



Using Vehicle Telematics for MOVES Activity Input

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Background

- EPA's MOtor Vehicle Emissions Simulator (MOVES)
 - Estimates emission for mobile sources at the national, county, and project level.
 - Estimate criteria air pollutants, greenhouse gases, and air toxics.
- MOVES default activity parameters are primarily nation wide averages.
- States are instructed to replace MOVES defaults with local data whenever possible.
- Telematics data will be used primarily to improve the default national averages.
- Telematics data can also be used to improve inputs for State and local areas.



Telematics

- Telematics refers to any technology that provides a continuous stream of vehicle activity data.
- Challenges for using telematics include:
 - Providing privacy for vehicle owners.
 - Processing massive amounts of data.
 - Potential self-selection bias.
- Opportunities include:
 - Detailed region-specific activity.
 - Extremely large samples.



Telematics Analysis Issues

- Screening to eliminate bad measurements.
- Identify and account for variations.
 - Which factors significantly affect results?
 - Are regional differences important?
 - Are seasonal differences necessary?
- Identify and account for potential vehicle selection bias.
 - Do samples include a sufficient number of seldom used and inactive vehicles?
- Some vehicles enter and leave the data collection during the sampling period.



Telematics Data Sources

- EPA is currently working with three sources of telematics data:
 - Verizon Telematics
 - The National Renewable Energy Laboratory (NREL) Fleet DNA clearinghouse of commercial fleet vehicle operating data
 - University of California Riverside, Bourns College of Engineering – Center for Environmental Research and Technology (CE-CERT).



Verizon Telematics

- Data collected for management of light-duty vehicles and fleets.
- Contracts with: State Farm, Mercedes-Benz and Volkswagen.
- Customers can consent to monitoring
 - Participants are offered incentives
- EPA purchased data collected from CA, CO, GA, IL & NJ.
 - Data spans August 2015 through August 2016.

<https://www.verizontelematics.com/>



Verizon Telematics Data

- Vehicle Information
 - Make, model, model year
 - Place of residence (zip code only)
- Trip Information
 - Date, time, length
 - Urban (MSA) or rural based on owner residence.
 - Vehicle/engine speed distribution summary.
- Data is limited to 1996 and newer model year light-duty vehicles with on-board diagnostic capability.



Verizon Data Sample

State	Total Trips (Original)	Total Trips (Idle)*	Total Trips (Soak Time & Starts)*	%Trips**
California	1,958,858	1,886,947	1,761,184	90%
Colorado	5,644,374	5,390,417	4,977,334	88%
Georgia	15,457,392	14,654,336	13,465,865	87%
Illinois	12,955,252	12,318,387	11,448,257	88%
New Jersey	5,139,506	4,947,792	4,615,346	90%

*Only valid trips included in Idle analysis. Only valid trips with previous recorded valid trips included in start and soak analysis.

** Percent of total trips remaining after all screening (starts divided by original total).



Target Analysis Variables

- Engine starts per vehicle per day.
- Soak time between engine starts.
- Temporal allocation of starts and soaks to hour of the day.
- Total idle time as a fraction of total trip time.

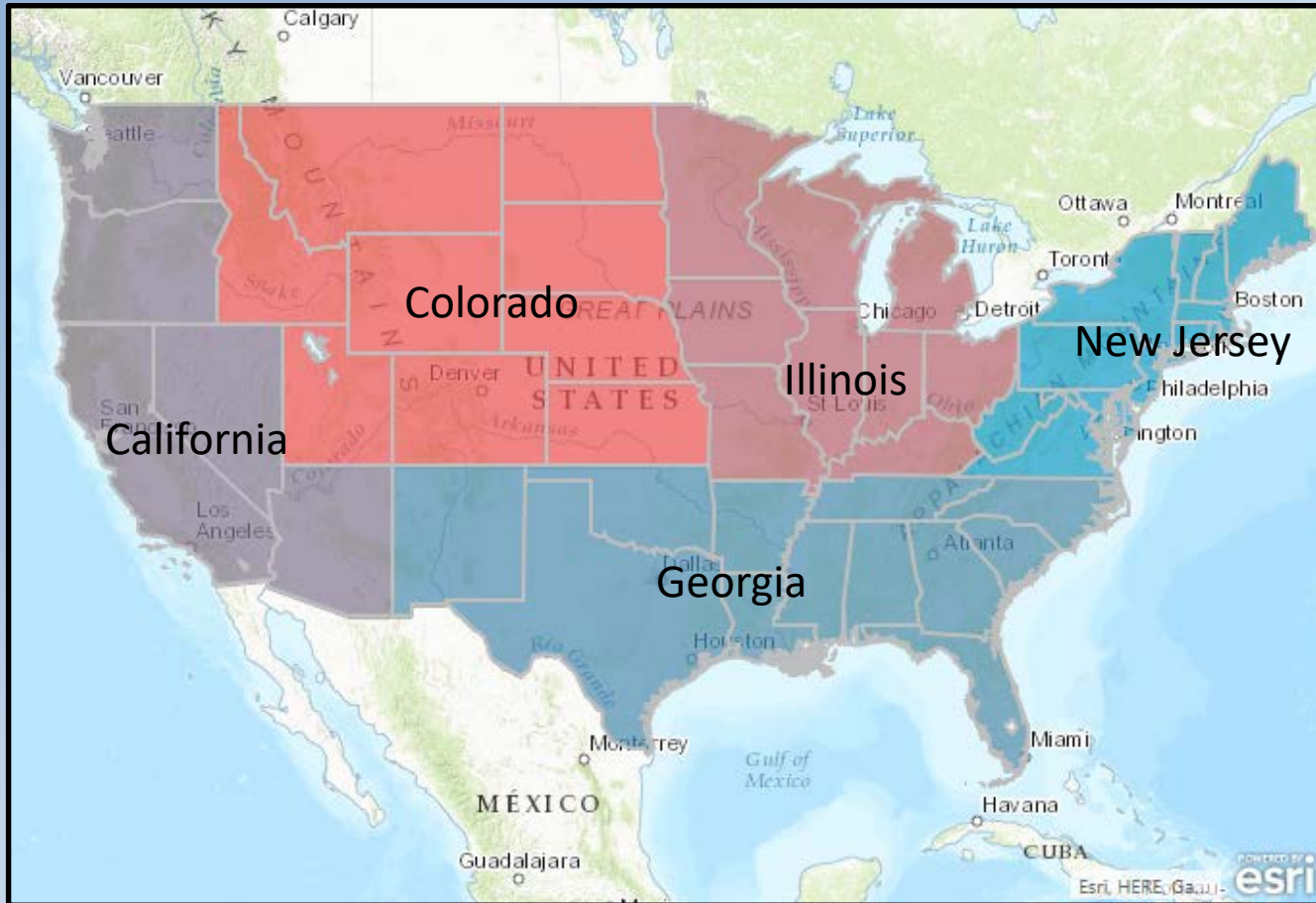


Calculating National Averages for MOVES

- The MOVES default database contains national averages for most activity.
- The results from each sampled state were used to represent a region.
- Light-duty vehicle populations in each region were used to weight the results from each sampled state.



Regions Selected for Weighting Light-Duty Activity



With data from only 5 states, we associate them with nearby states to create (a) weighted national averages or (b) regional-specific values.

Alaska is associated with Colorado.
Hawaii, Puerto Rico and the Virgin Islands are associated with California.

