MOVES
Motor Vehicle Emission Simulator

Heavy-Duty Vehicle Activity in MOVES: Idle, Starts, Soaks, and Hotelling

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HDV Idle Operation in MOVES2014

- In MOVES, overnight idling by long-haul combination trucks is accounted for as the extended idle fraction of hotelling activity
- All other idling in MOVES is estimated as the portion of driving schedules where the speed is zero
- HDV idle fractions currently derived from TomTom GPS average speed distributions and default driving cycles
  - Only light-duty vehicles in TomTom data
  - No off-network vehicle activity

Idle Operation: The Need for Change

- Recent focus on idling has highlighted the need for a more accurate assessment of idle time
  - Selective catalytic reduction or SCR (an exhaust after-treatment technology on 2010+ heavy duty trucks) is not as effective at reducing NOx when the exhaust temperature is below ~250°C. Lower temperatures are common during idling
  - New technologies are changing idling time (remote start, stop-start)
  - There is a desire to account for emission benefits of anti-idling policies
- Recent data indicate that total default idle time derived solely from MOVES driving schedules is too low
- MOVES driving schedules do not include idling that occurs in parking lots, driveways, or during "workday" truck operation such as queuing at a distribution center, loading freight, etc.

Adding "Off-Network" Idle to MOVES

- As described at March 2017 meeting
  - Compute total idle activity as a fraction of operating hours for all sourcetypes (light duty and heavy duty).
  - Subtract the idle time already in the driving cycles and consider the rest of the time as "off-network" idle activity
  - Calculate off-network idle emissions using the same emission rates as used for the existing idle operating mode.

HDV Starts & Soaks in MOVES2014

- Starts and soak times based on 124 instrumented HD trucks
  - Batelle study of 120 California trucks (1997-1998)
  - Texas DOT study of 4 diesel dump trucks (2002)
- Bus and long-haul single-unit truck values adapted from other sourcetypes.

MOVES2014 Starts Per Day

Source Type	Weekday	Weekend
Motorcycles	0.78	0.79
Passenger Cars	5.89	5.30
Passenger Trucks	5.80	5.06
Light Commercial Trucks	6.05	5.47
Other Buses	2.77	0.88
Transit Buses	4.58	3.46
School Buses	5.75	1.26
Refuse Trucks	3.75	0.92
Single-Unit Short-Haul Trucks	6.99	1.28
Single-Unit Long-Haul Trucks	4.29	1.29
Motor Homes	0.57	0.57
Combination Short-Haul trucks	5.93	1.16
Combination Long-Haul trucks	4.29	1.29

Target Tables to Populate

New Table!

- TotalIdleFraction (workday)
  - Idle fraction by sourcetypeID, dayID

Now used for MOVES defaults as well as user inputs.

- StartsPerDay
  - Average starts per day by sourcetypeID, dayID
- StartsHourFraction
  - Start fraction by sourcetypeID, dayID, hourID
- StartOpModeDistribution
  - Soak fraction by sourcetypeID, dayID, hourID, and opmodeID

Also populating for LD as presented March & June 2017

Data Sources

- NREL FleetDNA database
  - 413 conventional vehicles
- CE-CERT version 5.2
  - 84 conventional vehicles

SourceType	Description	Vehicle Test Populations		
		NREL	CE-CERT	Total
42	Transit Bus	16	10	**26**
43	School Bus	7	0	**7**
51	Refuse Truck	36	6	**42**
52	Single Unit Short-Haul	118	32	**150**
53	Single Unit Long-Haul	0	*	**0**
61	Combination Short-Haul	105	36	**141**
62	Combination Long-Haul	131	*	**131**

*While CE-CERT classified some vehicles as “long-haul,” EPA found the activity did not include the multi-day trips expected from long-haul vehicles and reclassified them as “short-haul” for this analysis

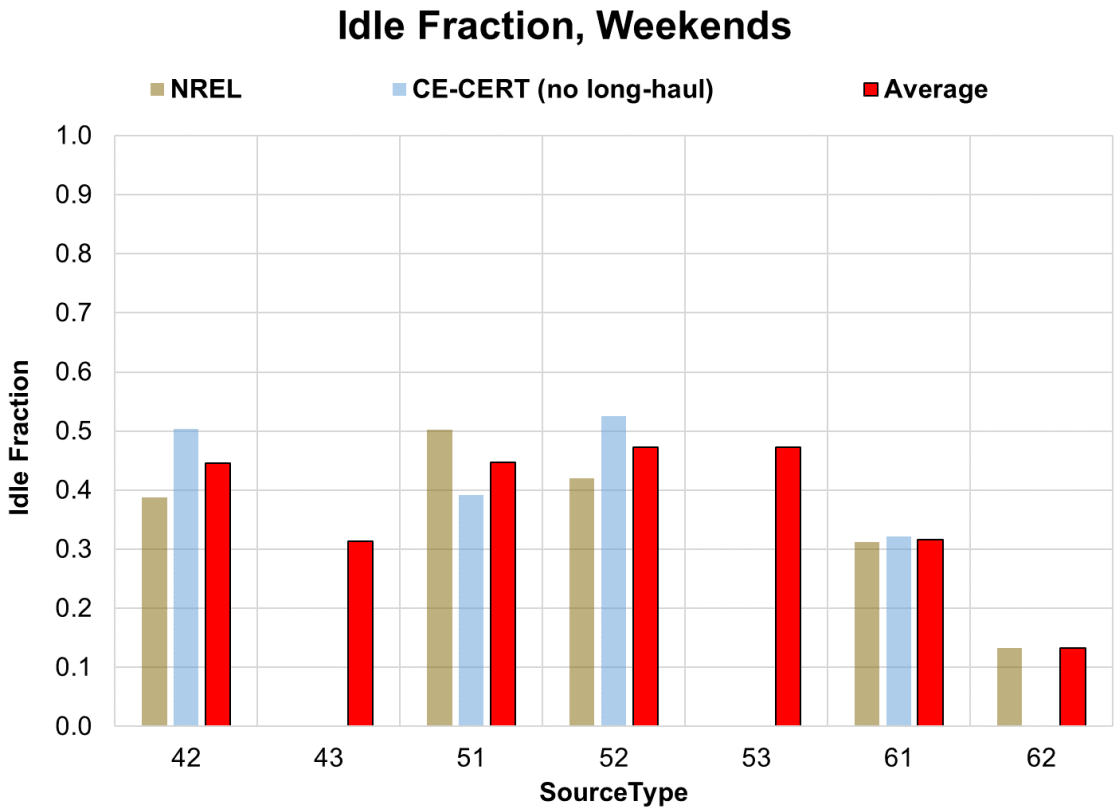
Notes on HDV Idle, Starts, & Soaks Analysis

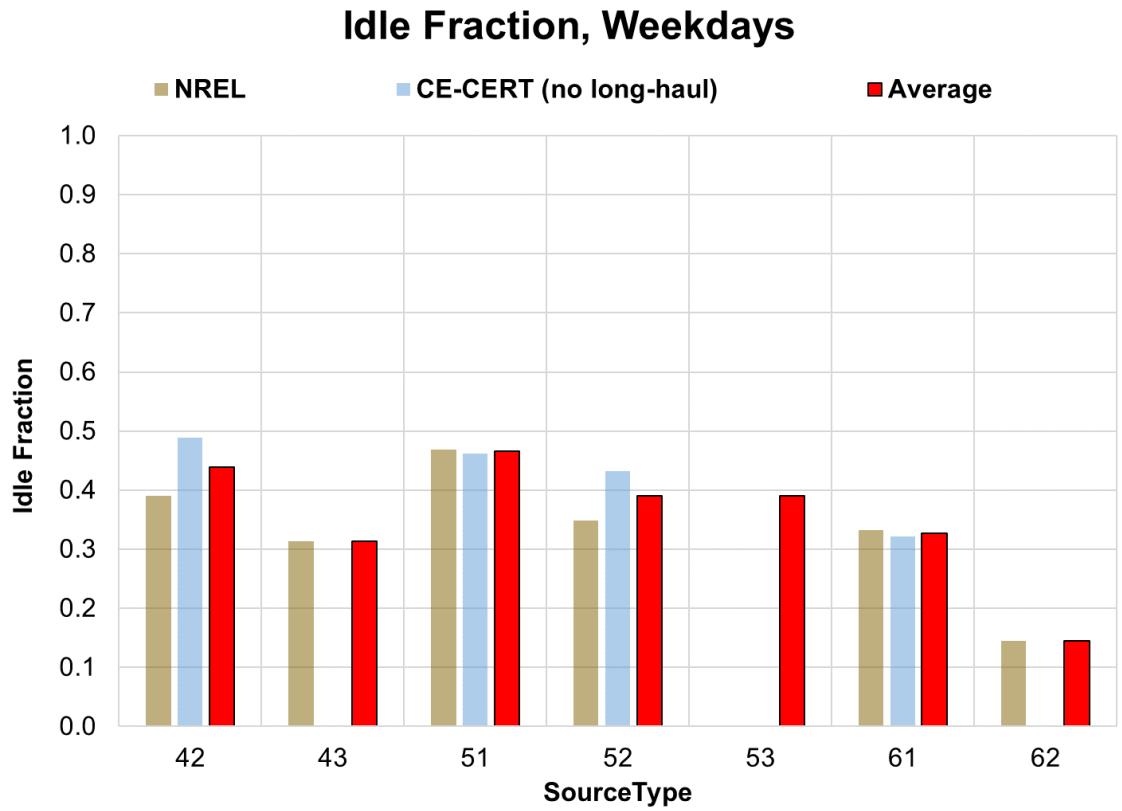
Source Type	Issue	EPA Proposal
Other Buses (41) (formerly intercity buses)	No data	• Use starts-per-day, idle fractions and hourly start & soak patterns from transit buses (42).
School Buses (43)	No weekend data	• Apply weekday-to-weekend VMT ratio to weekday starts per day (likely fewer starts on weekends) • Apply weekday idle, start, and soak fractions to weekend data (assumes similar behavior if operating on weekends)
Single unit Long-haul (53)	No data	• Use values from single unit short-haul trucks (52)
Motorhomes (54)	No data	• Use hourly start & soak patterns from passenger cars (21) • Use starts-per-day from MOVES2014 • Set off-network idle fraction to zero
Combination Long-haul (62)	MOVES distinguishes “extended” and “work-day” idle	• For these trucks, classify idle times > 1 hour as “extended”

