



MOVES

Motor Vehicle Emission Simulator

Vehicle Idle Activity in MOVES

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Idle Operation in MOVES2014

- In MOVES overnight idling by long haul combination trucks is accounted for as the Extended Idle fraction of Hotelling emissions.
- All other idling in MOVES (national and county level) is estimated as the portion of driving schedules where the speed is zero.
 - Restricted (freeway) roadway schedules have little or no idle time.
 - Unrestricted roadway schedules with lower average speeds have more idle than those with higher speeds.



Road Types in MOVES

roadTypeID	Description	FHWA Functional Types
1	Off Network	Off Network
2	Rural Restricted Access	Rural Interstate
3	Rural Unrestricted Access	Rural Principal Arterial, Minor Arterial, Major Collector, Minor Collector & Local
4	Urban Restricted Access	Urban Interstate & Urban Freeway/Expressway
5	Urban Unrestricted Access	Urban Principal Arterial, Minor Arterial, Collector & Local



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 effective at reducing NOx when the exhaust temperature is below (~250°C). Low 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.



Verizon Illinois Data

EPA is obtaining data from Verizon that includes information about total idle time for light-duty cars and trucks.

Trip Data

VEHICLE_ID	3
STARTX	1/1/2013 8:29
AVERAGE_SPEED	3.10572
MAX_SPEED	38.52501
ENDX	1/1/2013 9:06
TOTAL_MILES	1.90951
StartDate	1/1/2013
StartTime	8:29:01
TripDuration	4378
IdlingDuration	3608
IF	0.8241206

Vehicle Metadata

MAKE	FORD
MODEL	EXPEDITION
MODEL_YEAR	2004
CAR_TRUCK	T
MOBILE6	LDT
IM	0
URBAN	1
zip_5	61704
COUNTY	MCLEAN
STATE	IL

County refers to vehicle registration; not location of trip.

Idle fraction (IF) = $\frac{\text{Source Hours Idling (SHI)}}{\text{Source Hours Operating (SHO)}}$



