Federal Highway Administration
RESOURCE CENTER

**Technical Support**

# Two Approaches for Evaluating the Difference in Emissions Between Diesel and CNG Buses

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**AQ Technical Support Team**
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**February 20, 2013**



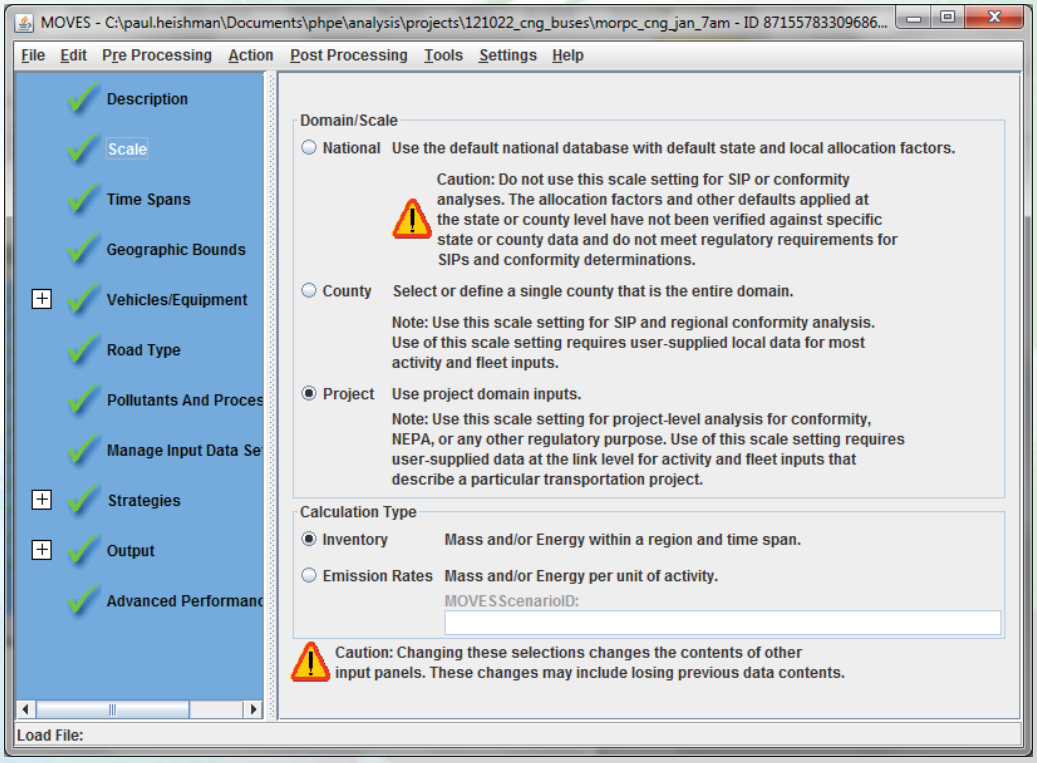
## Shifting Gears Using MOVES Scaling Capabilities

**The first half looked at a telescopic approach**

- Might use this approach to evaluate entire fleet
  - Referenced to average conditions across network
  - Might be used for TIP conformity analysis
  - Able to look at longer, multiple timeframes

**Now we are looking at a microscopic approach**

- Use more detail to look at specific roadway segments
- Use with dispersion model for NEPA or hot-spot conformity
- Might also be used for benefits of local CMAQ project
- Limited to one hour of one day of one year per run



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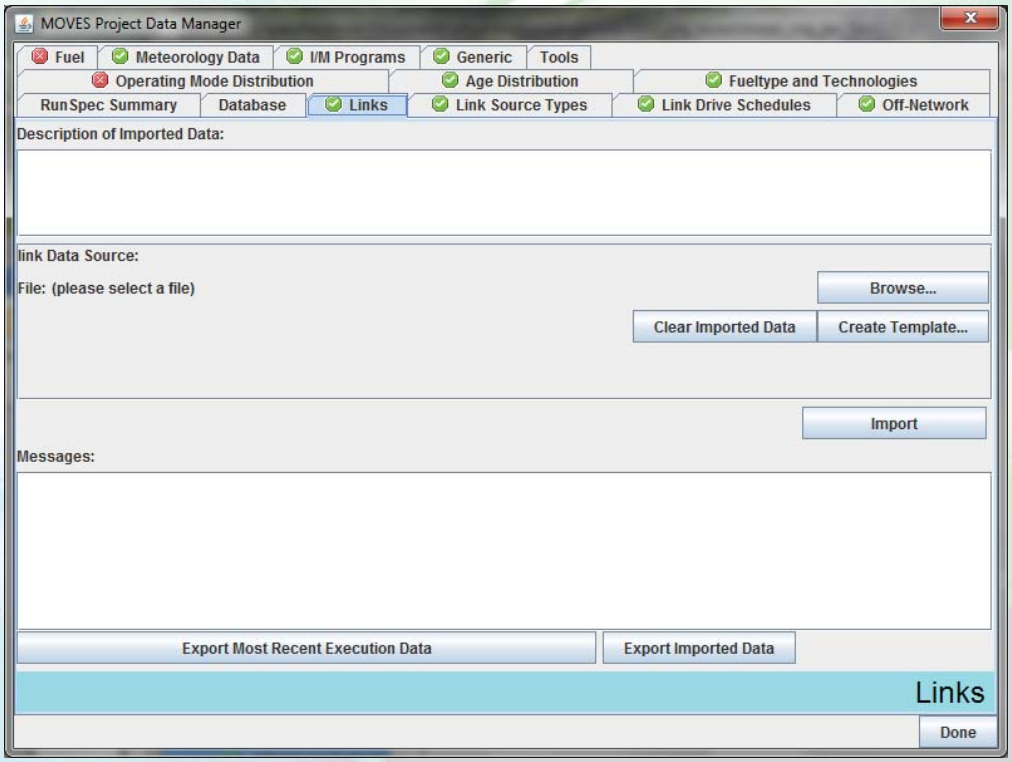