All HDV SourceTypes

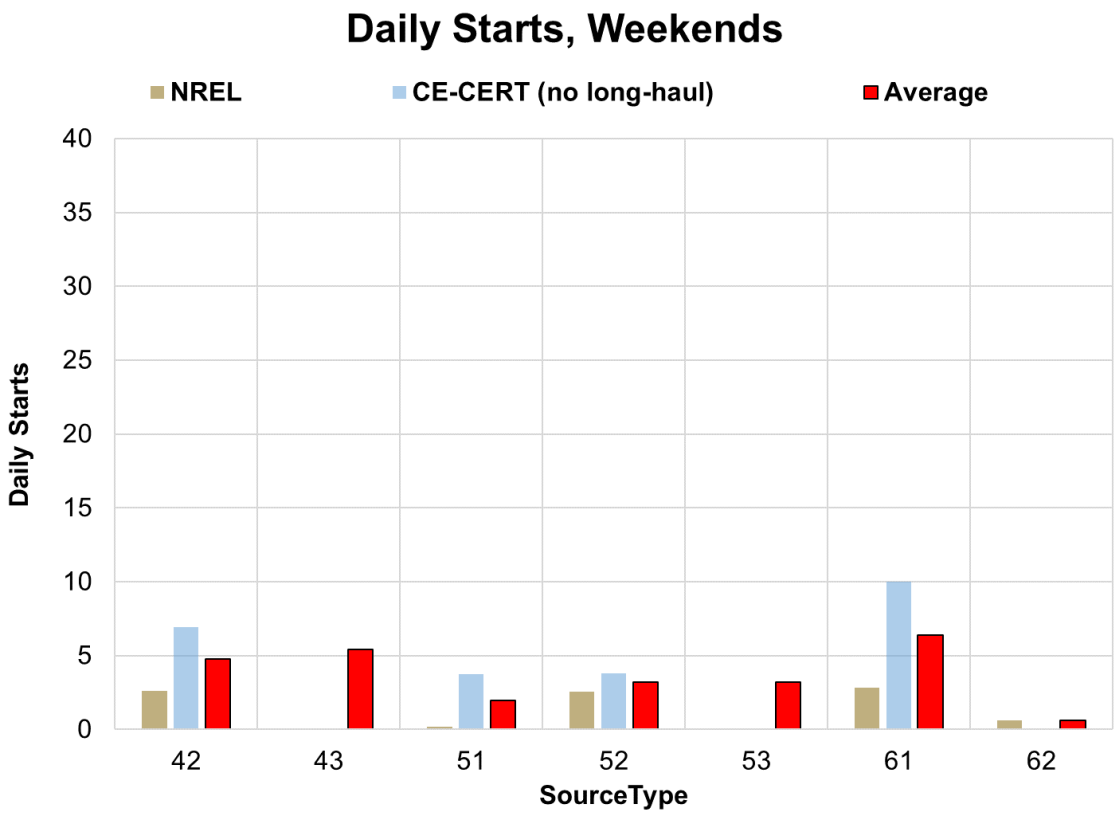
IDLE FRACTIONS & AVERAGE DAILY STARTS

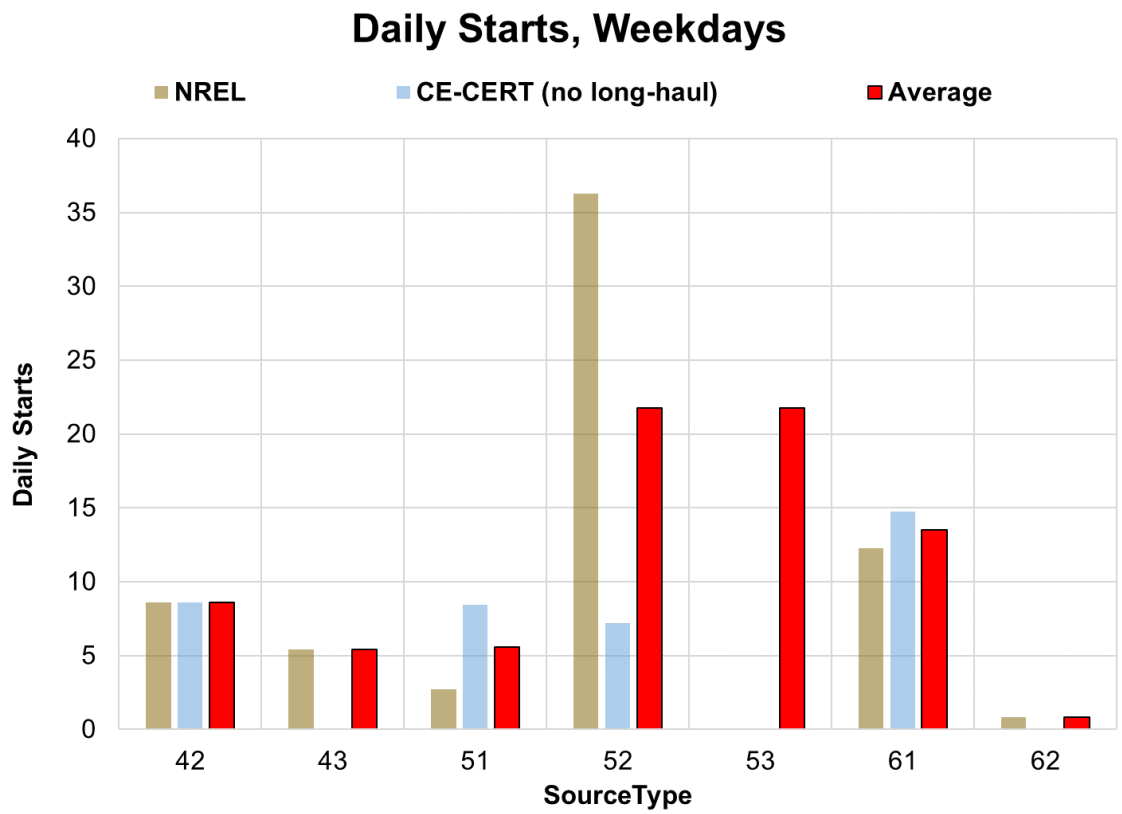
Idle Fraction Results





Average Daily Starts Results





SourceTypes 42, 52, 61, 62

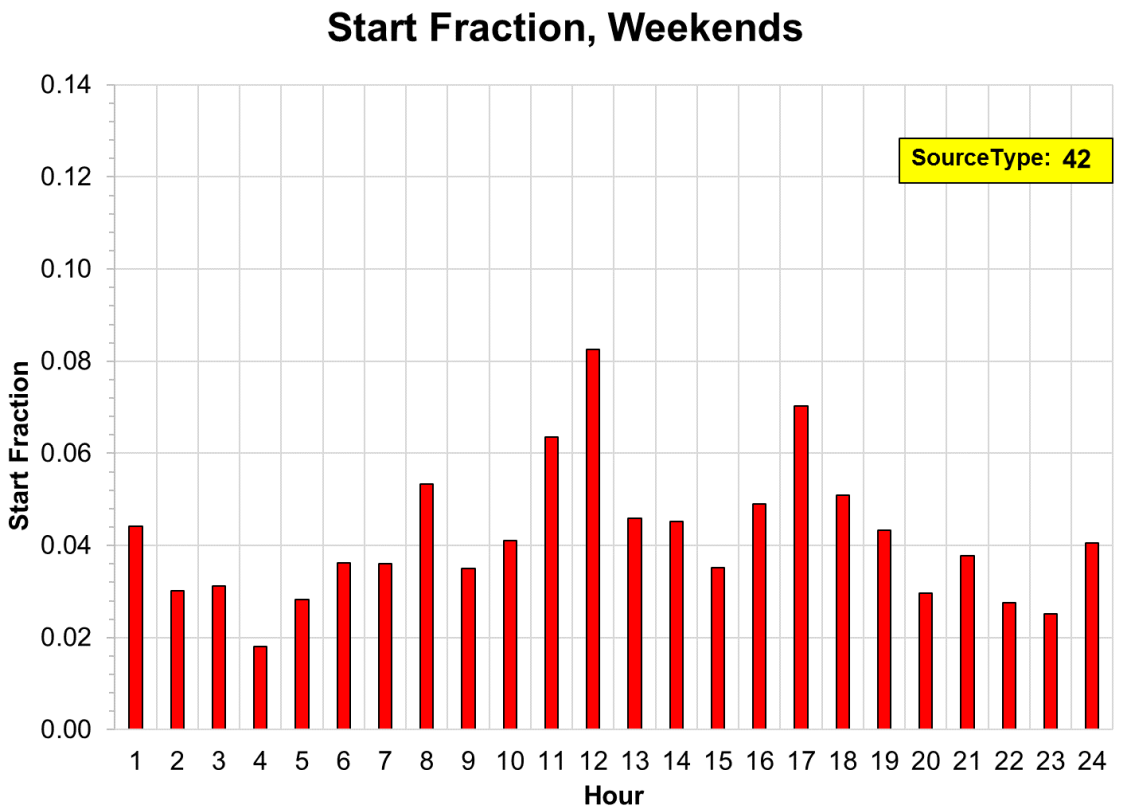
START FRACTIONS & SOAK FRACTIONS

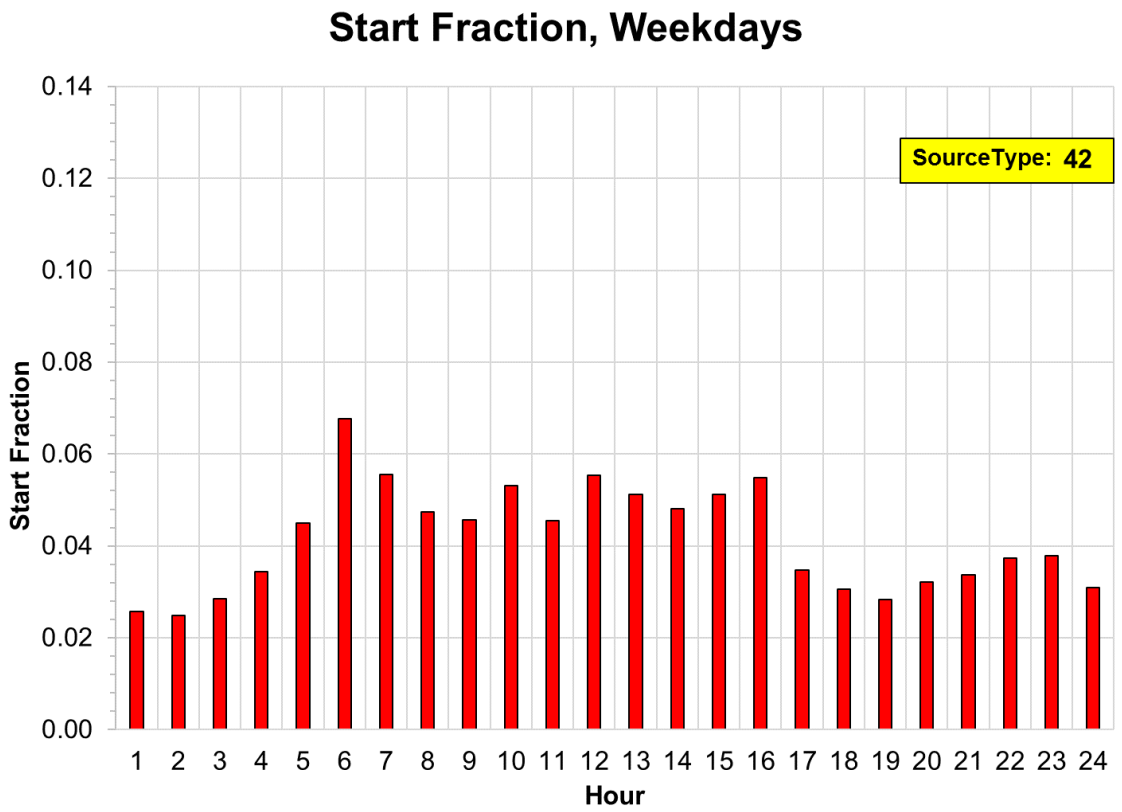
Notes on HDV Analysis for Start & Soak Fractions

- Sourcetypes 42, 52/53, 61, and 62 are presented
- Hourly Start Fractions
  - Replaced instances of zero with 0.001
    - Only needed for sourcetypes 43, 51
    - Renormalized to sum to 1.0 over 24 hours
- Hourly Soak Fractions
  - Replaced instances of zero with 0.001