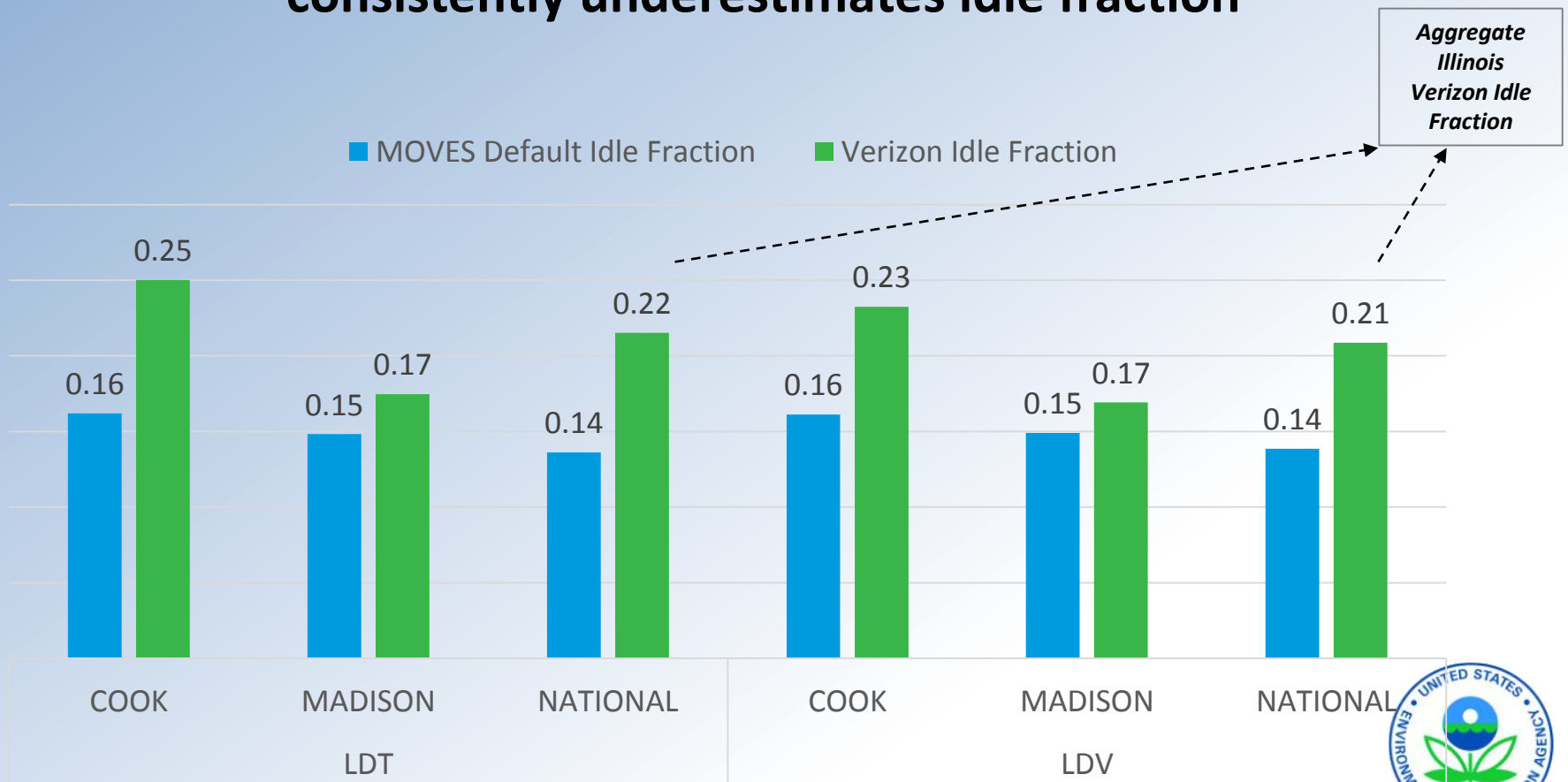
MOVES Default Idling

- MOVES calculates the running exhaust operating modes from the driving schedules, including idle.
- The amount of idle depends on the choice of drive cycle, and, thus, the mix of road types and the average speed distributions.
- Increasing default idle time means:
 - adding additional “source hours operating” to vehicles in addition to the time spent by vehicles on roads
 - more exhaust idle emissions.



Verizon Illinois Data

Compared to the Verizon data for Illinois counties, MOVES consistently underestimates idle fraction



National refers an aggregated Illinois Verizon idle fraction and MOVES national averages.