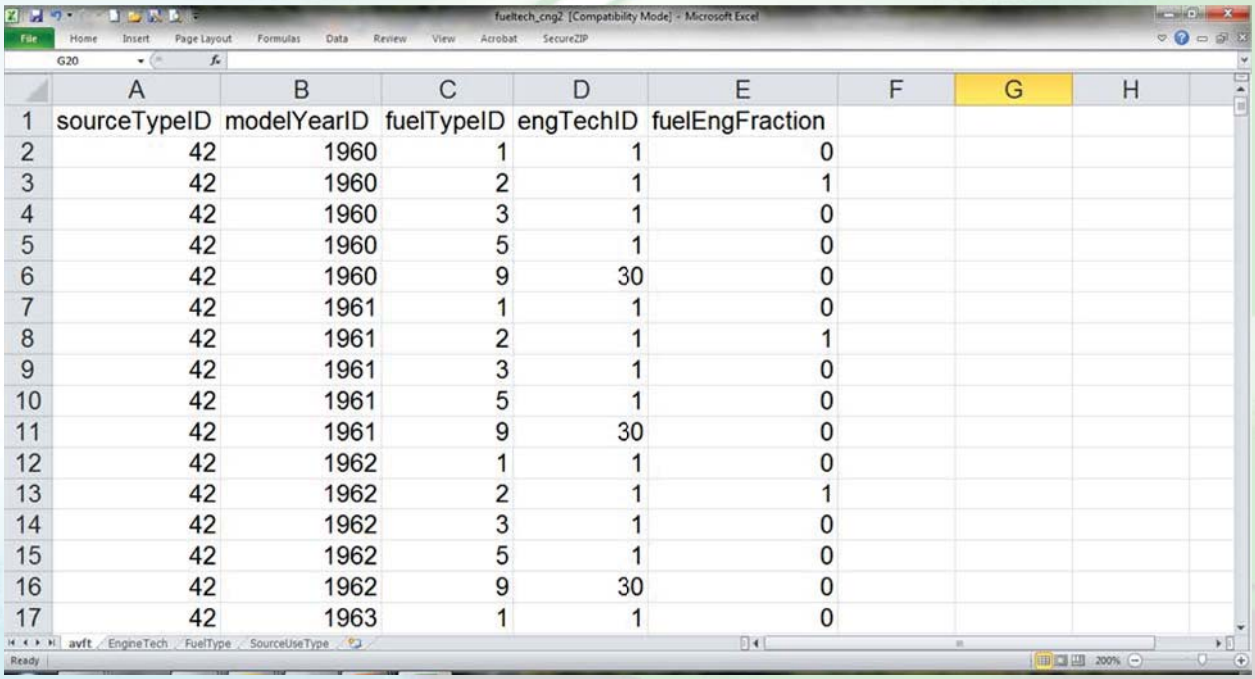


| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | sourceTypeID | modelYearID | fuelTypeID | engTechID | fuelEngFraction | | | |
| 2 | 42 | 1960 | 1 | 1 | 0 | | | |
| 3 | 42 | 1960 | 2 | 1 | 1 | | | |
| 4 | 42 | 1960 | 3 | 1 | 0 | | | |
| 5 | 42 | 1960 | 5 | 1 | 0 | | | |
| 6 | 42 | 1960 | 9 | 30 | 0 | | | |
| 7 | 42 | 1961 | 1 | 1 | 0 | | | |
| 8 | 42 | 1961 | 2 | 1 | 1 | | | |
| 9 | 42 | 1961 | 3 | 1 | 0 | | | |
| 10 | 42 | 1961 | 5 | 1 | 0 | | | |
| 11 | 42 | 1961 | 9 | 30 | 0 | | | |
| 12 | 42 | 1962 | 1 | 1 | 0 | | | |
| 13 | 42 | 1962 | 2 | 1 | 1 | | | |
| 14 | 42 | 1962 | 3 | 1 | 0 | | | |
| 15 | 42 | 1962 | 5 | 1 | 0 | | | |
| 16 | 42 | 1962 | 9 | 30 | 0 | | | |
| 17 | 42 | 1963 | 1 | 1 | 0 | | | |