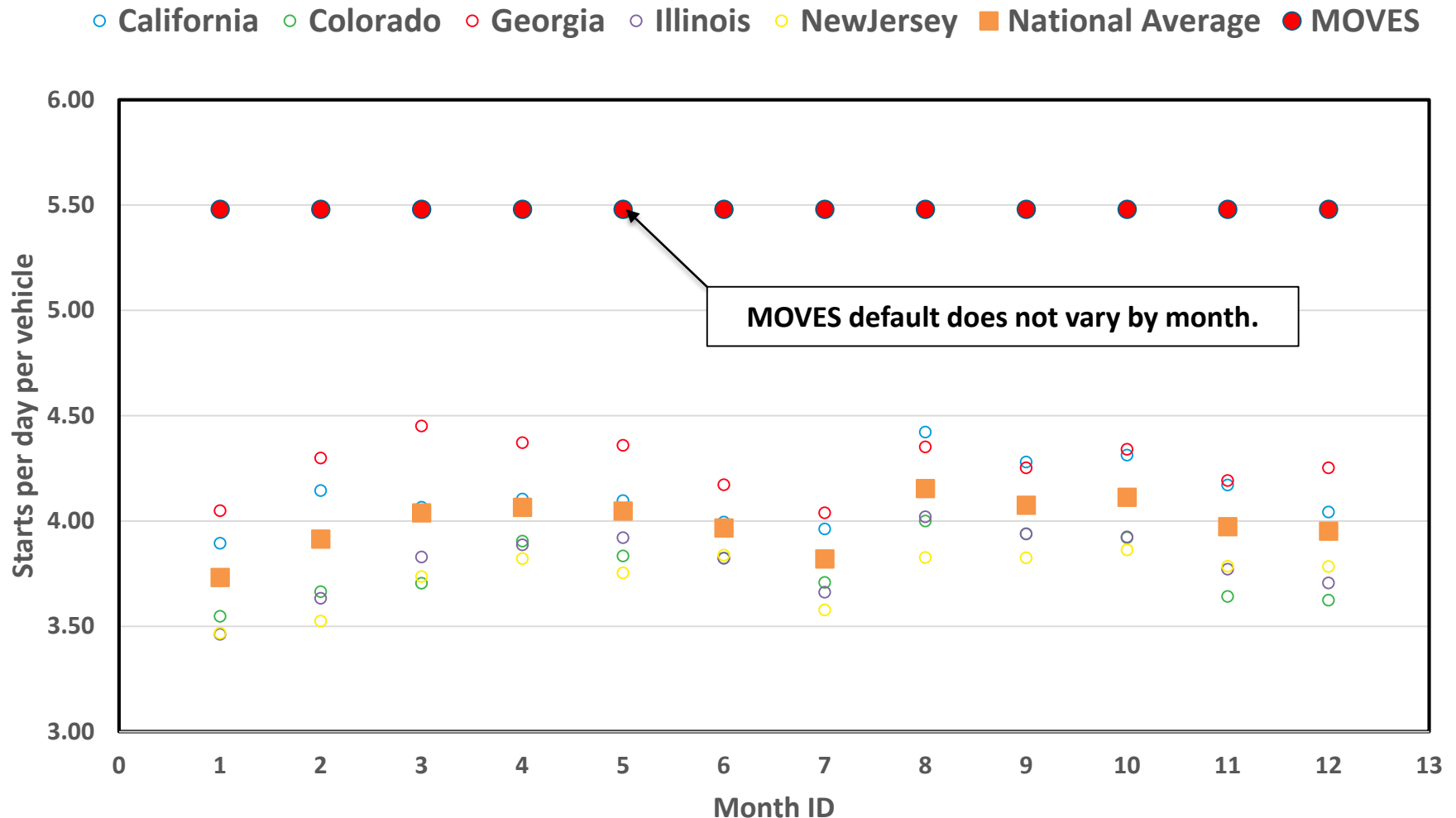


Vehicle Engine Starts

- Currently MOVES calculates the default number of starts per day per vehicle using trip information from a small set of instrumented vehicles distinguished by:
 - Source Type
 - Day Type (Weekday or Weekend Day)
- MOVES2014 added the capability to replace defaults with user-supplied:
 - Starts per day per vehicle.
 - Hourly start distribution.
 - Start adjustment for month of the year.

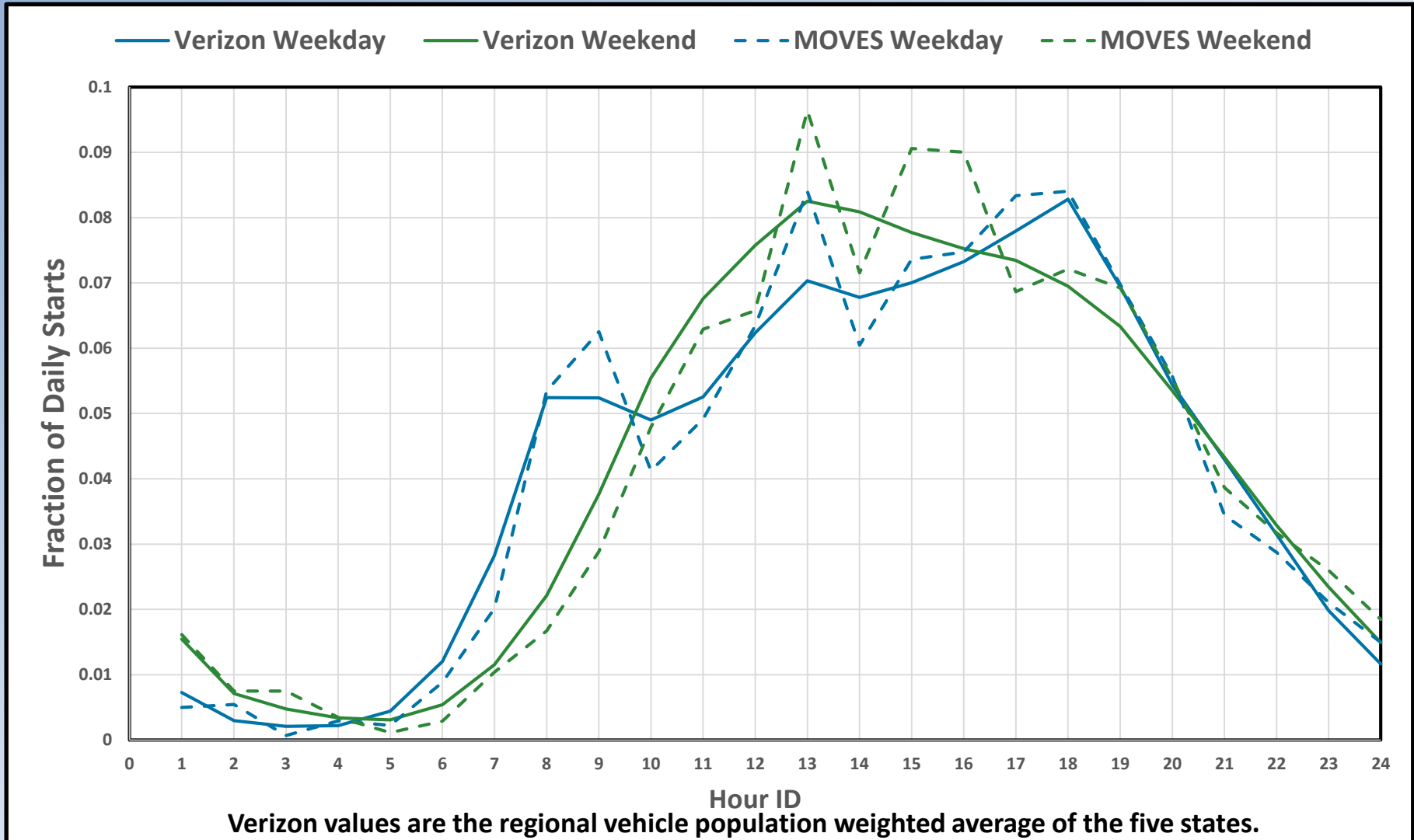


Verizon Weekday LDV Starts Per Day Per Vehicle



National average is the regional vehicle population weighted average of the five states.