    - Only needed for sourcetypes 43, 51
    - Renormalized to sum to 1.0 over the eight soak opModes in each hour
  - Used 4-hour averages to account for hour-to-hour inconsistencies

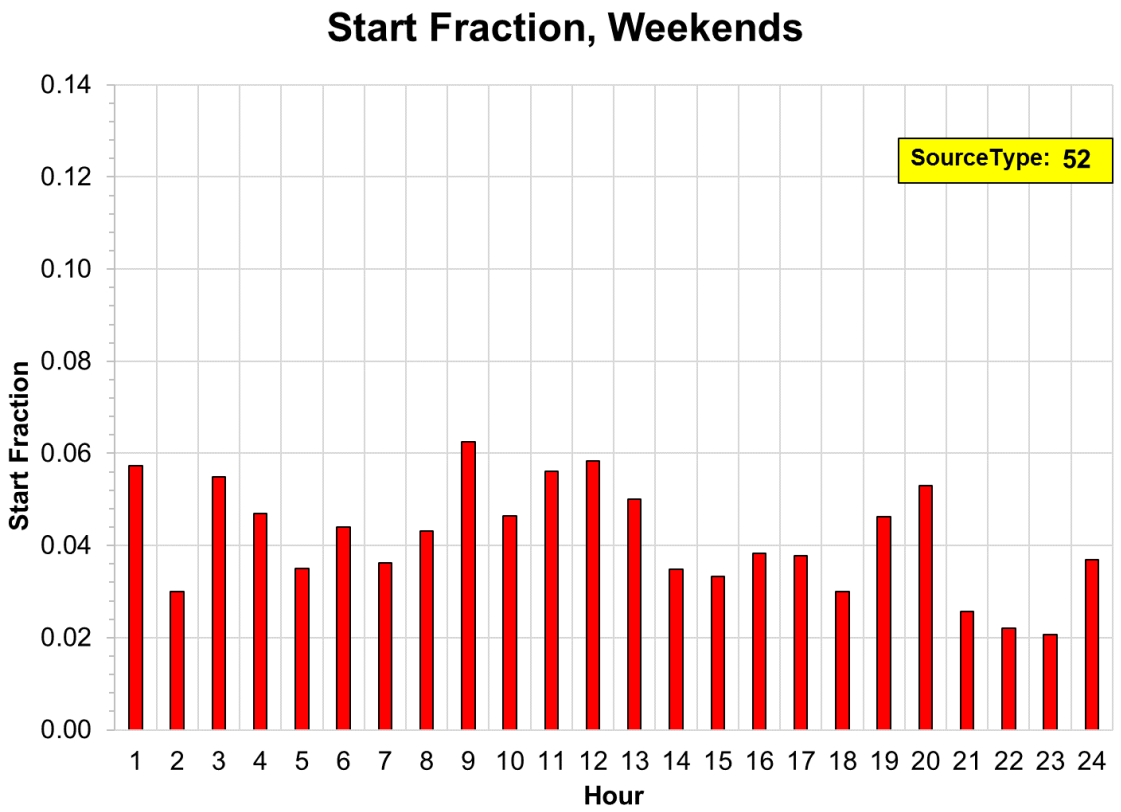
OpmodeID Code	Operating Mode Description
101	Soak Time < 6 minutes
102	6 minutes ≤ Soak Time < 30 minutes
103	30 minutes ≤ Soak Time < 60 minutes
104	60 minutes ≤ Soak Time < 90 minutes
105	90 minutes ≤ Soak Time < 120 minutes
106	120 minutes ≤ Soak Time < 360 minutes
107	360 minutes ≤ Soak Time < 720 minutes
108	720 minutes ≤ Soak Time

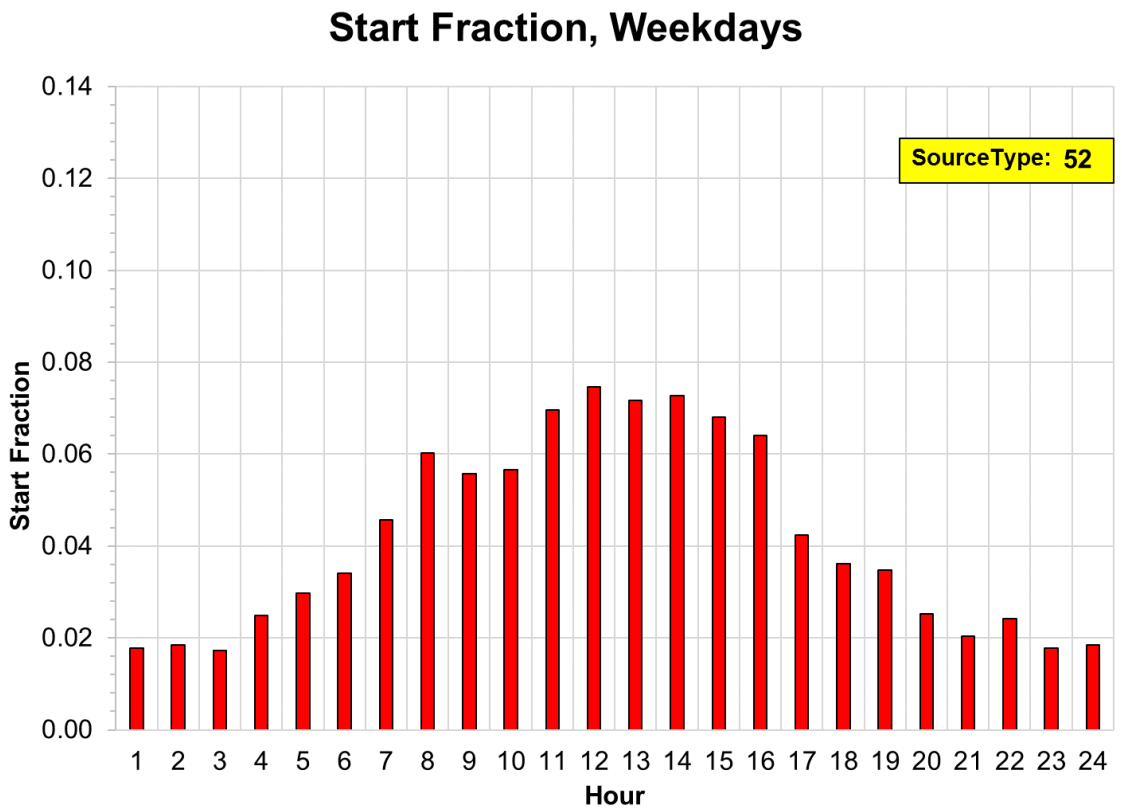
Hourly Start Fraction Results (SourceType 42: Transit Bus)