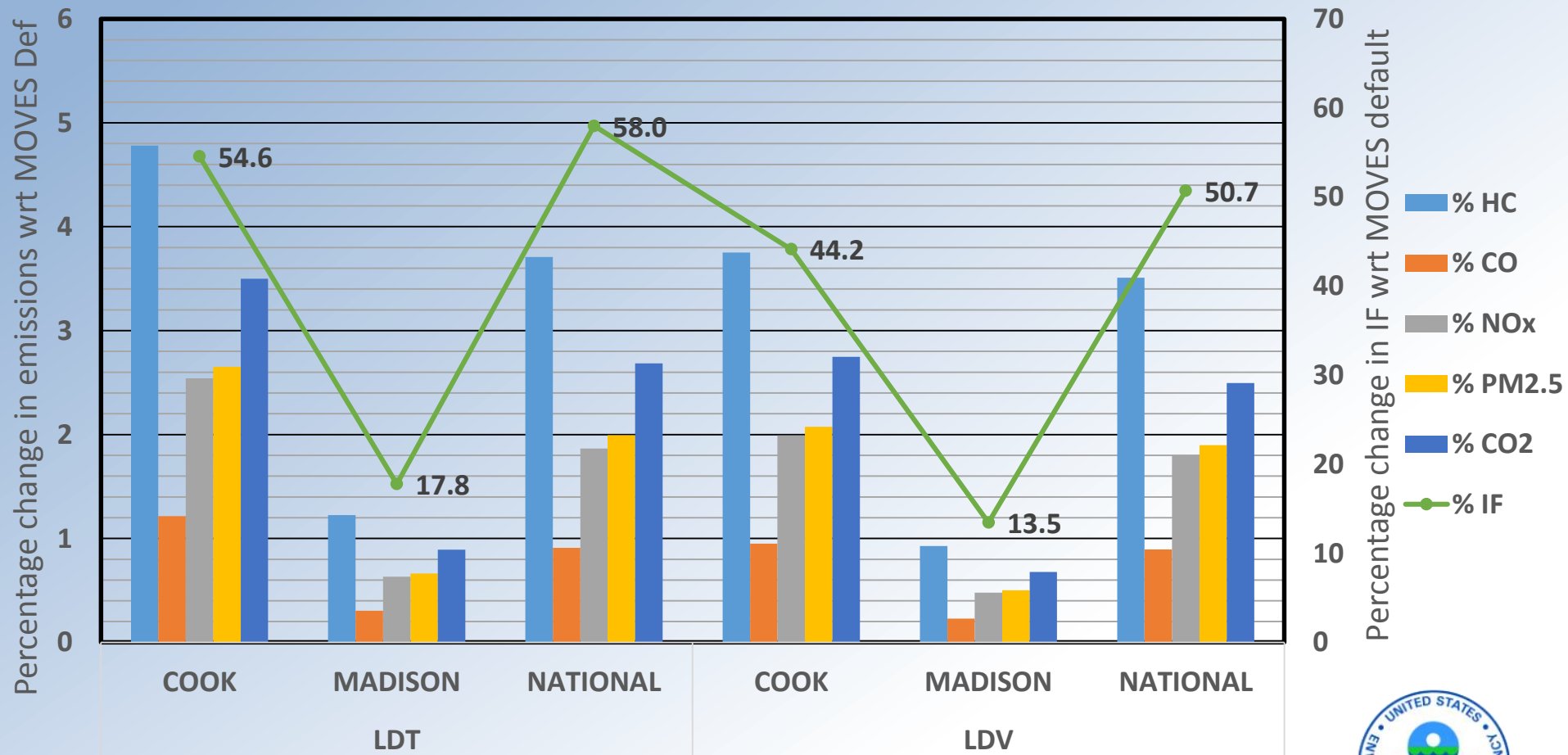
Relative Emissions Impact

- The potential emission impact of increasing idle time can be estimated by manually calculating the emissions resulting from an operating mode distribution.
 - Emission rates for each operating mode (including idle) are available in the MOVES default database.
 - Default operating mode distributions for any location can be determined from local road type distributions and average speed distributions.
 - From this, the relative impact (percent change) can be determined for any location.



Light-duty Exhaust Running Emissions

Impact of using Verizon Idle Fractions



$$\text{Percent Change} = \frac{X_{\text{Verizon}} - X_{\text{MOVES}}}{X_{\text{MOVES}}} * 100$$

Adding Idling to MOVES

Considerations:

- The available data (Verizon telematics) does not specify where the idling occurs, just the fraction of the total time
- Much of the increase in idle time likely does not occur on roadways.
- For additional idling that does occur on roadways, we don't know how to vary with average driving speed (that is, how much to add to each driving schedule).
- Allowing separate output of the additional idle may be useful.



Off-Network Idle Proposal

- Added idle hours would be reported as off-network exhaust emissions for all sourcetypes (light duty and heavy duty).
 - We expect some fraction of the “additional idle” does occur on roadways
 - However, allocating all to to the off-network avoids the need to make assumptions about where the idling happens
 - Because MOVES does not currently report any exhaust running emissions for the off-network road type, this approach allows the “additional” idle to be a separate output if desired.
- Emission calculations would use the same emission rate used for the idle operating mode used for driving schedules.
- Emission rates could be reported as both mass per hour and mass per vehicle.