Verizon National Average Temporal LDV Start Distributions



MOVES2014 Soak Times

- Soak time is the time period between key off and key on when the engine is not running.
- MOVES2014 calculates the default soak times using the same small set of sampled instrumented vehicles used for calculating starts per vehicle.
- In MOVES2014, these same soak times are used for calculations of evaporative emissions.
- The soak times for engine starts will be updated using the Verizon data.

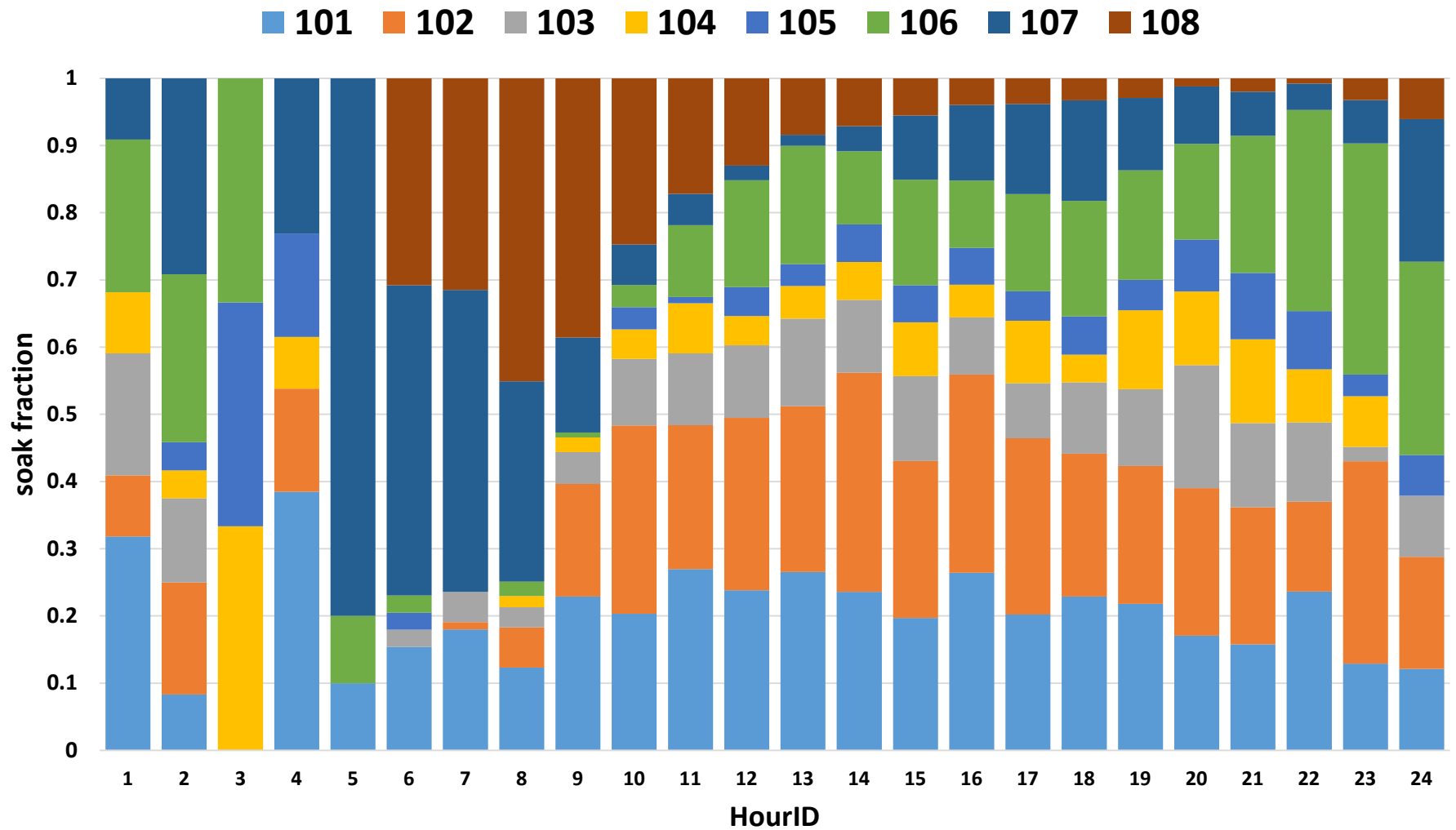


MOVES2014 Engine Soak Bins

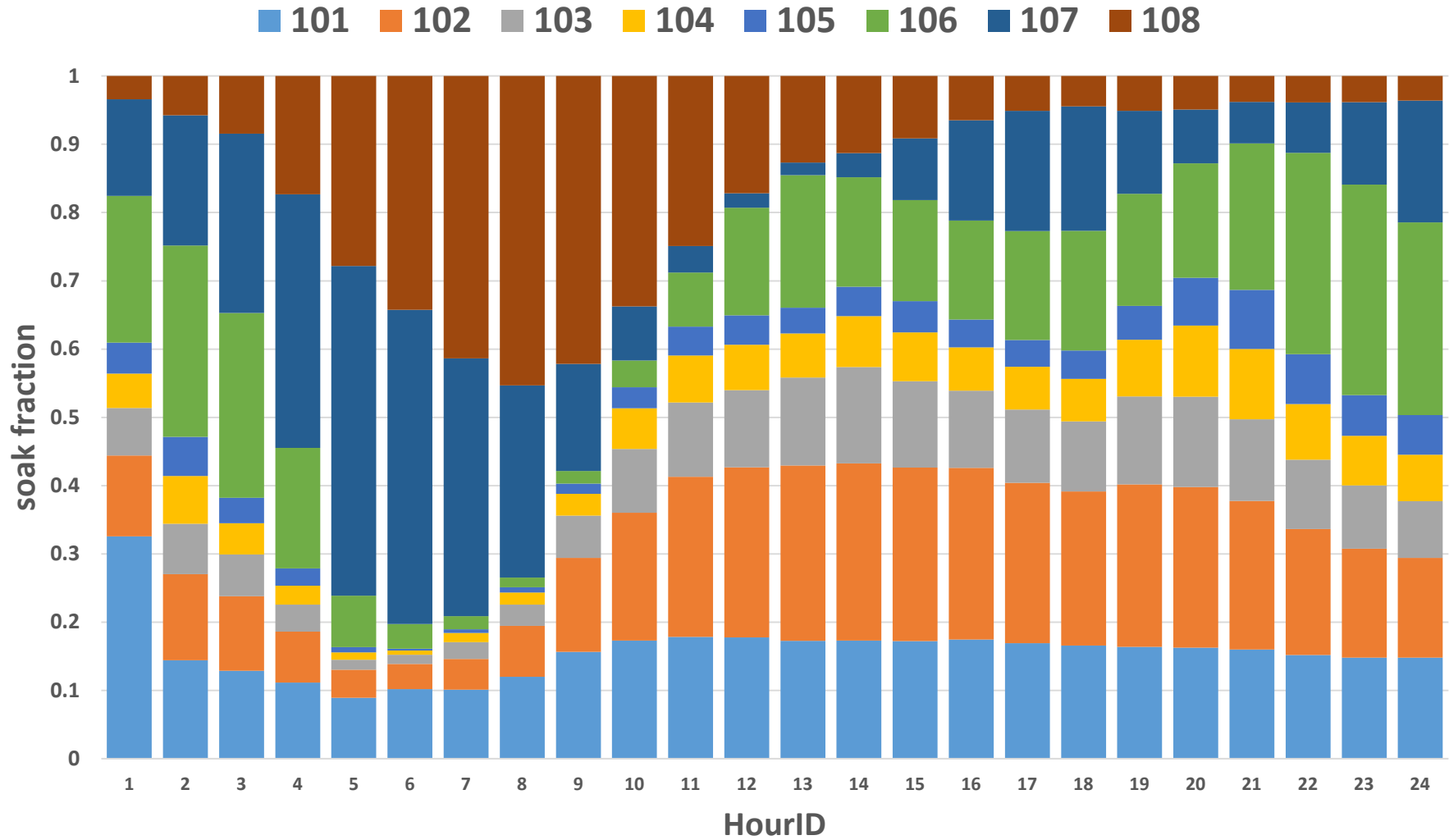
opModelID	Description
101	Soak Time < 6 minutes
102	6 minutes <= Soak Time < 30 minutes
103	30 minutes <= Soak Time < 60 minutes
104	60 minutes <= Soak Time < 90 minutes
105	90 minutes <= Soak Time < 120 minutes
106	120 minutes <= Soak Time < 360 minutes
107	360 minutes <= Soak Time < 720 minutes
108	720 minutes <= Soak Time



