

# Introduction to MOVES for Non-Modelers

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## Training Outline

- **What is MOVES?**
- **How is MOVES different from MOBILE?**
- **How do emissions differ from MOBILE?**
- **Versions of MOVES**
- **Using MOVES at the county level**
  - Demo of MOVES generating county-level inventory

## Training Outline

- **How do MOVES inputs differ from MOBILE?**
- **What should I look at as a reviewer?**
- **What are some common MOVES mistakes?**
- **Using MOVES at the project level**
- **What documentation and resources are available?**

## What is MOVES?

- Motor Vehicle Emission Simulator
- Estimates total emissions & energy use from all on-road sources (cars, trucks, buses, motorcycles)
- Replaces MOBILE for on-road vehicle emissions
  - Significant expansion of capabilities compared to MOBILE
- Uses a state-of-the-art modeling framework
  - Modular database structure is easier to update
  - Could eventually include other mobile sources (e.g., non-road, marine, locomotive, aviation sources)

## Why Did EPA Develop MOVES?

- **Clean Air Act requires EPA to regularly update emission factors and emission factor models**
- **FORTTRAN code used in MOBILE6.2 is obsolete and difficult to maintain; more modern database design needed**
- **National Research Council 2000 recommended changes in EPA's mobile source modeling program (e.g., ability to model emissions at a smaller scale)**

# How Is MOVES Different from MOBILE?

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**MOVES**



## MOVES Input Structure Is More Flexible

- **MOVES uses a Graphical User Interface (GUI)**
  - MOBILE used text input and output files
- **MOVES uses Java and MySQL software and operates in Windows**
  - MOBILE was written in FORTRAN and operated in DOS
- **MOVES uses a relational database structure to store data in tables that are easy to modify and update**
  - In MOBILE, many data elements were hard-coded, requiring changes to model code to update

## MOVES Offers More Output Options

- **MOVES can estimate a total emission inventory as well as emission rates**
  - MOBILE only provided emission rates, requiring extensive external post-processing to produce an emission inventory
- **MOVES output is easily customizable with many levels of aggregation and disaggregation possible**
  - MOBILE had limited fixed output formats



## MOVES Covers Multiple Scales and Time Periods

- **MOVES can generate emissions estimates at multiple geographic scales, from national level to county level to project level, with different input options at each level**
  - MOBILE only produced emissions based on regional-scale trip patterns with no geographic specificity
- **MOVES can generate emissions by hour, day (weekday or weekend), month, or year**
  - MOBILE had very limited temporal capabilities

## MOVES Is a Modal Model

- **MOVES emission rates are based on “operating modes” that can account for different patterns of acceleration, cruising, and deceleration, as well as average speed**
- **MOBILE was based on aggregate driving cycles and only accounted for differences in average speed**