Off-Network Alternative

The Verizon data provides idle hours as a function of time.

- Our proposal links the idle fraction to the total hours of vehicle operation:
 - Idle hours would be sensitive to average speeds.
- An alternative approach would link the idle fraction to the distance:
 - Total idle hours would be unaffected by changes in average speeds.
 - However, Verizon distance is estimated, not measured.



Calculating Off-Network Idle

- Since driving schedules already include idle time, off-network idle hours must not double-count idling already included in roadway estimates.
- We propose that MOVES determine the amount of idle in the driving schedules during run-time.
 - This on-network idle time will continue to vary depending on the average speed distribution and road type mix.
 - Speeds and road types depend on time, location and user inputs.
- The proposed method will reconcile differences between idle hours estimated currently in MOVES from drive cycles with the idle hours observed in vehicle telematics data (Verizon).



Calculating Total Vehicle Idle

Knowing the total hours idle fraction (TIF) of total source hours operating (from Verizon data), the total source hours of idle (SHI) can be calculated from the total source hours operating (SHO) calculated by MOVES.

$$\mathbf{SHI}_{\text{MOVES}} = \mathbf{TIF}_{\text{Verizon}} * \mathbf{SHO}_{\text{MOVES}}$$



Calculating Off-Network Idle

- Total source hours operating (SHO) in MOVES will need to be the sum of:
 - The off-network idle hours.
 - SHO for roadTypeID = 1
 - The operating hours calculated for the driving schedules
 - SHO for roadTypeIDs 2, 3, 4 & 5.
- Currently MOVES only accounts for the SHO calculated for the on-network driving.



Calculating Off-Network Idle

Summing the SHO calculated for the driving schedules (roadTypeIDs 2, 3, 4 & 5) with the off-network SHO for (roadTypeID=1) gives the new total source hours operating (SHO).

$$SHO_{\text{MOVES}} = \left(\sum_{i=2}^5 SHO_i \right) + SHO_1$$

where $i = \text{roadTypeID}$



Calculating Off-Network Idle

The total idle fraction (TIF) is the ratio of the source hours of idle (SHI) from both the driving schedules and off-network, divided by the total source hours operating (SHO), including the additional idle.

$$\text{TIF}_{\text{Verizon}} = \frac{(\sum_{i=2}^5 \text{SHI}_i) + \text{SHO}_1}{(\sum_{i=2}^5 \text{SHO}_i) + \text{SHO}_1}$$

where $i = \text{roadTypeID}$



Calculating Off-Network Idle

The previous equation can be rearranged with TIF as an input and off-network idle time (SHO1) as the result.

This will be calculated by MOVES at run time as a function of on-network activity.

$$SHO_1 = \frac{(\sum_{i=2}^5 SHO_i) \times TIF_{Verizon} - \sum_{i=2}^5 SHI_i}{(1 - TIF_{Verizon})}$$