MOVES2014 Average LDV Soak Time Distribution for Weekdays



Verizon National Average LDV Soak Time Distribution for Weekdays



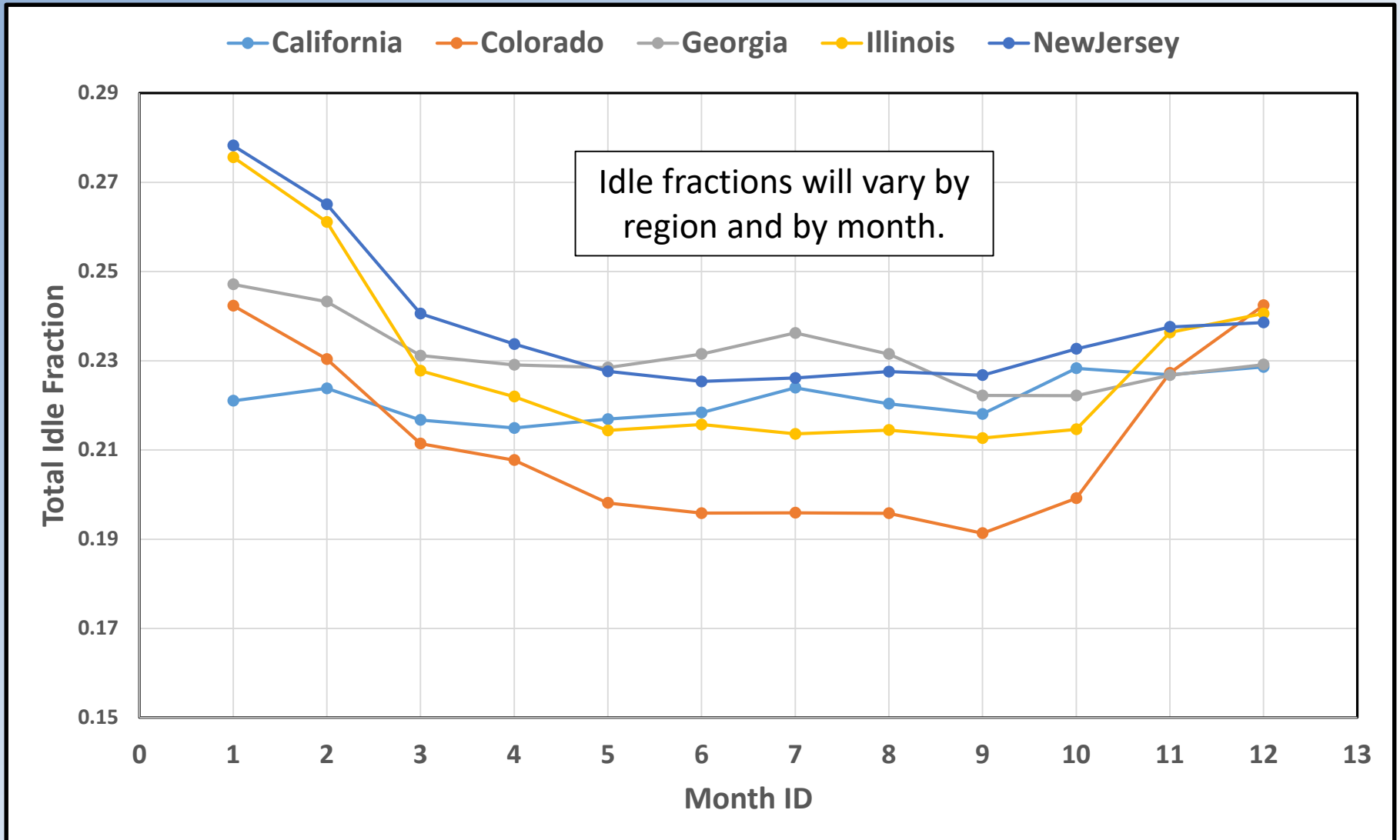
Verizon values are the regional vehicle population weighted average of the five states.

Engine Idle in MOVES2014

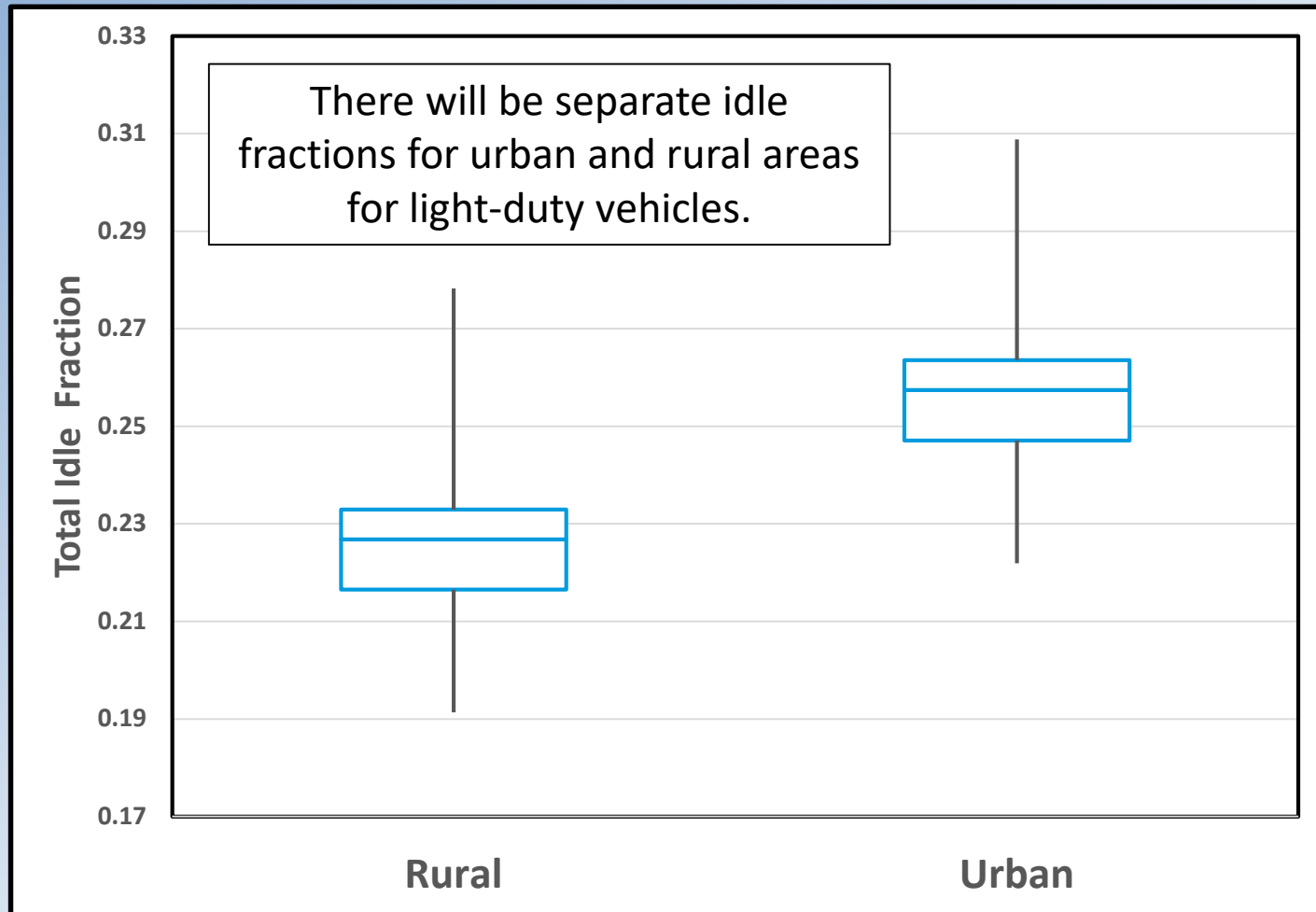
- Light-duty engine idle in MOVES2014 only occurs during the driving schedules.
 - Idle varies by average speed.
 - Idle varies by road type.
- Telematics data clearly demonstrates that total idle time included in the MOVES2014 driving schedules is too low.
 - EPA intends that the next version of MOVES will include an estimate of off-network idle to account for this additional idle time.