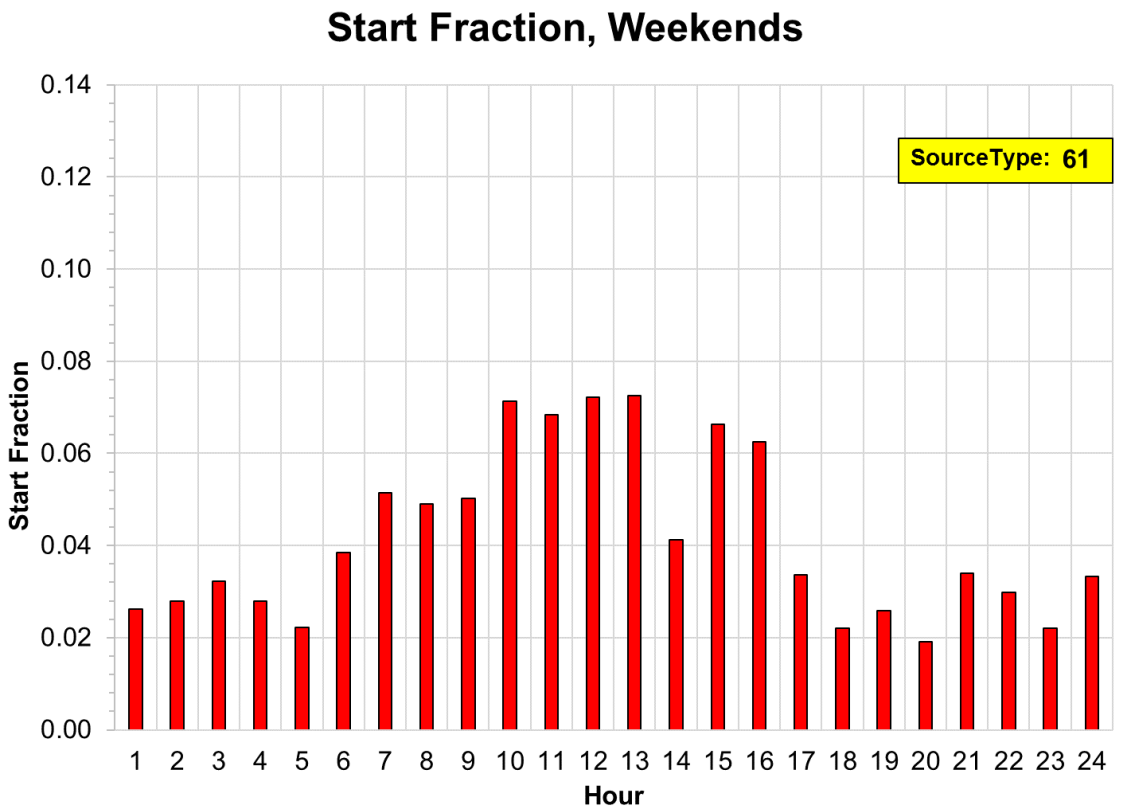


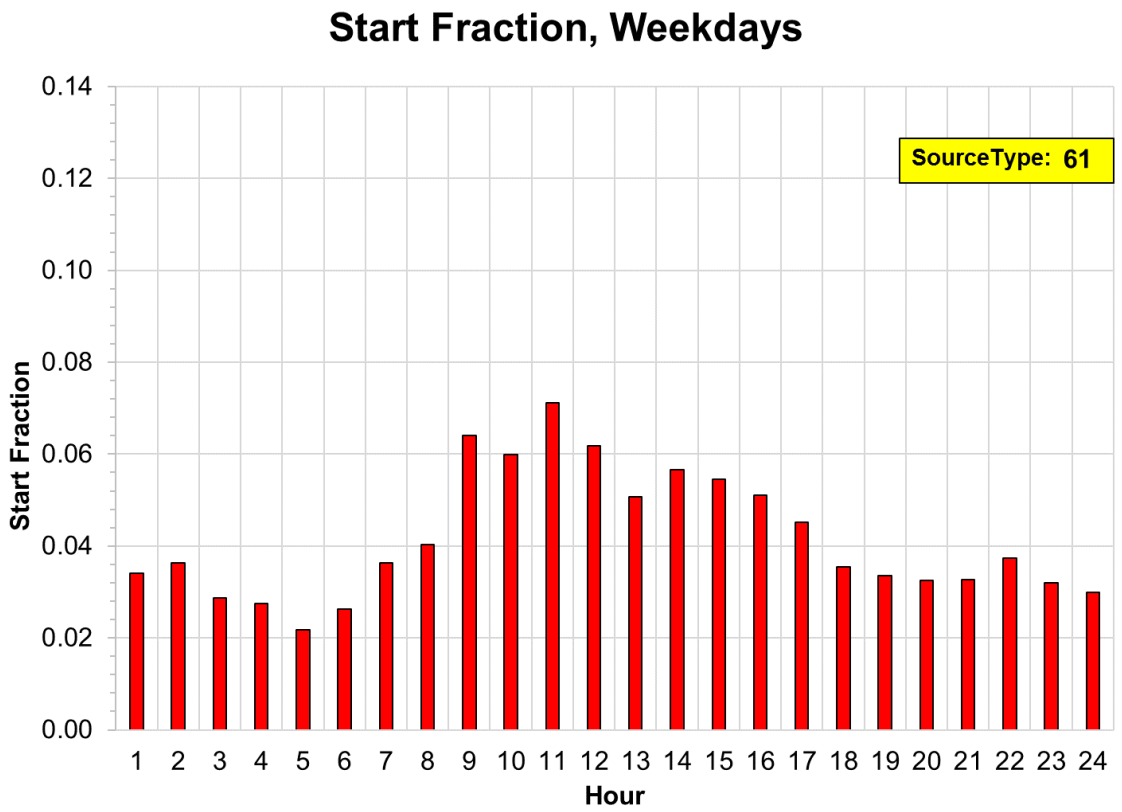
Hourly Start Fraction Results (SourceType 52 & 53: Single-Unit Trucks)



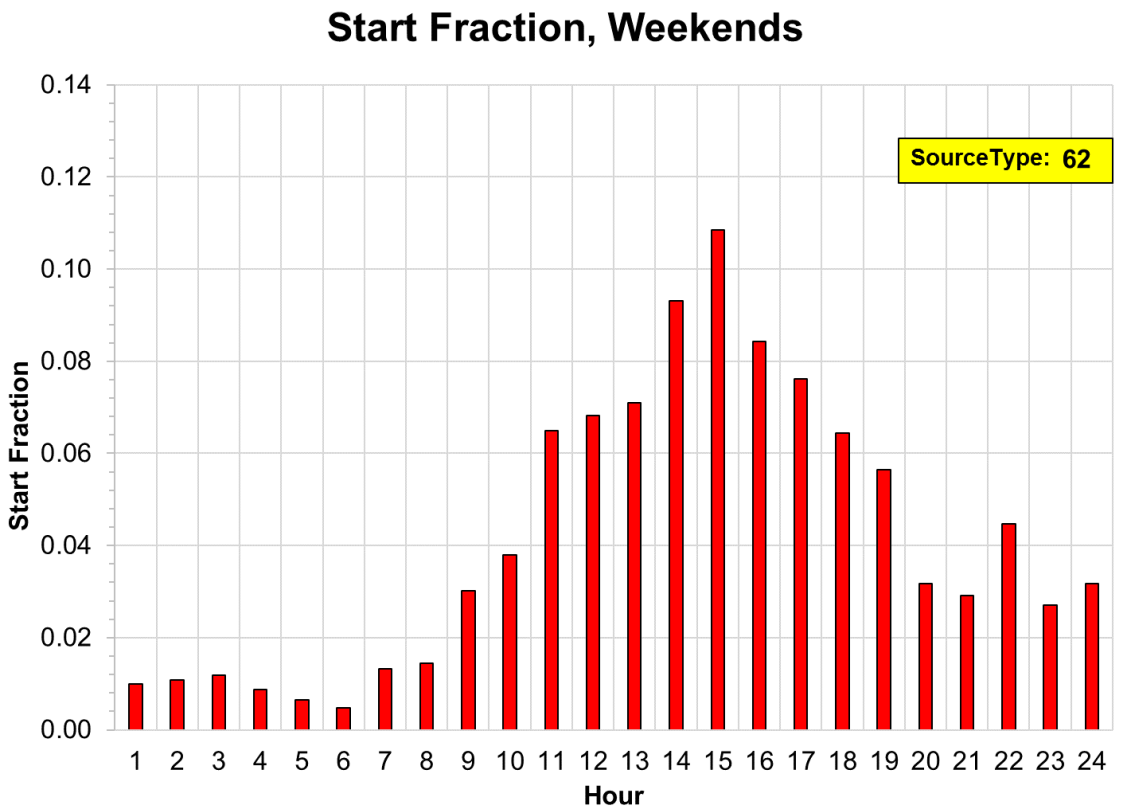


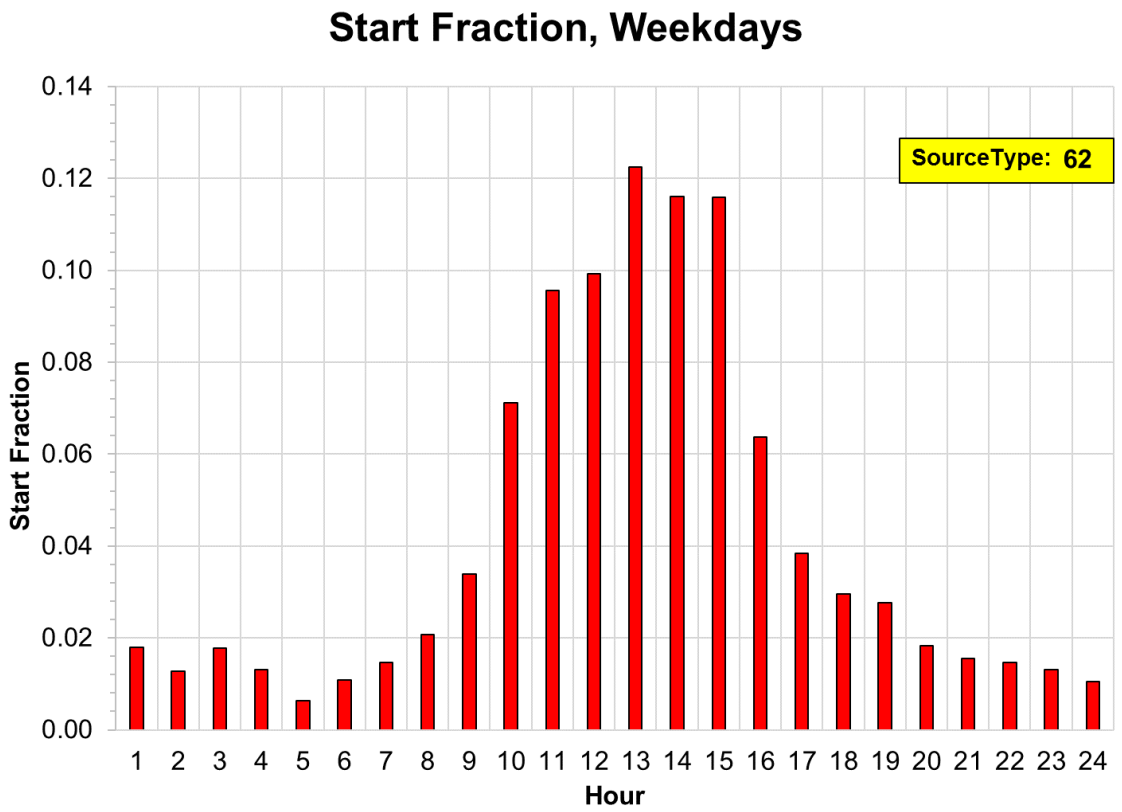
Hourly Start Fraction Results (SourceType 61: Combination Short-Haul)