where $i = roadTypeID$



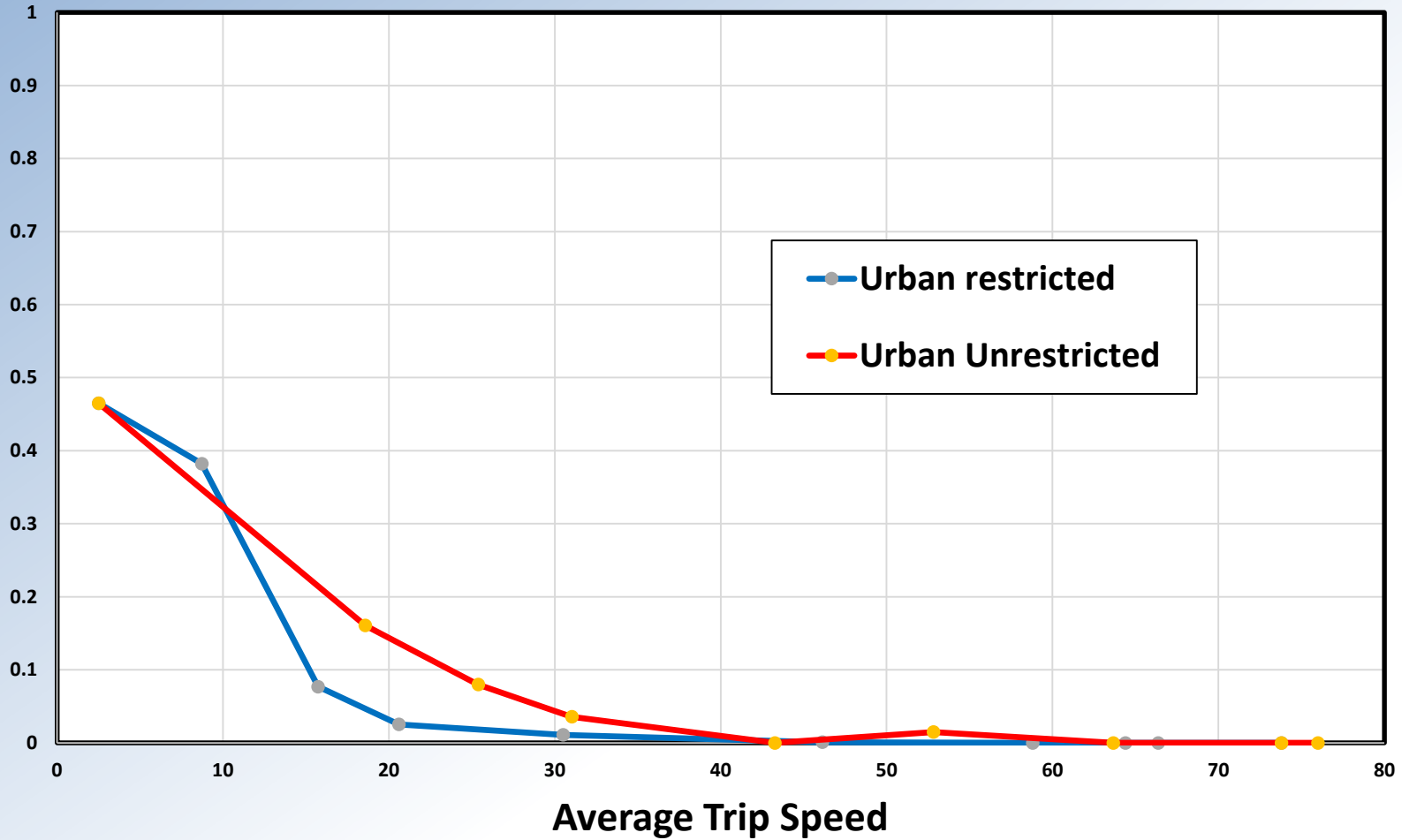
Case Study

This case study is intended to demonstrate how the proposed off-network idle can be impacted by changing average speed inputs.

- Baseline Scenario:
 - Passenger cars
 - A mix of road types
 - Area wide average speed = 35 mph
 - Target total idle hours = 25% of on-network hours operating
 - On-network idle hours = 17.4% of on-network hours operating
- Test Scenario
 - Passenger cars
 - A mix of road types
 - Area wide average speed = 40 mph
 - Target total idle hours = 25% of on-network hours operating
 - On-network idle hours = 14.6% of on-network hours operating