Total Weekday Urban LDV Idle Fraction



Verizon Five State Average Weekday Urban and Rural LDV Idle Fractions



“Urban” refers to data from counties within Metropolitan Statistical Areas.



Heavy-Duty Telematics

- EPA has obtained telematics summary results from NREL and CE-CERT measurements.
- Final analysis of the data has not yet been completed.
- Data analysis will address:
 - Engine starts per vehicle per day.
 - Soak time between engine starts.
 - Temporal allocation of starts and soaks to hour of the day.
 - Total idle time as a fraction of total trip time.



NREL Heavy-Duty Telematics

- The National Renewable Energy Laboratory (NREL) operates the Fleet DNA clearinghouse of commercial fleet vehicle operating data
- The DNA data collects real-world vehicle operation data for medium- and heavy-duty commercial vehicles from a variety of vocations and locations

<https://www.nrel.gov/transportation/fleettest-fleet-dna.html>



NREL Vehicle Sample

Fleet DNA Vehicles Matching the MOVES Source Types									
MOVES				Vehicles with	Fuel			Powertrain	
sourceTypeID	Description	Vehicles	Electric	Engine RPM	Diesel	CNG	Propane	Conventional	Hybrid
42	Transit Buses	71	12	56	27	12	17	45	11
43	School Buses	256	0	11	7	2	2	11	0
51	Refuse Trucks	86	0	86	65	21	0	61	0
52	Single Unit Short-Haul	698	446	211	211	0	0	146	64
61	Combination Short-Haul	226	0	208	206	2	0	160	46
62	Combination Long-Haul	85	0	85	85	0	0	85	0

Analysis will only contain the conventional vehicles.

- Analysis sample includes:
 - Only vehicles with engine RPM data, needed to identify engine operation times.
 - Only conventional powertrain trucks (no hybrids).



NREL Engine Operation Data

Summary of NREL Data used for Starts and Idle Analysis				
Source Type	ID	Seconds of Data	Weekdays	Weekend
Transit Bus	42	17,369,566	339	62
School Bus	43	3,247,704	230	-
Refuse	51	26,466,050	1,097	40
Single Short Haul	52	68,602,358	3,080	508
Comb. Short Haul	61	174,818,257	4,567	956
Comb. Long Haul	62	208,262,098	3,877	1,300
Totals:		498,766,033	13,190	2,866
(Hours)		138,546		



CE-CERT Heavy-Duty Data

- University of California Riverside, Bourns College of Engineering – Center for Environmental Research and Technology (CE-CERT).
- Instrumented heavy-duty trucks selected by vocation from 19 different groups.
- All trucks were 2010 and newer model year, except for one 2008 drayage truck. All buses were CNG fueled.



CE-CERT Vehicle Sample

Source Type	SourceTypeID	Total Vehicles	Vehicle Miles Traveled	Days	Trips
Transit Bus	42	16	121,633.3	1,448.9	10,171
Refuse Truck	51	6	25,526.1	597.4	2,288
Single Short Haul	52	30	89,203.7	2,764.5	12,235
Single Long Haul	53	2	22,079.0	132.4	953
Comb. Short Haul	61	27	109,231.6	10,269.5	16,623
Comb. Long Haul	62	9	139,384.5	535.5	6,671
	Grand Total	90	507,058.3	15,748.1	48,941

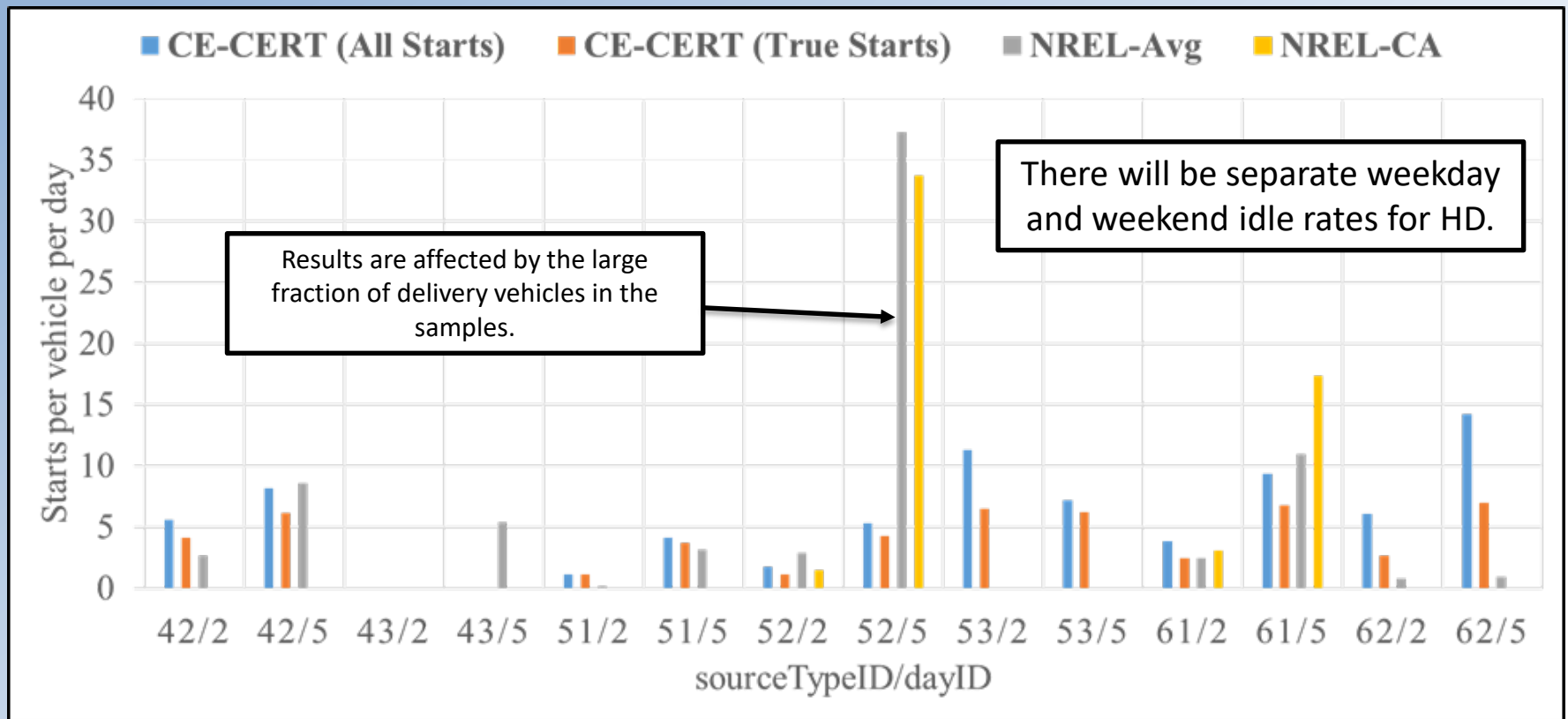


Issues in Analyzing Engine Starts

- Some trucks equipped with start/stop technology stop their engines during trips.
 - Mid-trip starts caused by start/stop technology have been removed from the analysis.
- Since MOVES start activity applies to all model years, the effect of start/stop technology needs to be removed from the defaults.
- Start/stop effects on engine start emissions will be an issue to address separately.