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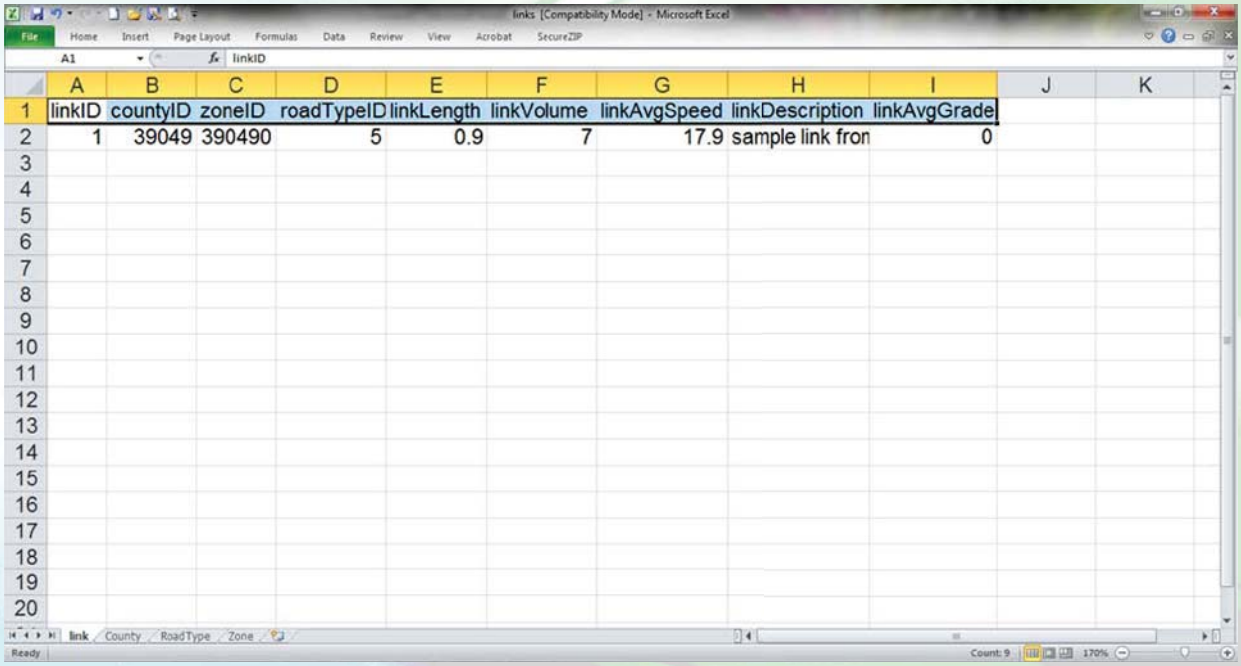
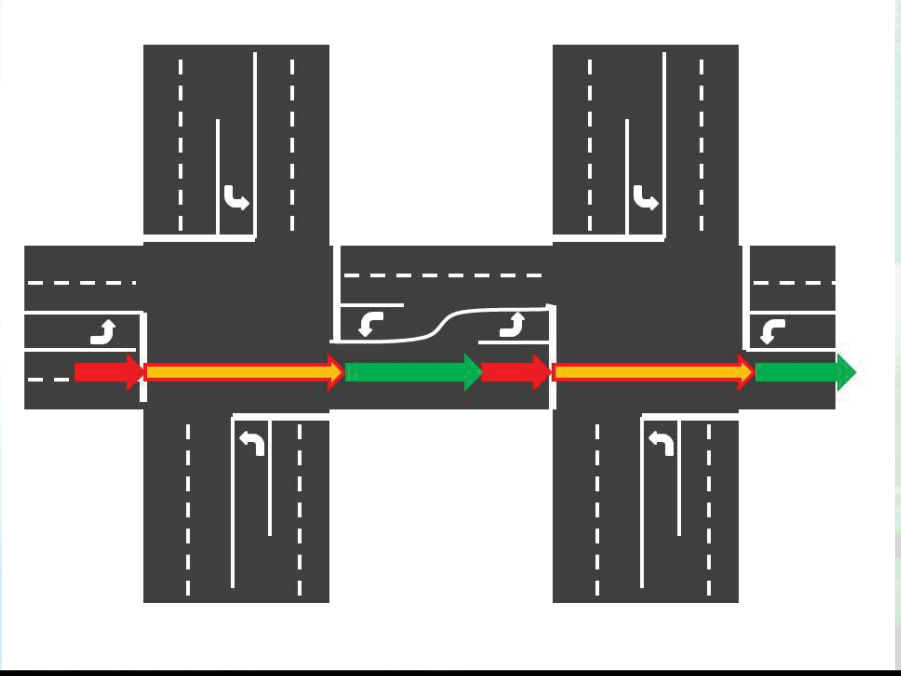



| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | linkID | countyID | zoneID | roadTypeID | linkLength | linkVolume | linkAvgSpeed | linkDescription | linkAvgGrade | | |
| 2 | 1 | 39049 | 390490 | 5 | 0.9 | 7 | 17.9 | sample link fron | 0 | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |
| 11 | | | | | | | | | | | |
| 12 | | | | | | | | | | | |
| 13 | | | | | | | | | | | |
| 14 | | | | | | | | | | | |
| 15 | | | | | | | | | | | |
| 16 | | | | | | | | | | | |
| 17 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |