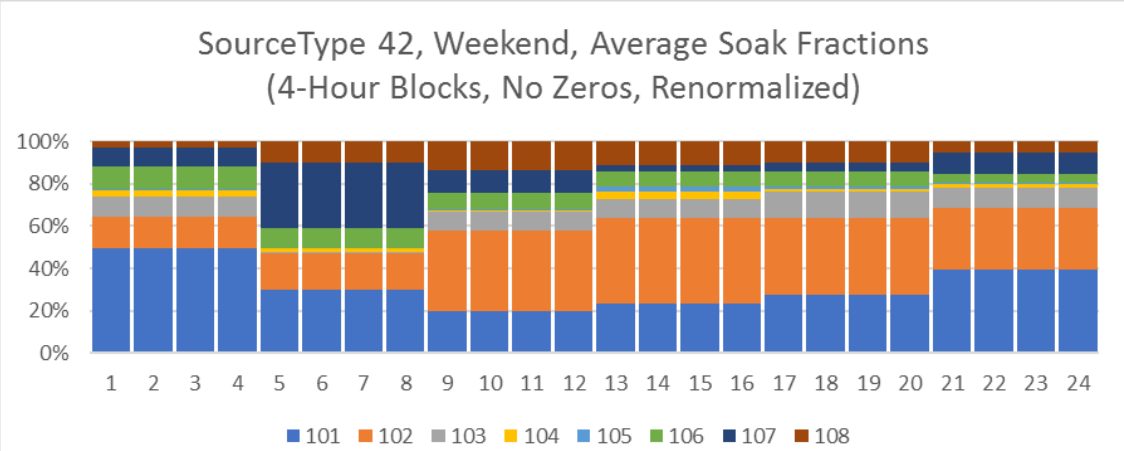


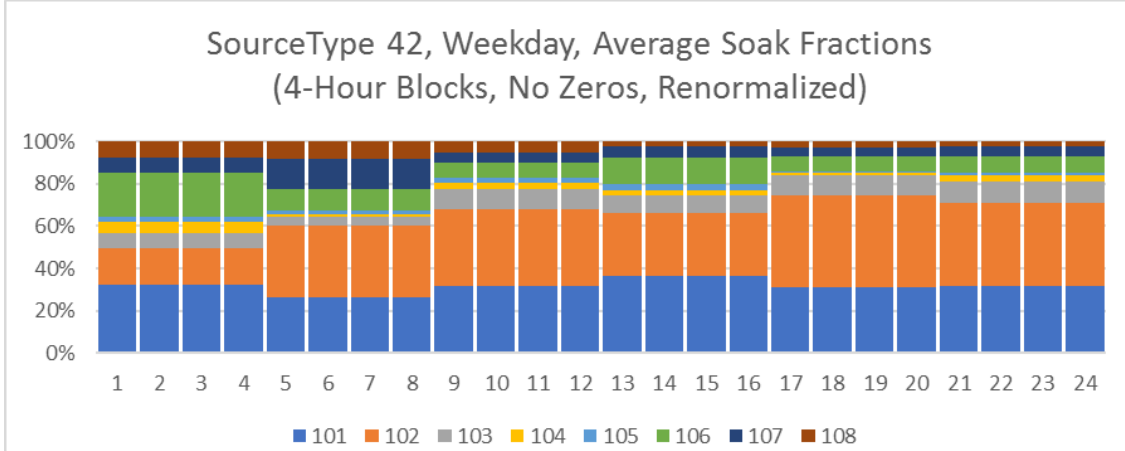
Hourly Start Fraction Results (SourceType 62: Combination Long-Haul)

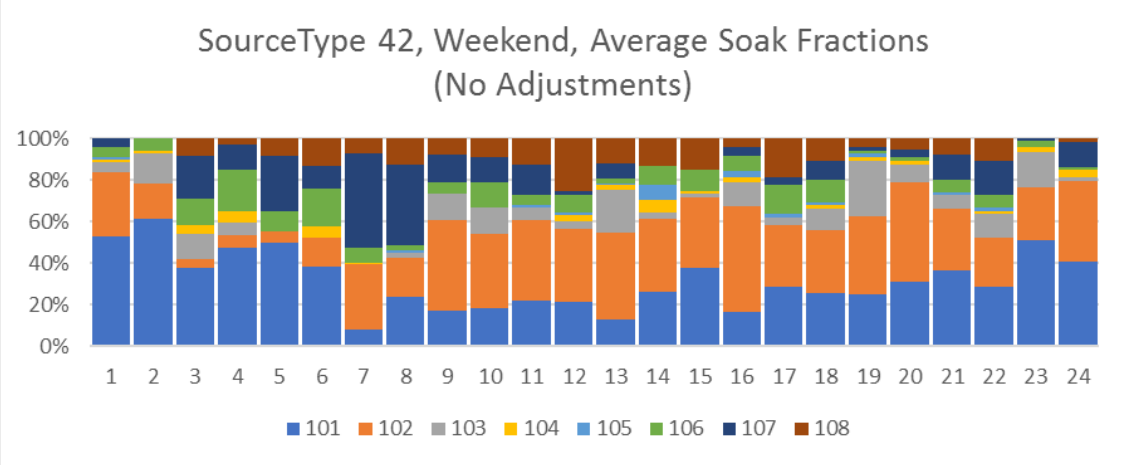


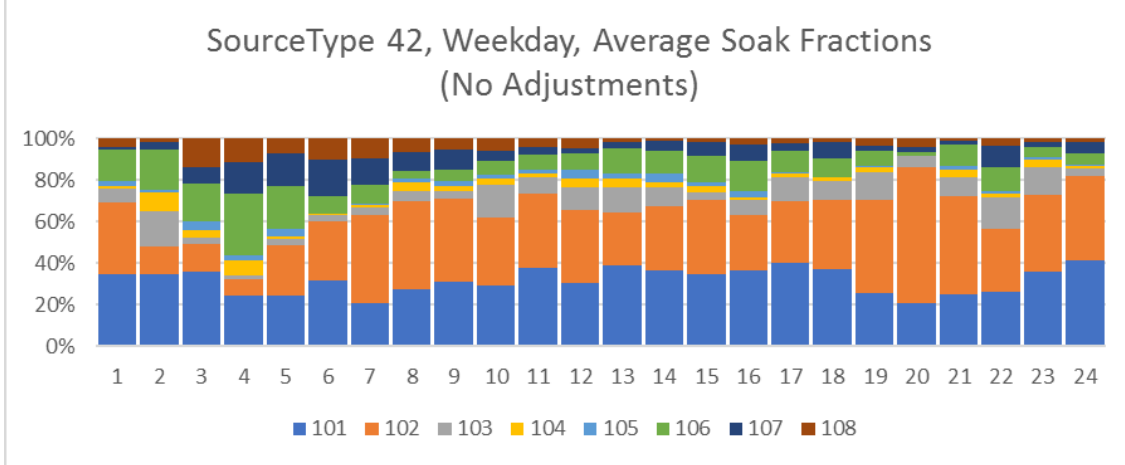


Hourly Soak Fraction Results (SourceType 42: Transit Bus)