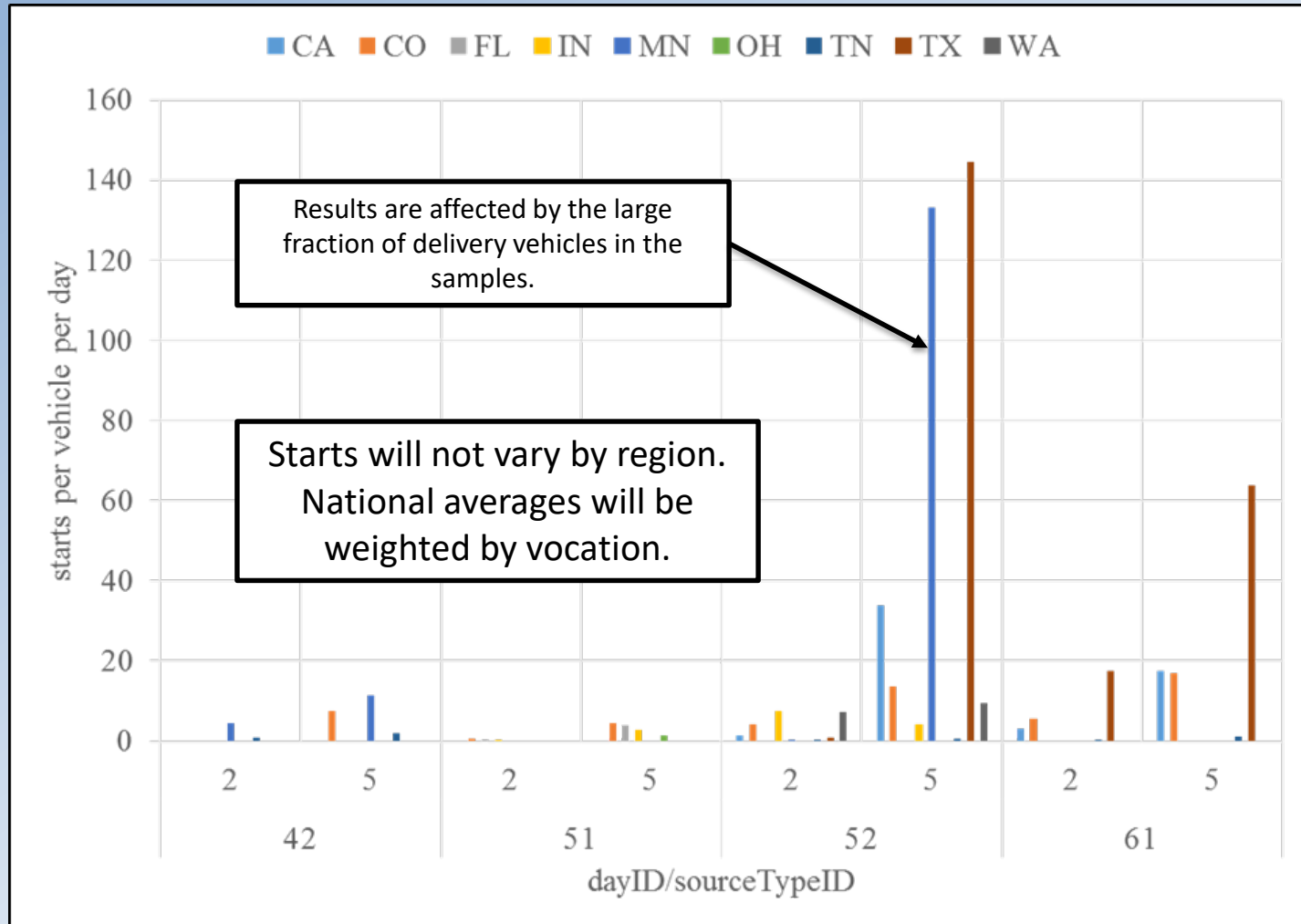
Comparison of Starts Per Day



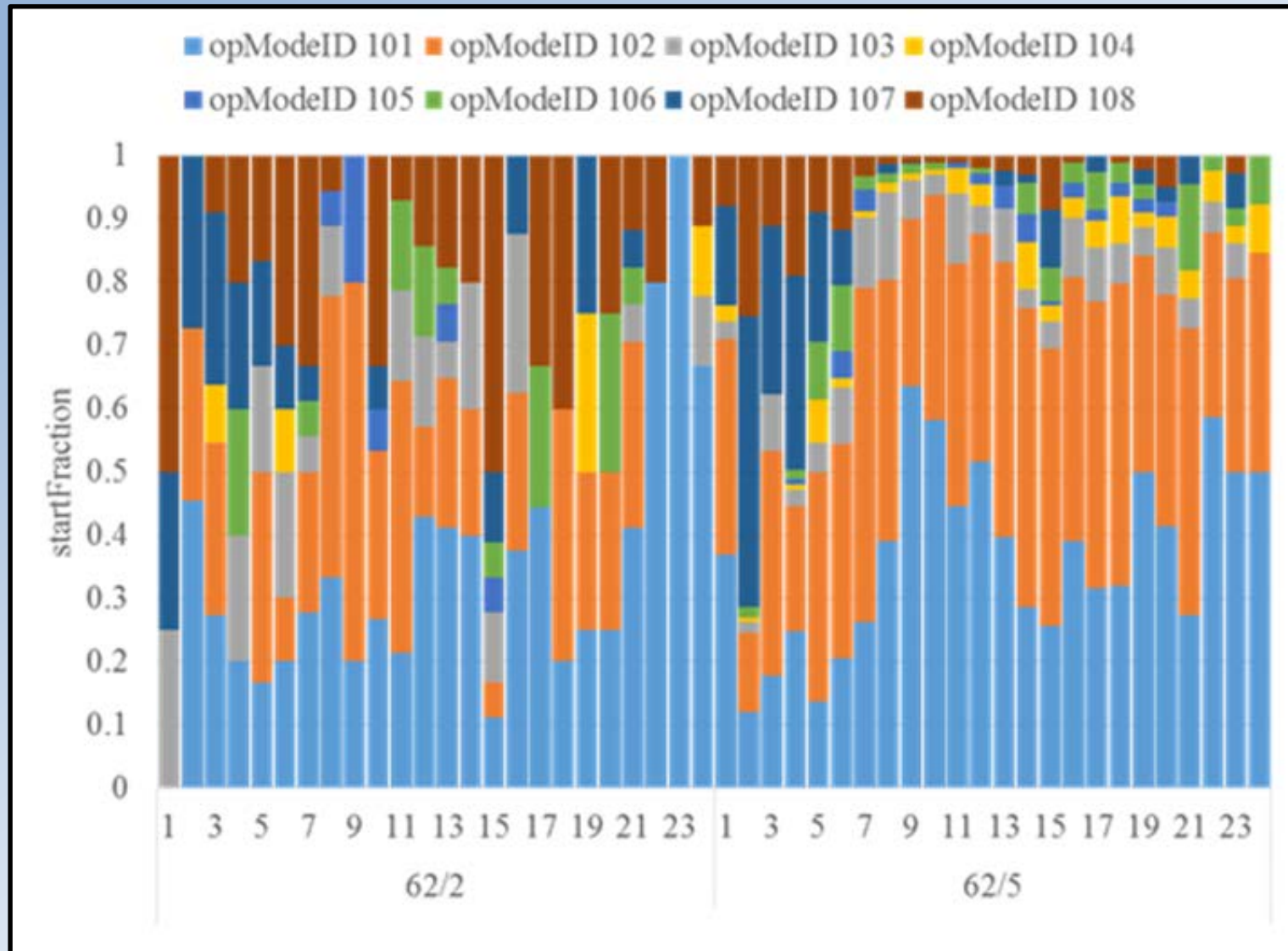
SourceTypeID - (42:Transit Bus, 43:School Bus, 51:Refuse Truck, 52:Single-Unit Short-Haul, 53:Single-Unit Long-Haul, 61:Combination Short-Haul, 62:Combination Long-Haul)
 DayID - (2:Weekend, 5:Weekday)