## Traffic Activity



Queue Link

Accel Link

Cruise Link



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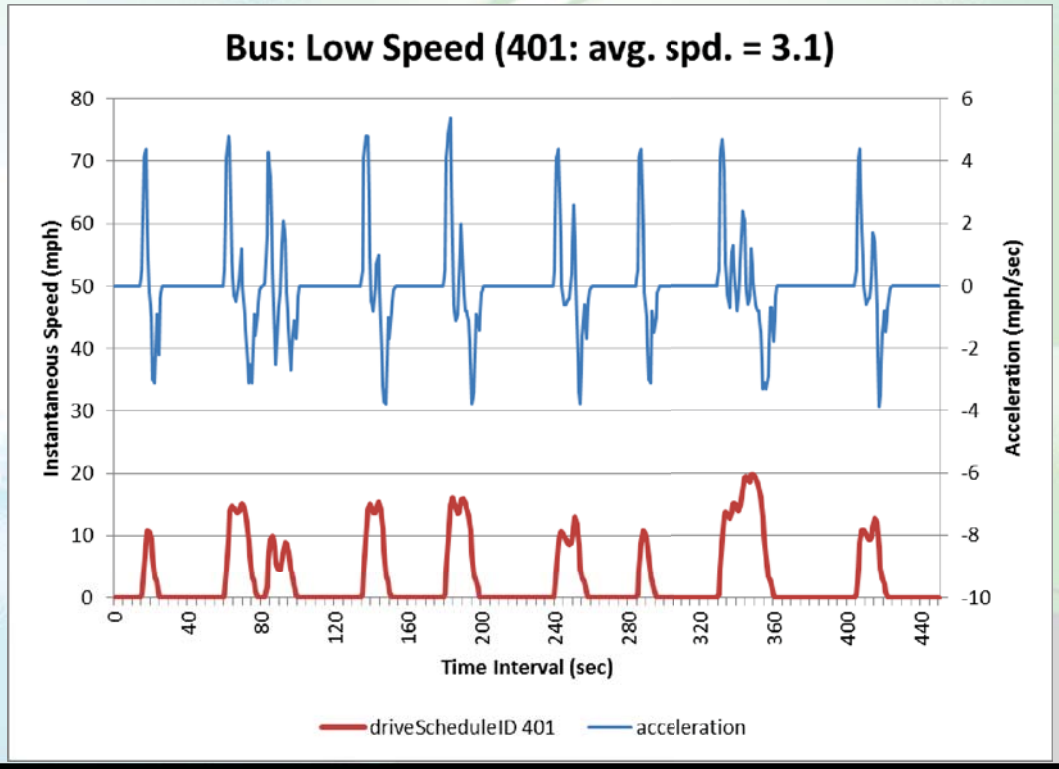
## Traffic Activity

**There are a several factors in defining separate links, such as:**

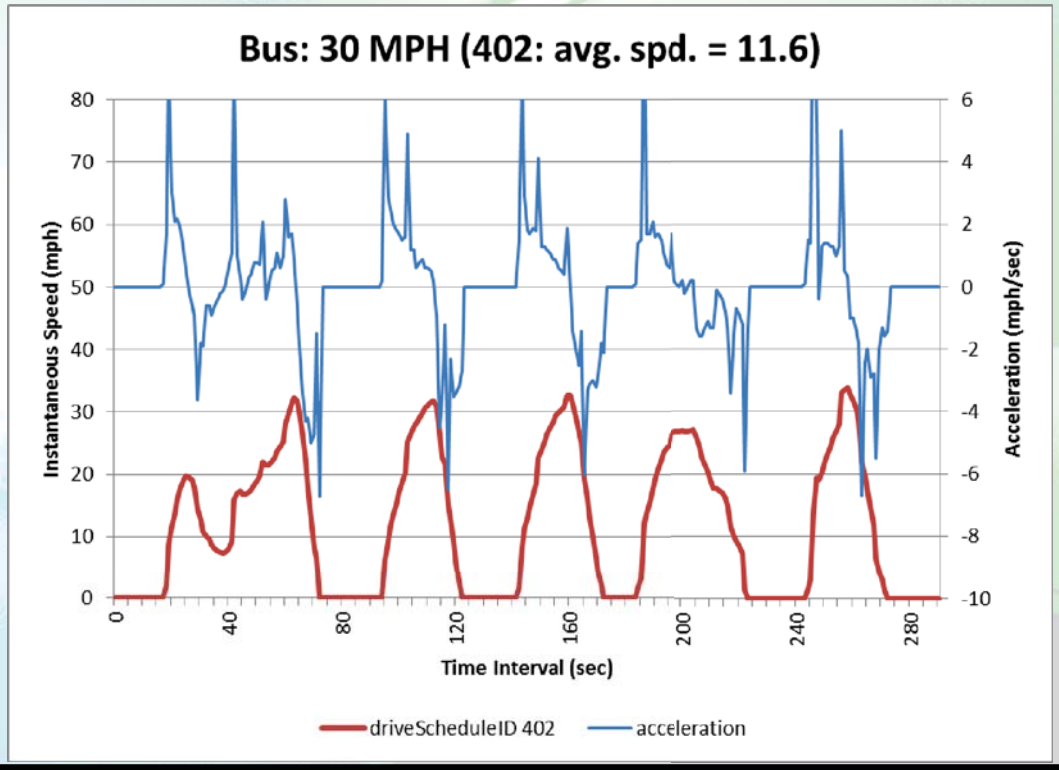
***Different Links Needed for Different Travel Activity Patterns***