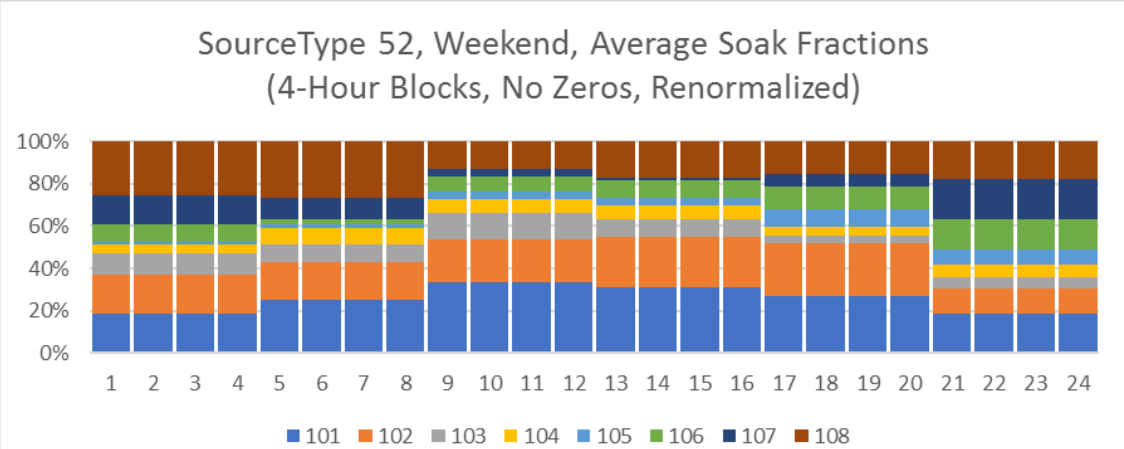


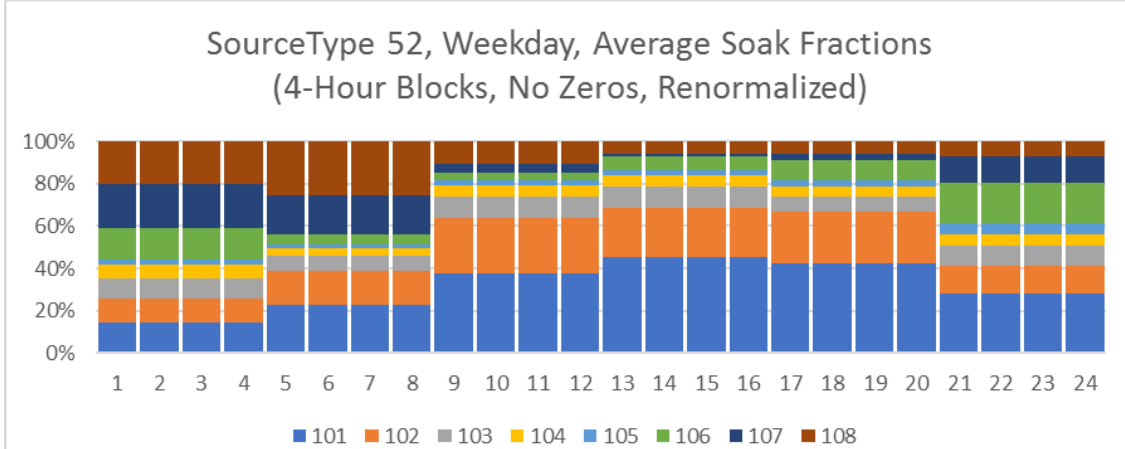


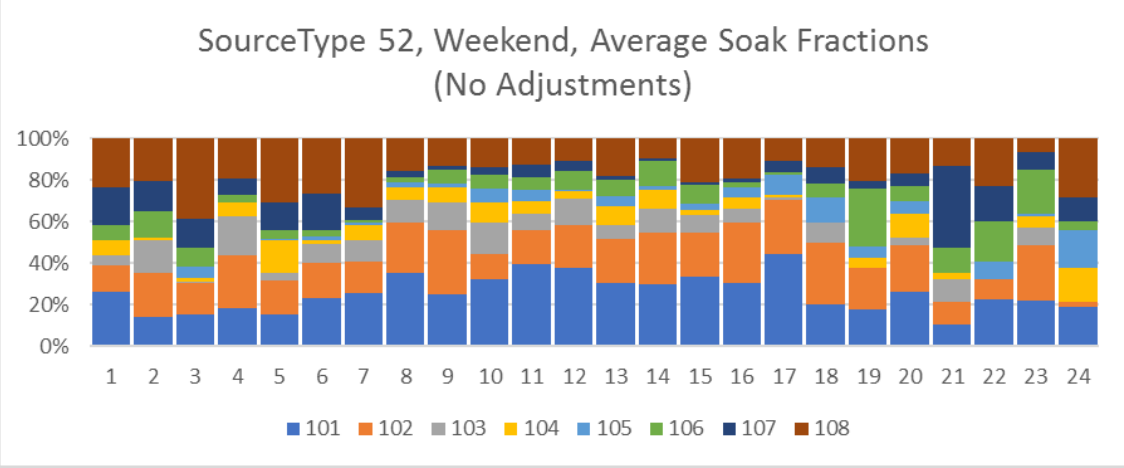


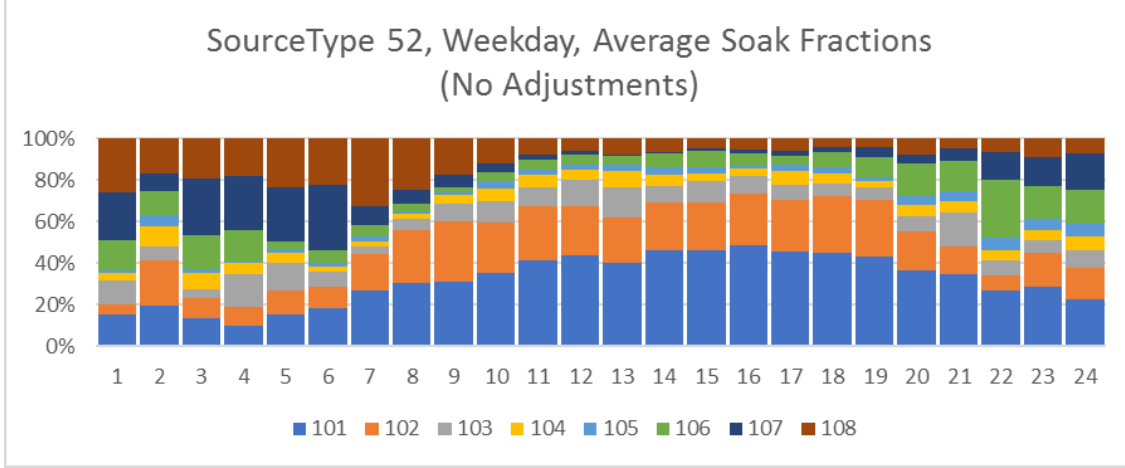


Hourly Soak Fraction Results (SourceType 52 & 53: Single-Unit Trucks)