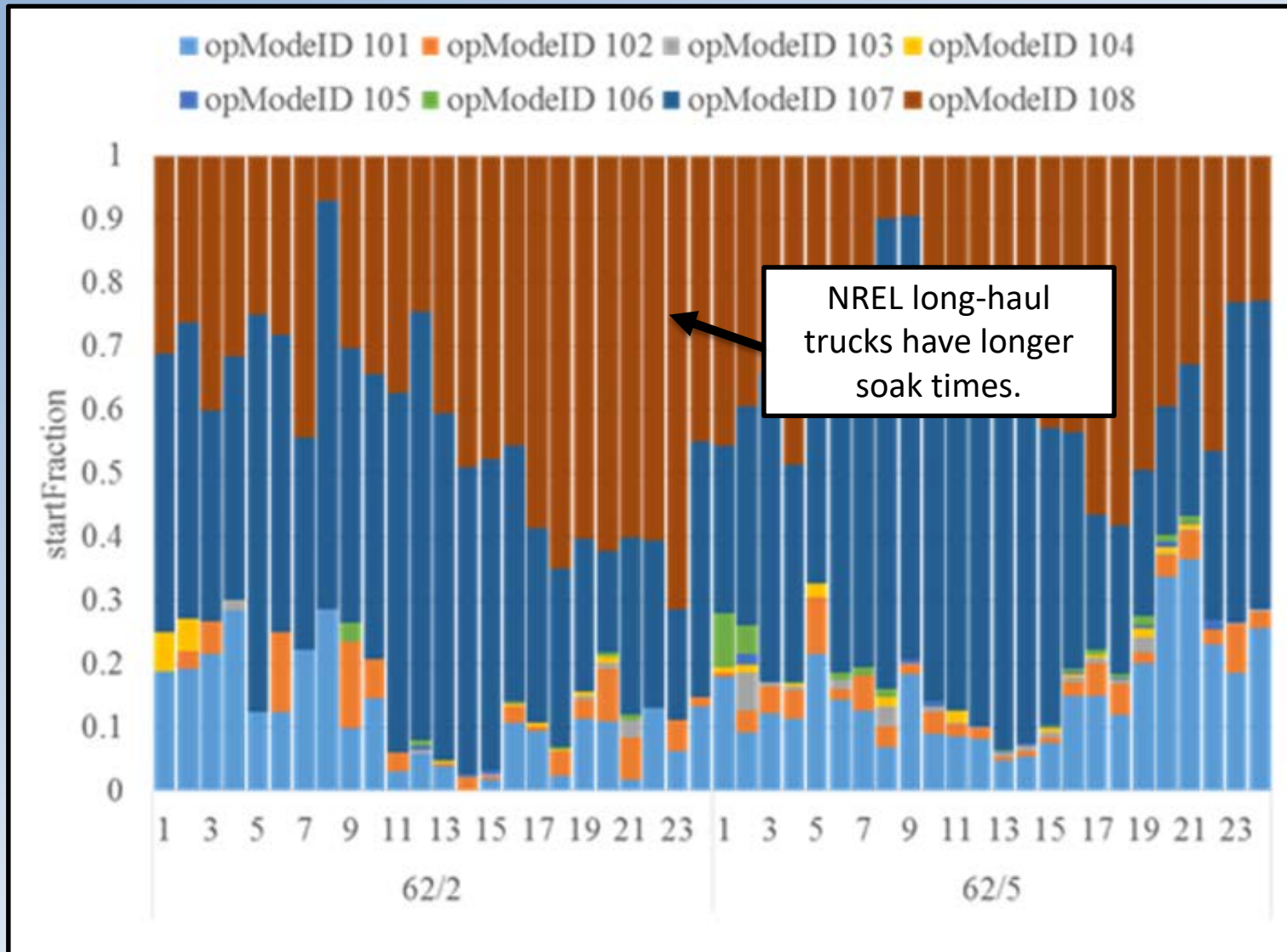
Starts Per Day by State



CE-CERT Soak Time Distributions



NREL Soak Time Distributions



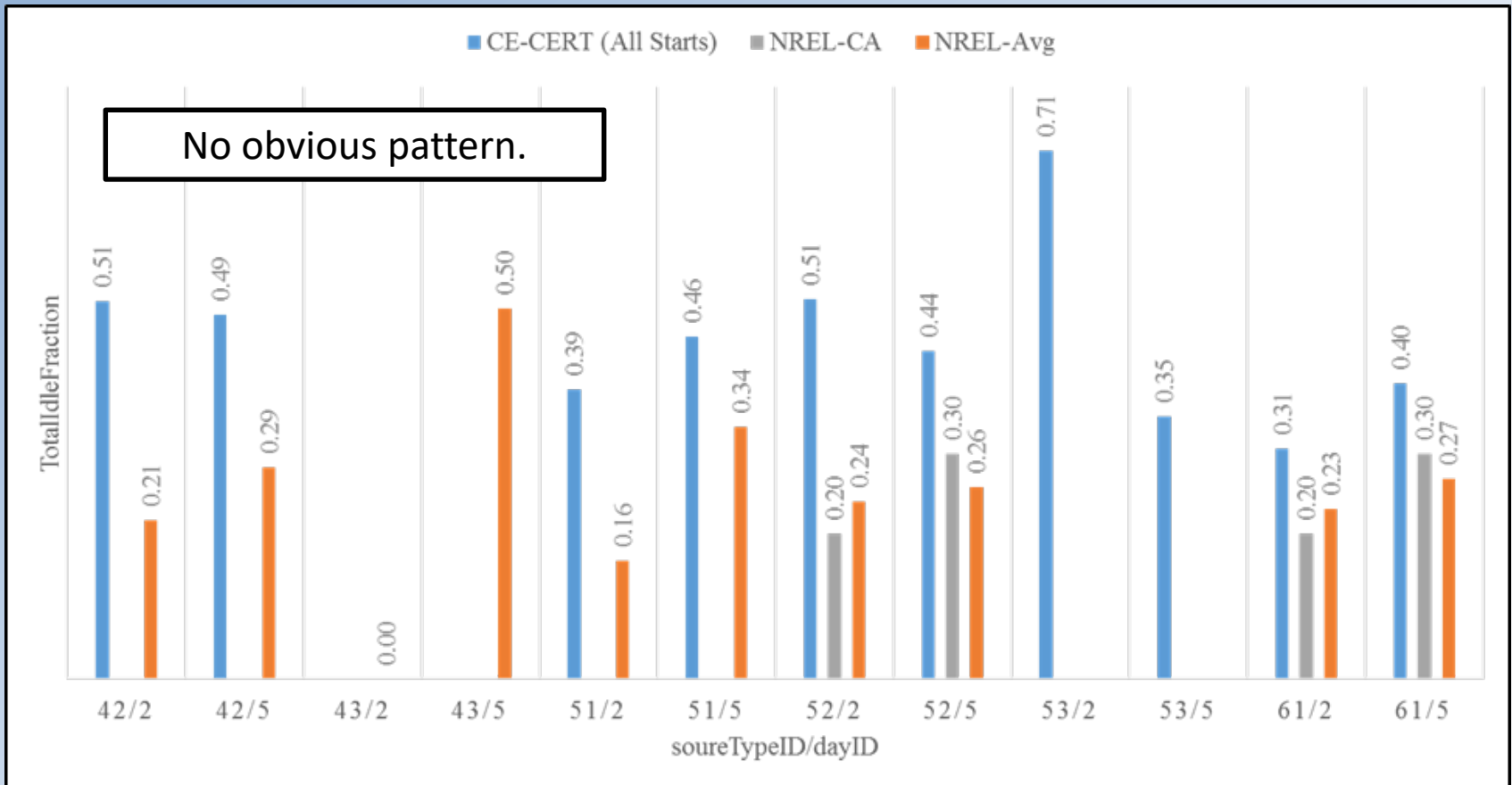
Long-Haul Combination Truck Idle Fractions