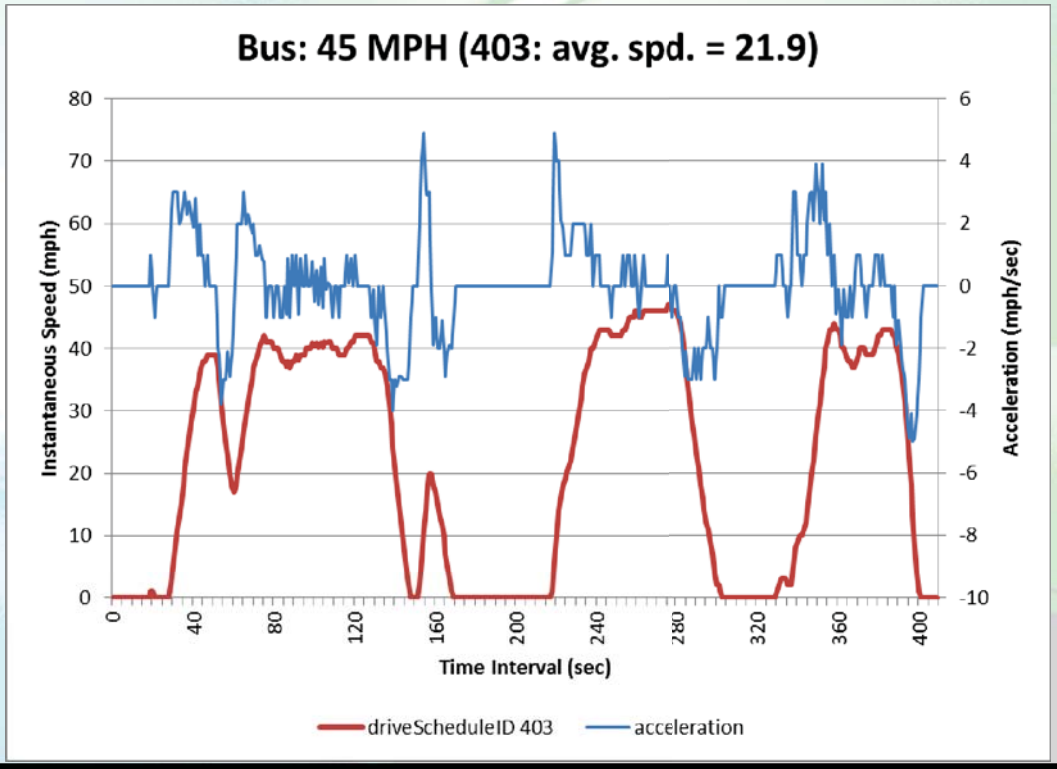
- Might Consider Three Link Types
  - Road Segment Characterized by ***Queuing***
  - Road Segment Characterized by ***Acceleration***
  - Road Segment Characterized by Steady ***Cruise***
- Possibly Consider a Fourth Type for ***Deceleration***
  - It's Factored into Queuing Link in the Example
- Different Activity Will Result in Different Emissions
  - MOVES Allows *Average Speed*, *Drive Schedule*, and *Operating Mode Distribution*


Bus: Low Speed (401: avg. spd. = 3.1)
Instantaneous Speed (mph)
Acceleration (mph/sec)
Time Interval (sec)
driveScheduleID 401
acceleration






Bus: 30 MPH (402: avg. spd. = 11.6)
Instantaneous Speed (mph)
Acceleration (mph/sec)
Time Interval (sec)
driveScheduleID 402
acceleration