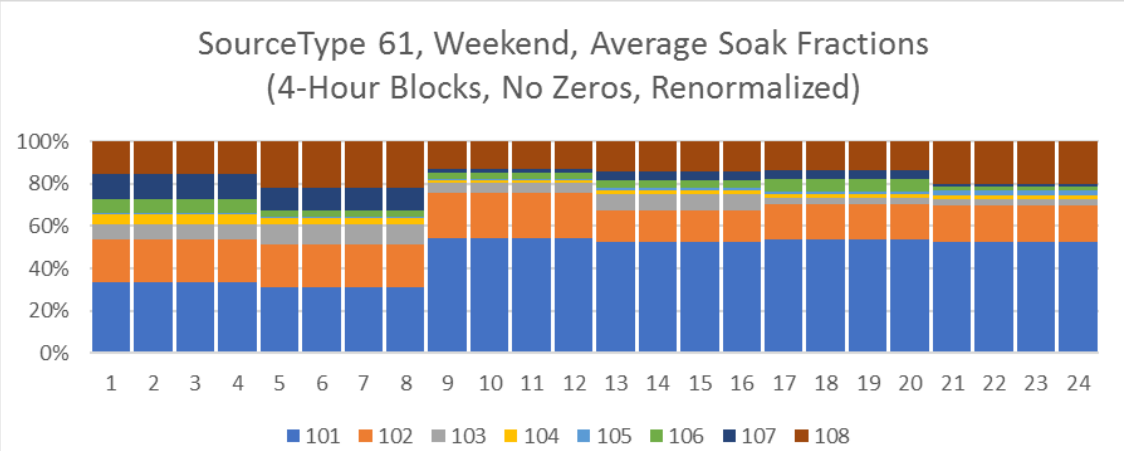


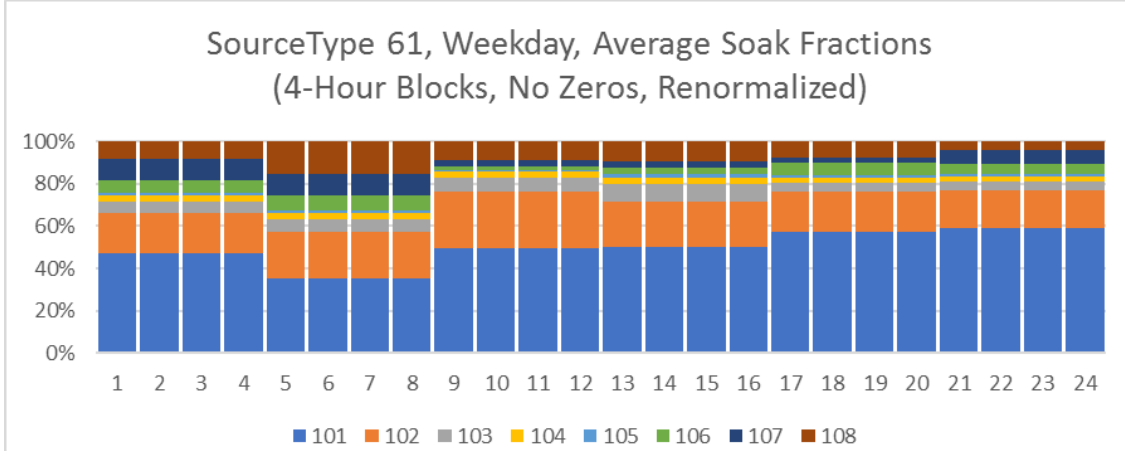


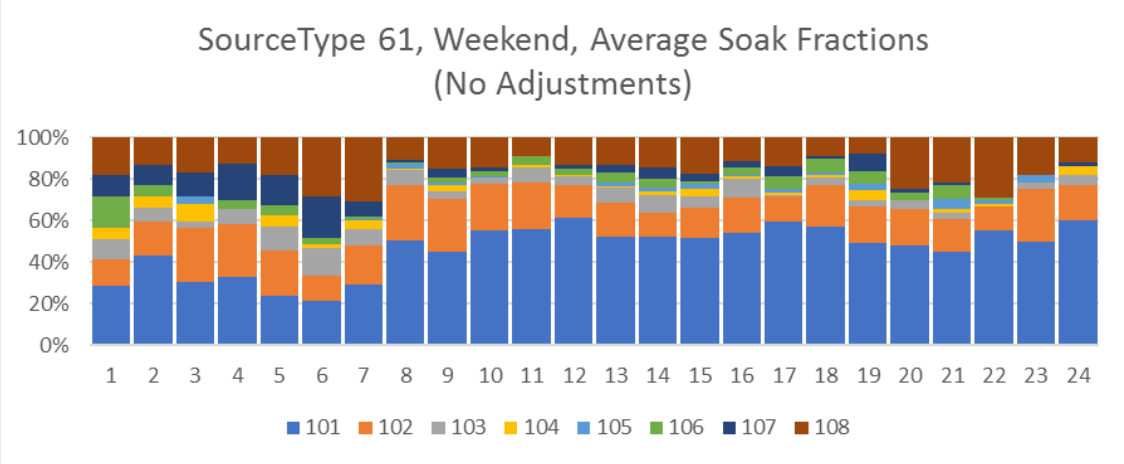


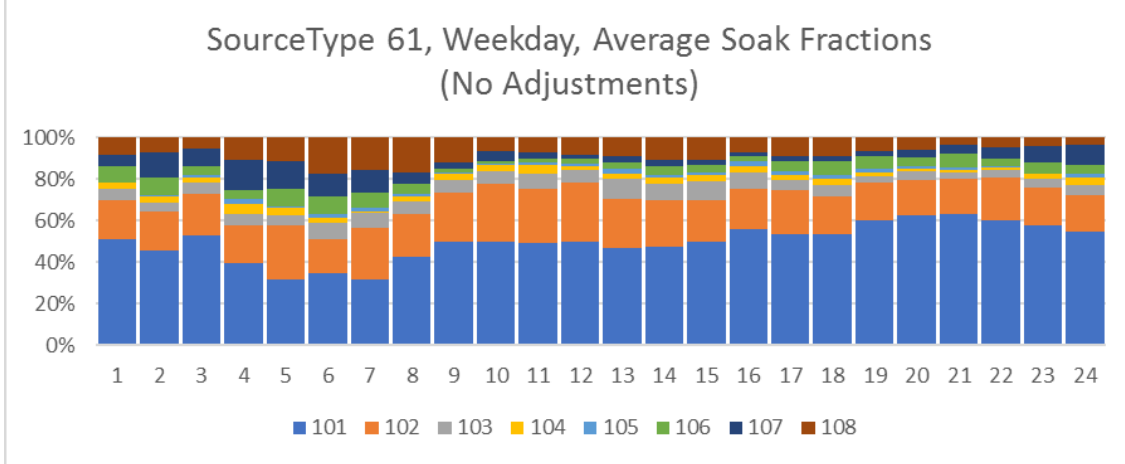


Hourly Soak Fraction Results (SourceType 61: Combination Short-Haul)

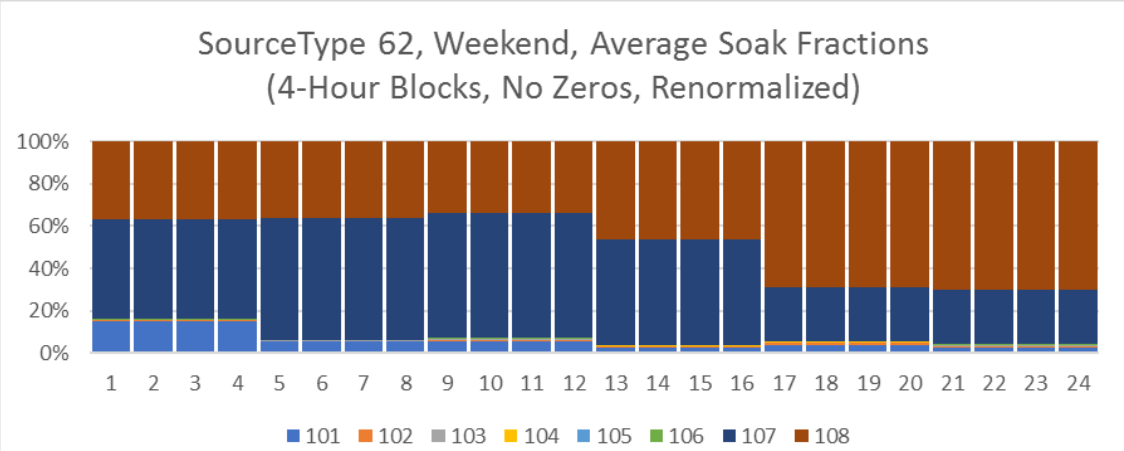


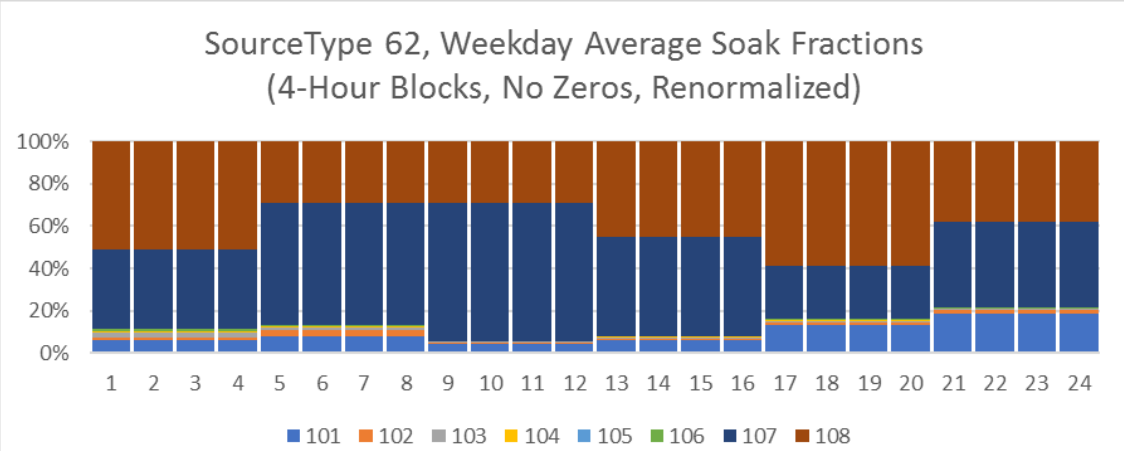


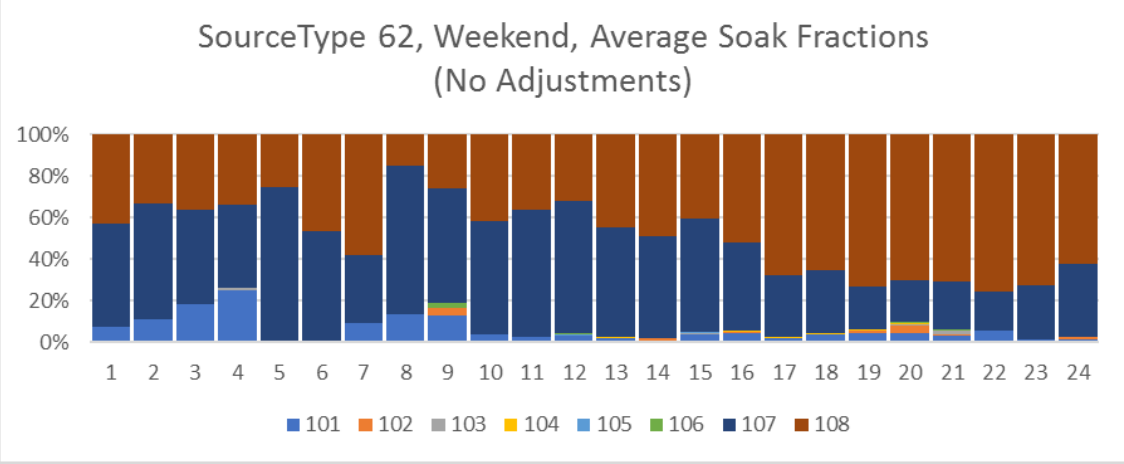


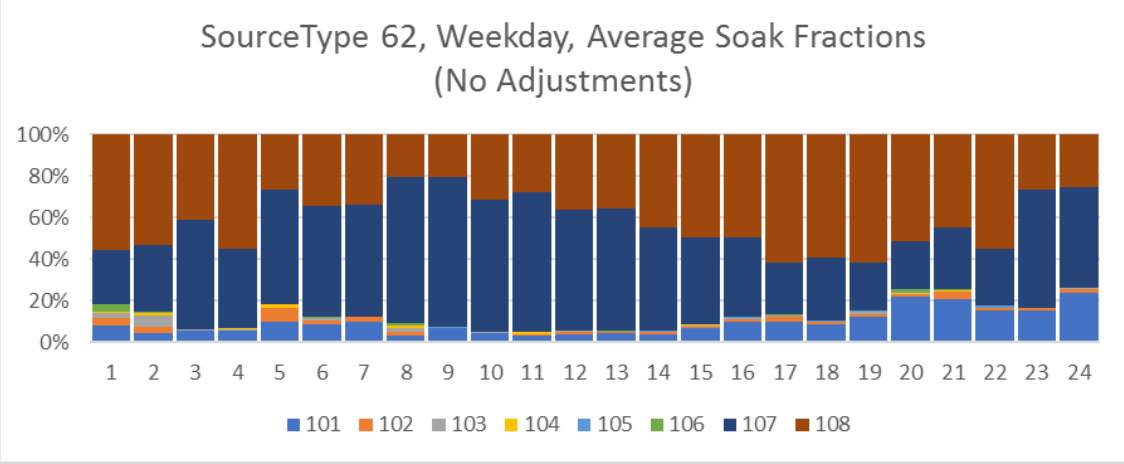


Hourly Soak Fraction Results (SourceType 62: Combination Long-Haul)