- Extended idle is an important issue for long-haul combination trucks:
 - Hotelling greatly increases total idle time.
 - MOVES2014 reports hotelling idle separately.
- NREL reported idle time greater than one hour as “extended idle” separately from total idle.
- CE-CERT data includes no extended idle.

Long-Haul Combo	Idle Fractions			
	CE-CERT	CE-CERT	NREL	NREL
	Total	Extended	Total	Extended
Weekend	0.34	0	0.25	0.13
Weekday	0.24	0	0.25	0.14



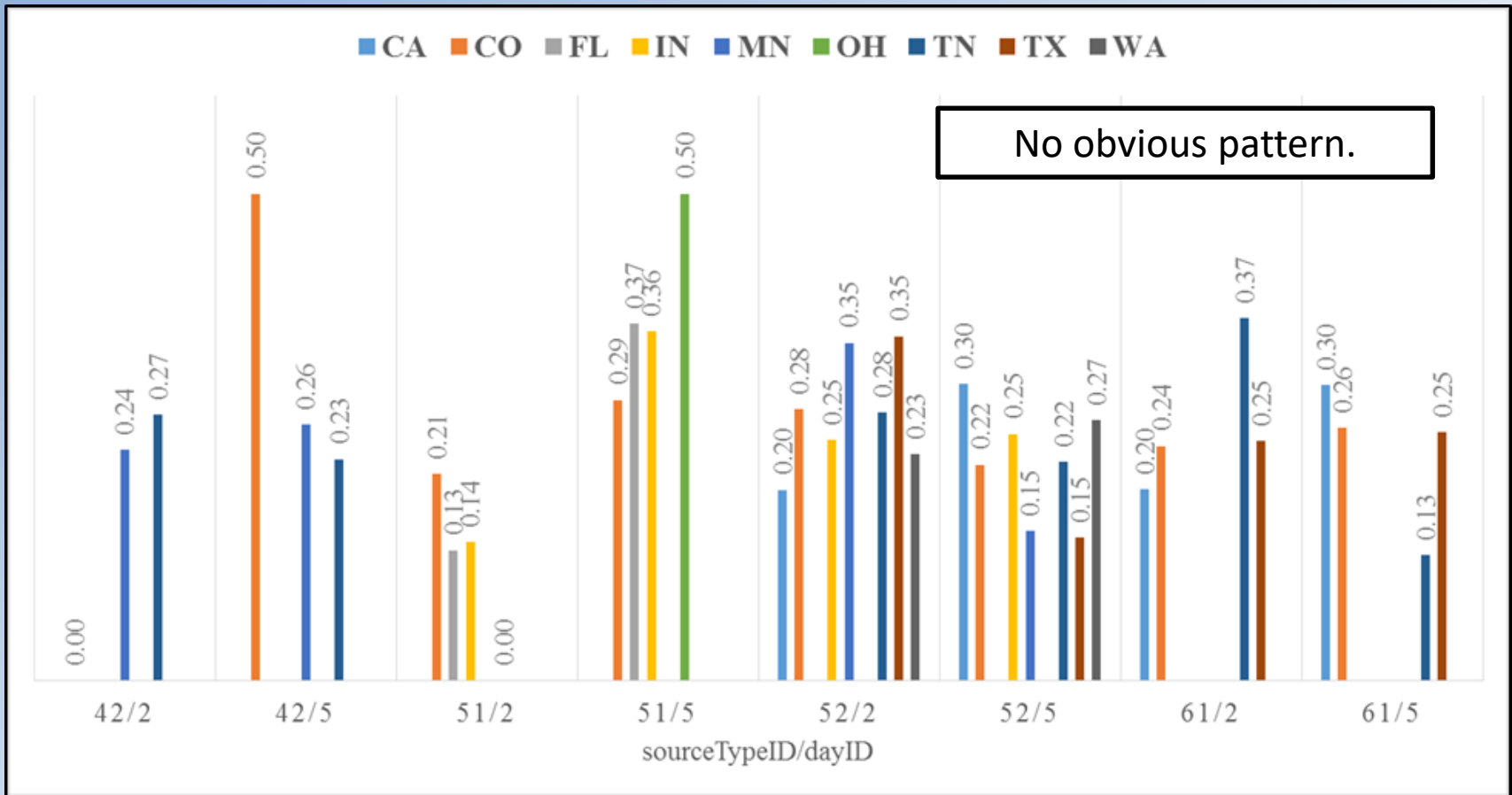
Total Idle Fractions by Source Type and Day Type



Total idle excludes idle periods lasting more than one hour.



Idle Fractions by State



Total idle excludes idle periods lasting more than one hour.



Combining Data Sources for Heavy-Duty

- Updated heavy-duty vehicle activity will not vary by urban/rural.
- Truck vocation appears to be the most important factor that affects engine starts.
 - Default engine start activity for the next version of MOVES will be calculated by weighting results by vocation.
 - Vocation distributions will be derived from the recent EPA data purchase from IHS/Polk for calendar year 2014.



NREL Sample Vocations

Combination Short-Haul	Vehicles	Single-Unit Short Haul	Vehicles
Beverage Delivery	10	Warehouse Delivery	10
Food Delivery	13	Parcel Delivery	39
Local Delivery	7	Food Delivery	30
Parcel Delivery	6	Linen Delivery	17
Drayage	29	Snow Plow	14
Freight	22	Towing	4
Tanker	25	Shredder	1
Refrigerated Truck	7	Propane Tank	1
Dump Truck	5	Dump Truck	3
Concrete	3		
Regional Haul	1		
Transfer Truck	29		
Dry Van	3		



Summary—Plans for the Next Version MOVES

- Update default start frequency and soak distributions for light-duty and heavy-duty vehicles.
 - LD based on national average Verizon data.
 - HD based on CE-CERT and NREL data.
- Add off-network idle.
 - LD based on urban/rural region-specific Verizon data.
 - HD based on CE-CERT and NREL data.
- No update to soak time activity for evaporative emissions calculations.