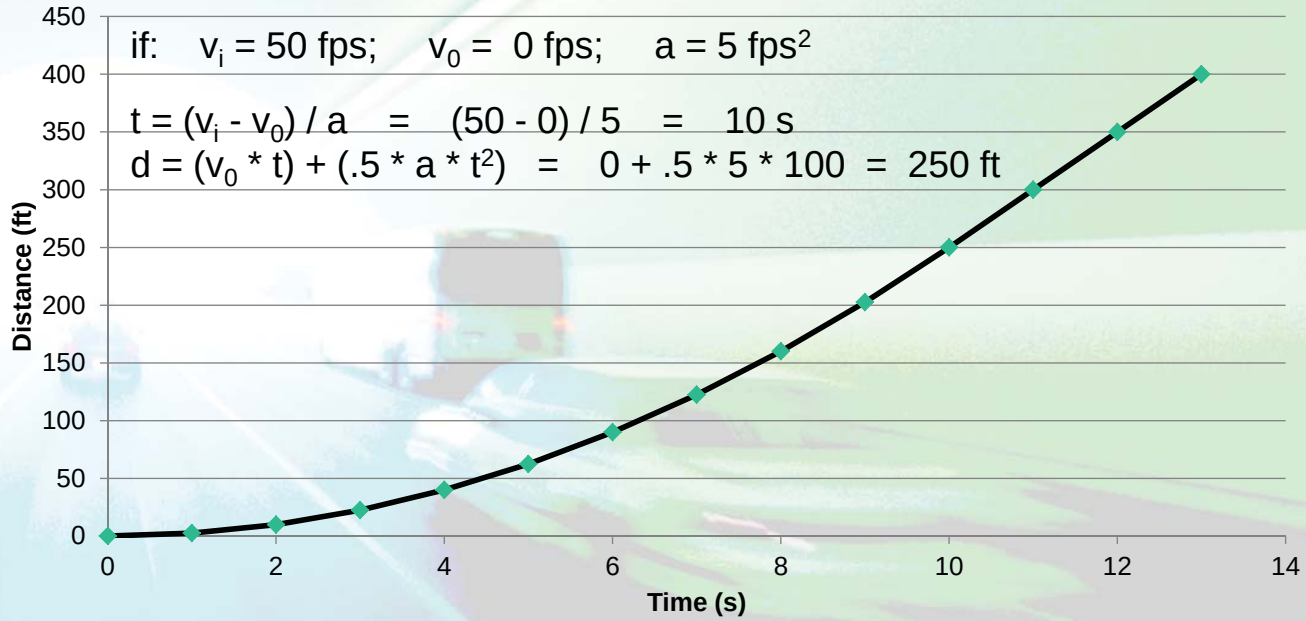


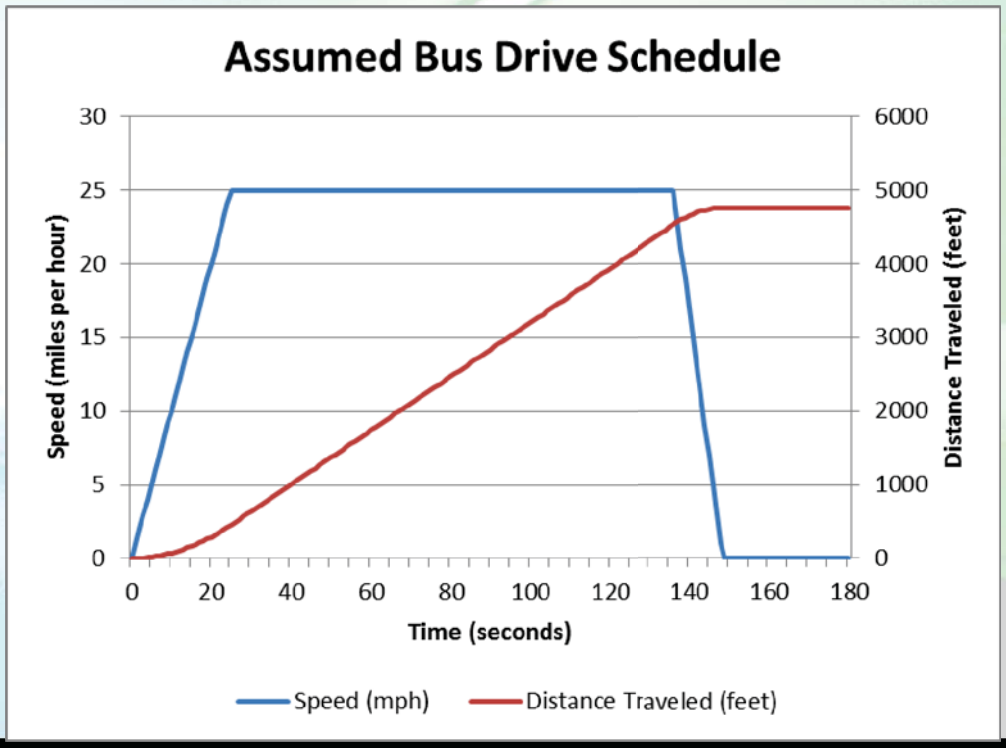





# Traffic Activity

**Example: Acceleration Link Length**





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## Traffic Activity

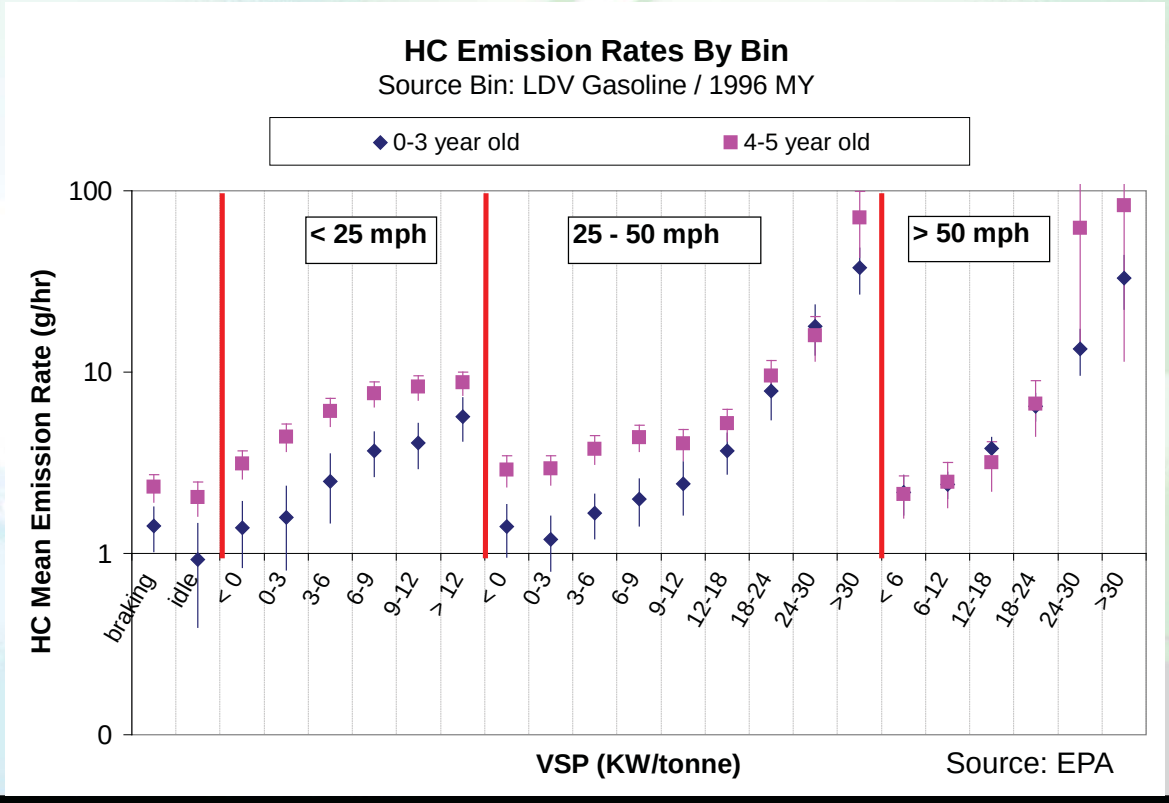
| VSP Class (kW/tonne) | Speed Class (mph) 1-25 | 25-50 | 50 + |
|---|---|---|---|
| 30 + | 16 | 30 | 40 |
| 27-30 | | | |
| 24-27 | | 29 | 39 |
| 21-24 | | 28 | 38 |
| 18-21 | | | |
| 15-18 | | | 37 |
| 12-15 | | 27 | |
| 9-12 | 15 | 25 | |
| 6-9 | 14 | 24 | 35 |
| 3-6 | 13 | 23 | |
| 0-3 | 12 | 22 | 33 |
| < 0 | 11 | 21 | |

### Vehicle Specific Power (VSP)

A measure of the energy the moving vehicle is using at a moment in time

Braking = Op Mode Bin 0
Idle = Op Mode Bin 1

Source: EPA