# How Do Emissions Differ from MOBILE?

MOVES



## Summary of Data Differences

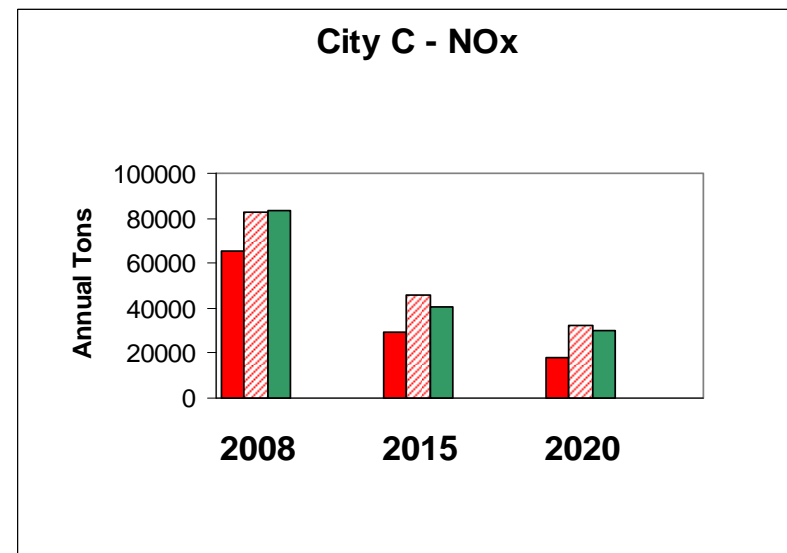
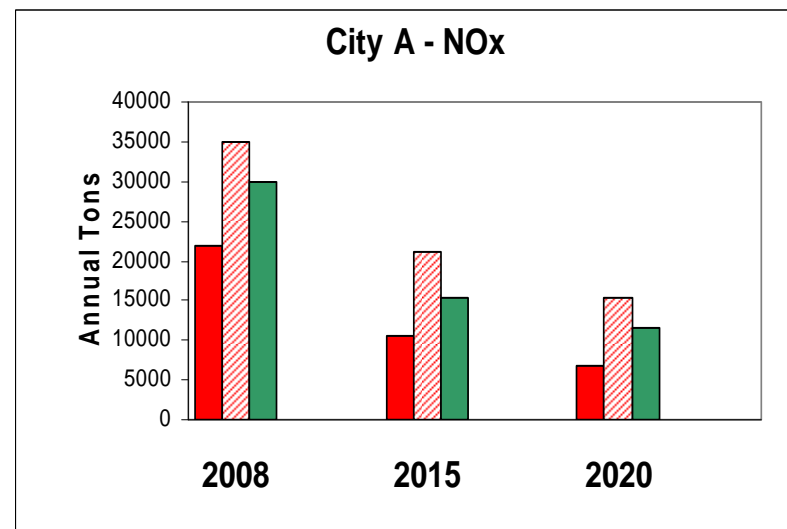
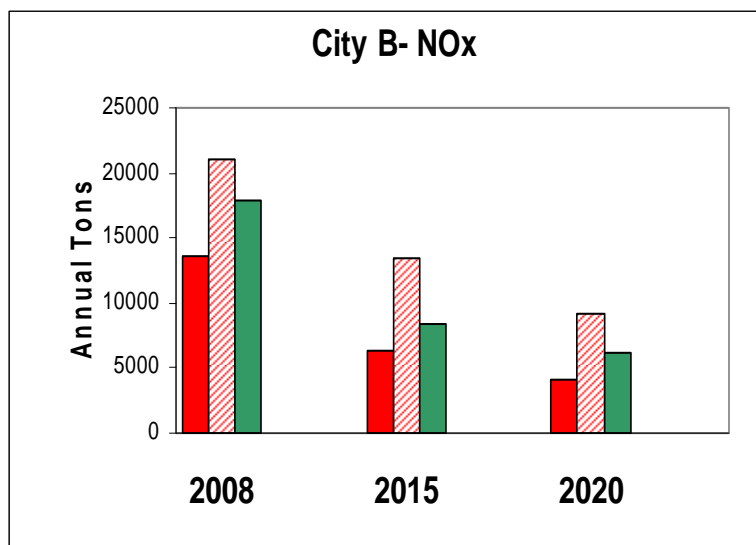
- **MOVES includes a much larger data set, including the first in-use data on light duty vehicles meeting Tier 1 and NLEV standards**
  - MOBILE had in-use data for pre-1994 vehicles; 1994-and-later vehicle emissions were primarily based on certification data
- **MOVES includes first in-use PM data for light duty vehicles with temperature effects**
  - MOBILE PM based on certification data with no temperature effects
- **MOVES includes first in-use data for heavy duty vehicles, including speed effects and crankcase, start, and extended idle emissions**
  - MOBILE based on certification data with no speed effects, or crankcase, start, and extended idle emissions.

## MOVES2010 Results

- Data collected since MOBILE6 released drives differences between MOVES and MOBILE6
- National trends
  - HC and CO emissions similar or lower than MOBILE6.2
  - Total NO<sub>x</sub> emissions higher than MOBILE6.2
  - Total PM emissions substantially higher than MOBILE6.2
- Local results may vary
  - Local fleet mix, fuels, activity are important
  - Temperature drives PM emissions
- For attainment analysis, relative change in emissions between base year and attainment year is more important than absolute emissions

## NO<sub>x</sub>

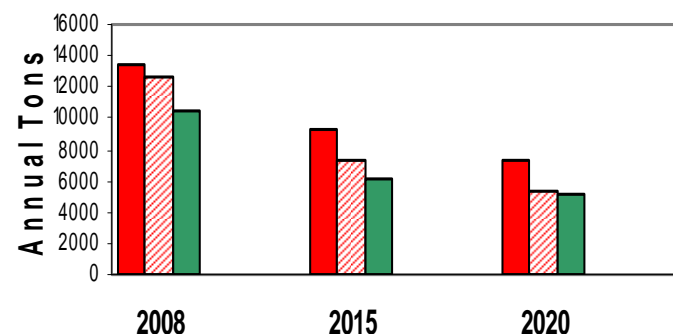
- I/M program data shows MOBILE6 underestimated NO<sub>x</sub> emissions from light trucks
- On-road data on heavy trucks shows higher emissions than MOBILE6 estimated from cert data
- Extended idle emissions become significant share of heavy-duty inventory in future



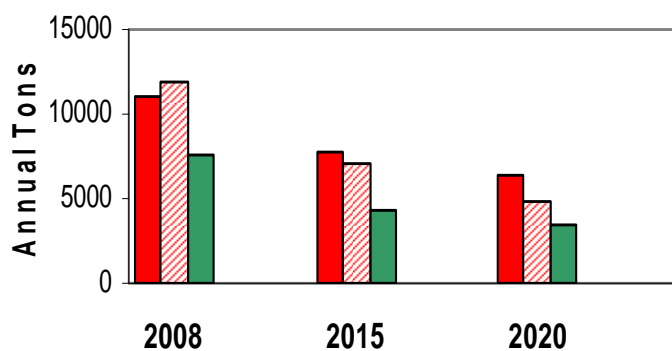
## VOC

- I/M program data shows MOBILE6 overestimated HC emissions from newer technology cars
- Evaporative emissions on newer technology vehicles very low