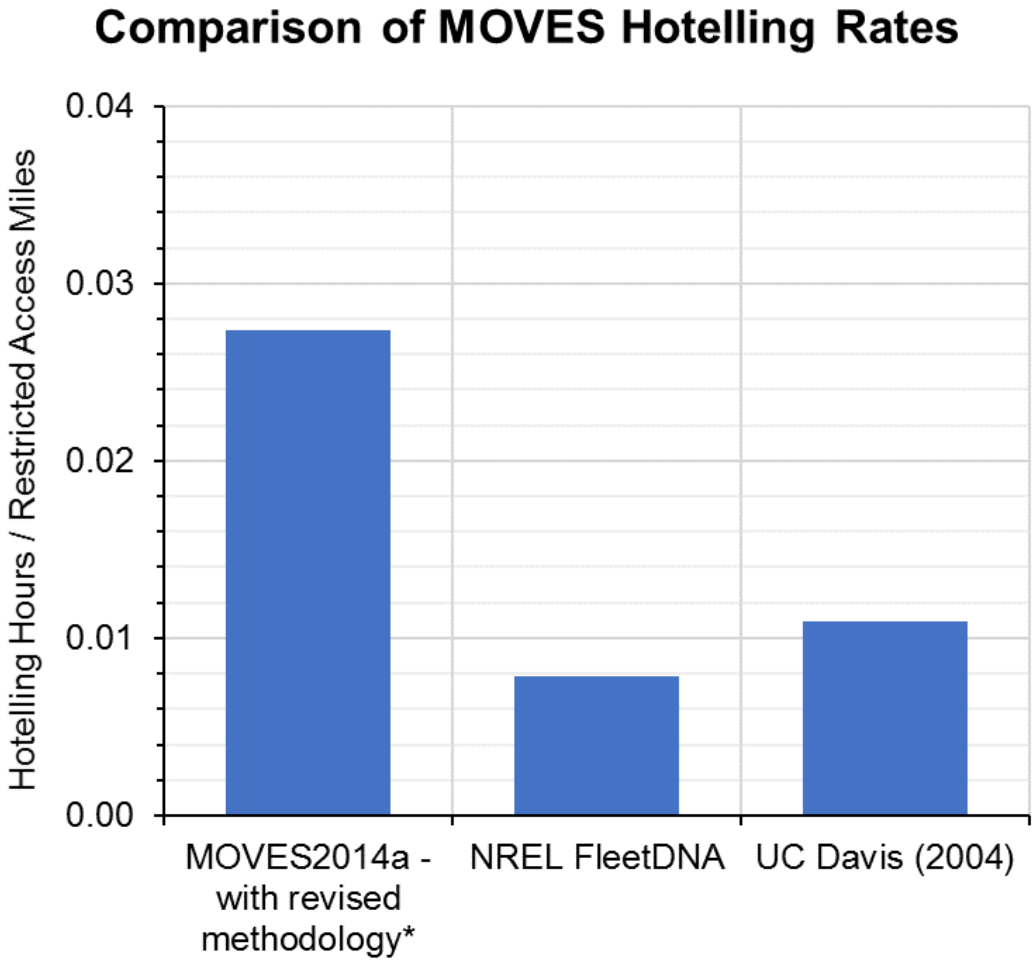




HOTELLING UPDATE

Hotelling Activity

- MOVES2014a hotelling activity
  - Based on an assumption of 8 hours of mandatory rest periods/10 hours of driving for all calendar years.
- Estimated hotelling activity from NREL FleetDNA data
  - Using idle events > 1hr in duration
  - Assume 80% of hotelling is extended idle
  - 139 long-haul trucks with recorded extended idling, based in 31 different states
  - Hourly data also available
- Yields significantly lower hotelling rates, which is consistent with other studies



* Using the ratio of hotelling hours to both urban and rural restricted access instead of just rural restricted access miles, as proposed in the "Updating Hotelling Hours in MOVES" Presentation to the MOVES Workgroup on Dec. 7, 2016

Summary

- EPA proposes creating and updating MOVES tables for workday idle fraction, average daily starts, start fraction, and soak fraction using an average of data from NREL and CE-CERT
  - Emissions impact are yet to be determined
  - EPA evaluated the impact of vocation using NREL data
    - By comparing vocation-weighted average for idle and daily starts over sourcetype and day
    - Averaging by vocation added complication without a clear benefit
- EPA proposes to use the data from NREL to update the combination long-haul truck hotelling activity

APPENDIX

Summary

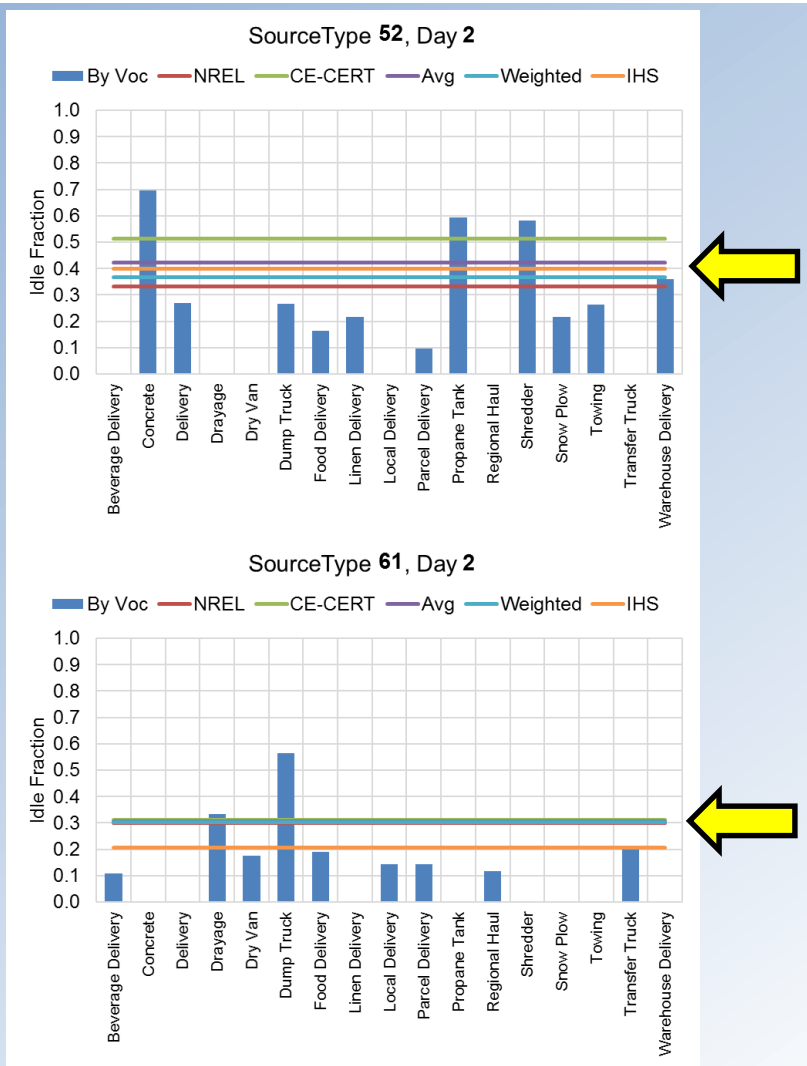
ANALYSIS OF VOCATION IMPACTS

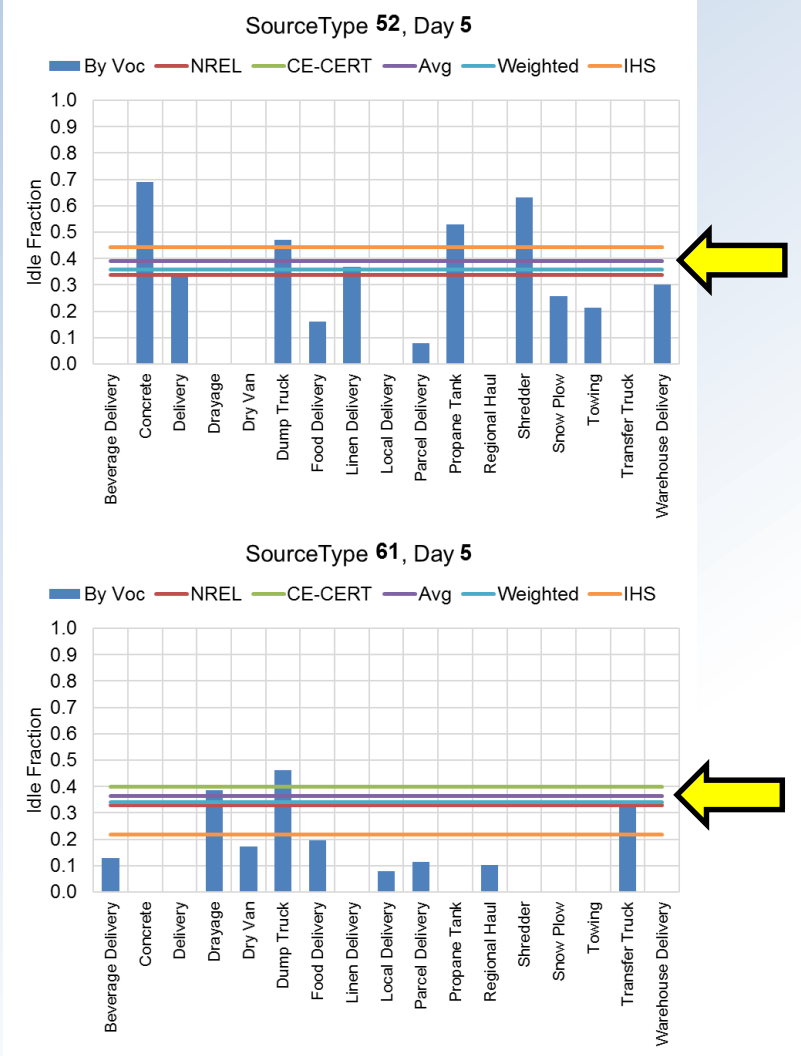
Compare Impact of Vocations

- NREL vocations mapped to IHS vehicle registration sub-groups
- Compared idle fraction and daily starts for NREL vocations to:
  - **NREL** only
  - **CE-CERT** only
  - **Average** of NREL and CE-CERT (equal weighting)
  - **Weighted** average of NREL and CE-CERT (by test population)
  - **IHS** weighted average from NREL vocations mapped to IHS sub-group

- In the graphs that follow, the yellow arrow (⇦) points to straight **Average** line that we recommend using to combine the NREL and CE-CERT data at this time

NREL Idle Fraction by Vocation





NREL Average Daily Starts by Vocation