Drive Schedule Idle Fractions

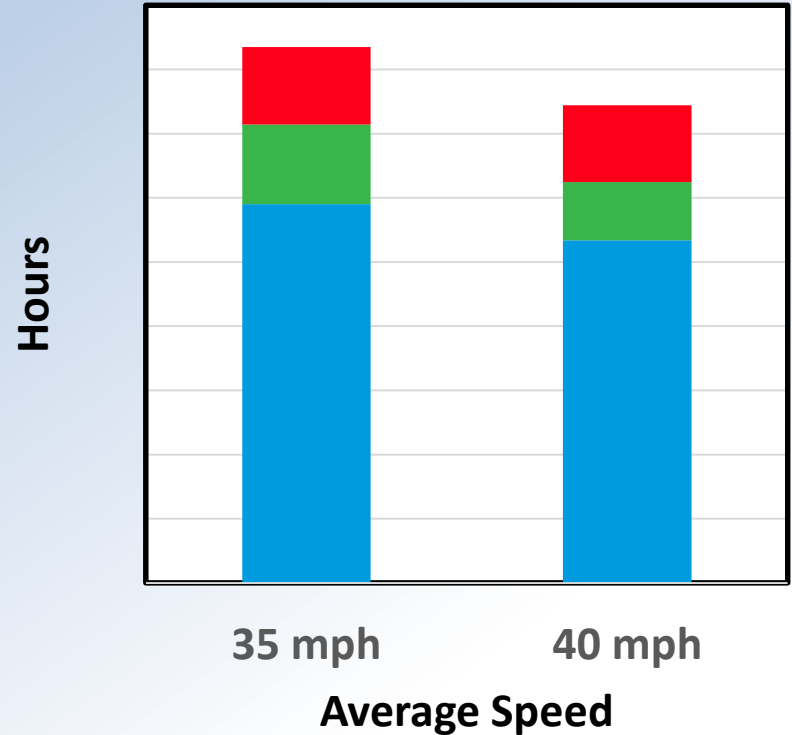


In general, increasing average speeds decreases idle time.



Case Study

- Adjust the scenario to use higher speed driving schedules:
 - Average speed is now 40 mph.
 - Driving schedule hours reduced 12.6% (less stop and go).
 - Drive schedule idle hours reduced 26.9%.
 - Off-network idle hours reduced 1.1% (from reduced total hours).
 - Total idle hours reduced 14.2%.
 - Total operating hours reduced 10.9%.



- Off-Network Idle
- Drive Schedule Idle
- Non-Idle Driving Hours



Case Study Results

- Increasing average speed decreased the overall source hours operating (SHO).
- Decreasing the overall source hours operated, decreased the total idle hours (e.g idle fraction * SHO).
- Increasing the average speed, decreased the amount of idle that occurred on the roadway by using a driving cycle with a higher average speed.
- Off-network idle is the difference between the drive cycle idle hours and the total idle hours.
- In this case, the off-network idle hours also decreased (slightly) because the total idle hours decreased more than the drive cycle hours.



Case Study Summary

- The proposed method reconciles differences between on-network idle hours estimated currently in MOVES with the idle time measured from vehicle telematics data.
- Total idle will always decrease with decreasing source hours operating.
- Off-network idle hours may increase or decrease with a change in source hours operating, depending on how the drive cycle idle changes relative to the total idle hours.
- This reconciliation may result in non-intuitive changes in the off-network idle hours.
- Despite this drawback, we are proposing this method, because:
 - It stays true to our data sources on total idle time, driving cycles, and user supplied average speed and roadtype VMT.
 - It is flexible, e.g. MOVES will dynamically calculate off-network idle with new driving cycles, user supplied idle time fractions, average speeds, and roadtype VMT.



Additional Idle Data

- EPA has purchased Verizon data from four additional states (CA, CO, GA, & NJ).
- EPA will be analyzing results from two heavy-duty databases:
 - FLEET DNA activity database by NREL.
 - CE-CERT/ARB heavy-duty instrumented vehicles study in California.
- Data will inform default idle fractions in MOVES
- EPA will evaluate regional and temporal differences in the data by source type.



User Input Options

- EPA is considering options that will allow users to calibrate idle hours to match local information.
- Detailed user input is already available at Project Level.
- What kind of detail might users need for County Level runs?



Summary

- EPA plans to add an new “Off-network idle” output, and options for user input.
- Data analysis of idle hours is on-going, so potential emissions impact are yet to be determined.
- At this stage, we are seeking for input on user needs regarding the structure for modeling idling before we incorporate into MOVES.

