type: none"> • Average is weighted by the vehicles with the most real-world activity • Controls for the different lengths of time each vehicle is instrumented

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<p>2</p>	<p>Method 3 used to average the individual vehicle data from the NREL data (remaining slides)</p> <p>Method 3 will be used to combine the NREL and CE-CERT data (analysis in progress)</p>	
<p>3 (Final)</p>	$Idle\ fraction = \frac{\sum (idle\ hours_i / days_i)}{\sum (operating\ hours_i / days_i)}$ <p>$days_i = \#\ of\ days\ vehicle_i\ is\ instrumented$</p>	<ul style="list-style-type: none"> • Average is weighted by the vehicles with the most real-world activity • Controls for the different lengths of time each vehicle is instrumented