Source: EPA



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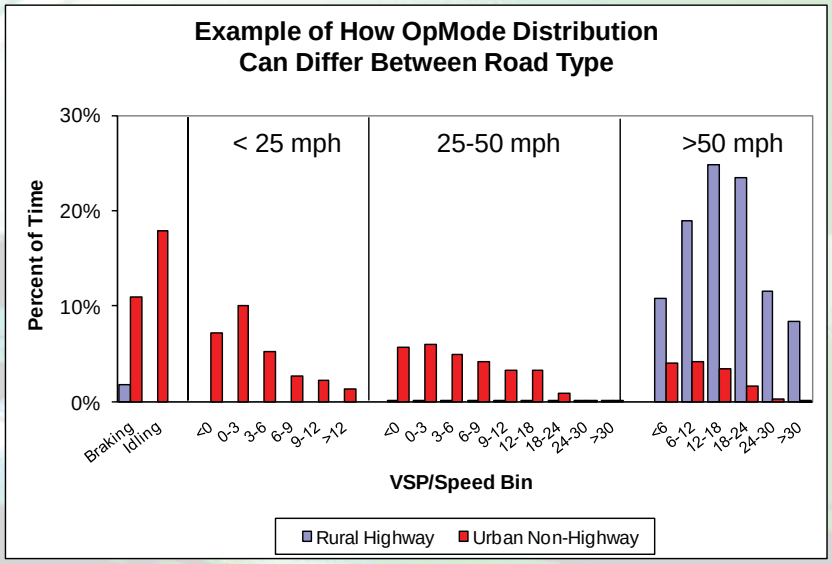
## Vehicle Activity

**All Running Links have an OpMode distribution (i.e., fraction of time spent in each operating mode)**

- » This can be explicitly defined by the user or…
- » MOVES can calculate an OpMode distribution based on either an average speed or vehicle trajectory provided by the user




Source: EPA

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## Project-Level Analysis with MOVES

**Make assumptions about treating travel activity**

- Assume that travel would be the same regardless of fuel
  - Can use default link drive schedules from MOVES
  - Alternatively, develop drive schedules to reflect local conditions

**Identify the inputs in MOVES that directly reflect fuel effects**

- In MOVES Run Specification, select bus - fuel combination
- In Project Data Manager (PDM), fuel based on Run Spec
- PDM Age Distribution tab should reflect fleet differences
- PDM Fueltype & Technology to reflect correct distribution

**Final approach will depend on study objectives (e.g., CMAQ)**



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## MOVES Run Specification

**You will need multiple runs to account for a full year**

- Different times of day (typically 4 representative periods)
- Different months of the year (typically 4 seasons)
- Perhaps repeat for multiple years for life cycle benefits

**Also separate runs to account for different cases (e.g., fuel)**

- One set of runs for diesel fuel; rerun with CNG

**Propose using inventory at Project Scale, but not required**

- In part depends on study objective
- You can derive the rates in post-processing

# MOVES Project Data Manager (PDM)

**Only change data to reflect cases being compared**

- Review assumption that links, operations, etc. are constant

**Key tables for this analysis:**

- Fuel Supply and Formulation tables (match current fuel)
- Fueltype and Technology table (set 100% for current fuel)
- Met table (vary for both cases to match hour of analysis)
- Links table (may need to vary traffic volumes for time of day)
- Age distribution table (if replacing old fleet with new fleet)

**May need to expand run data to account for full annual VMT**

**Note that in this procedure only comparing running emissions**

- Review assumption that start emissions aren't critical



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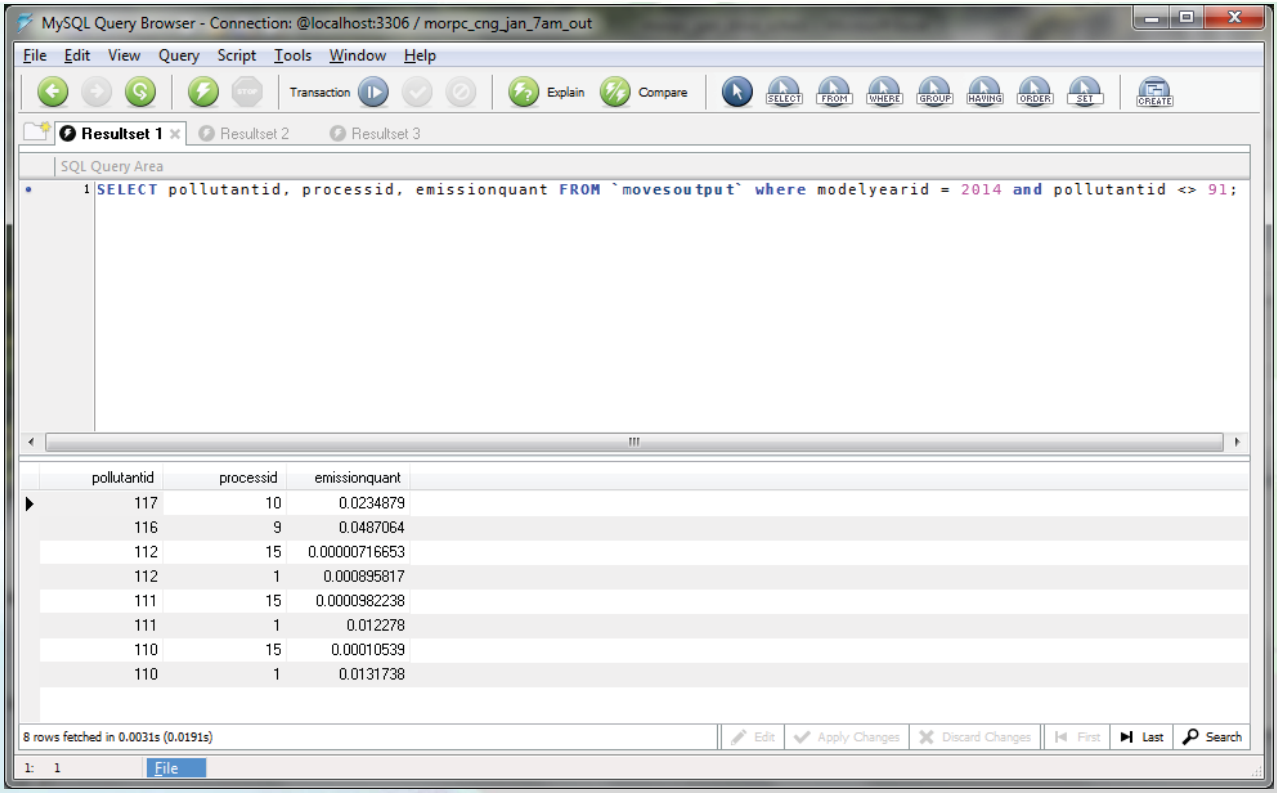

## In Closing

**MOVES offers users flexibility**

- We have seen options for working at different scales
- Can be applied to different kinds of projects
- But it also has large data demands
- In general, use data that is consistent with regional analyses

**We are in a period of transition with implementation**

- In new conformity work, MOVES is required (or will be soon)
  - EPA has specific guidance for these analyses
- Other studies (NEPA, CMAQ) may have optional procedures
  - Document your assumptions and decisions
  - Seek agency concurrence





## Questions

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