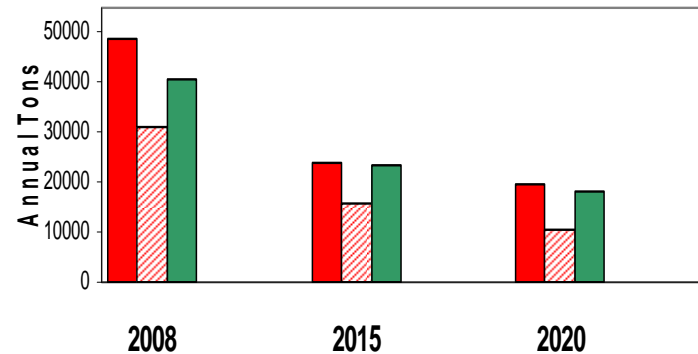
City A - VOC



City B - VOC



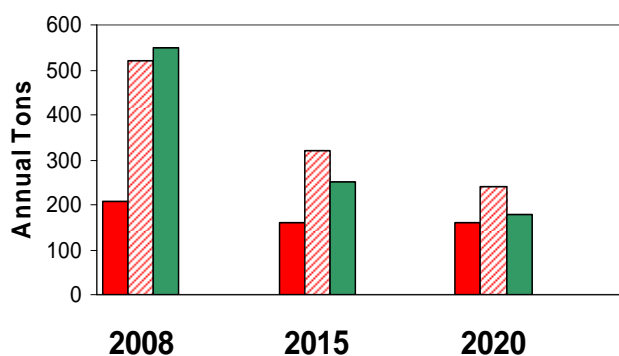
City C - VOC



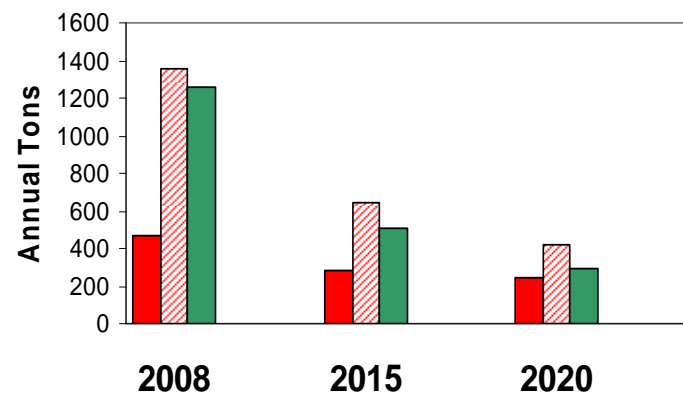
## PM<sub>2.5</sub>

- Kansas City program found high gas PM emissions esp. at cold temps
- New data on heavy trucks shows higher deterioration than MOBILE6
- MOVES accounts for impact of vehicle speed – MOBILE did not

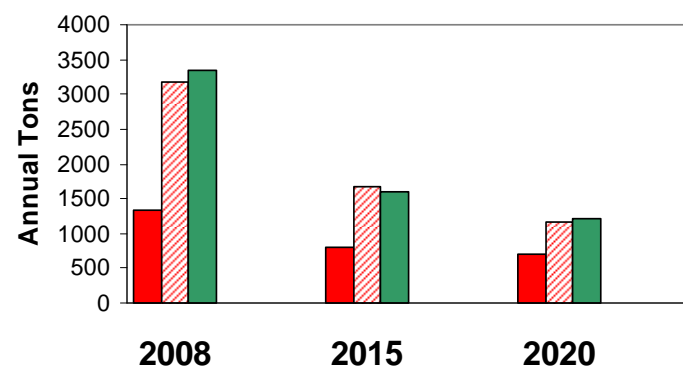
City B - PM 2.5



City A - PM 2.5



City C - PM 2.5



■ M6

▨ DraftMOVES2009

■ MOVES2010



## Percent Reduction in On-Road Emissions: 2008 to 2015

	City A		City B		City C	
	MOBILE6	MOVES	MOBILE6	MOVES	MOBILE6	MOVES
<b>VOC</b>	31%	41%	30%	43%	51%	42%
<b>NO<sub>x</sub></b>	52%	49%	53%	53%	56%	51%
<b>PM<sub>2.5</sub></b>	40%	60%	23%	54%	40%	52%

## What It Means

- **Higher NO<sub>x</sub> and PM emissions mean on-road mobile sources have bigger role in attainment**
- **PM<sub>2.5</sub> shows higher overall emissions and higher % reductions**
  - Effect on attainment demonstrations could be positive
- **NO<sub>x</sub> shows higher overall emissions but lower % reduction**
  - Could be harder to show attainment
  - Future NO<sub>x</sub> control measures could have a bigger impact
- **Percent reduction from base year is key to attainment analysis**
  - States need to consider these effects on SIPs and conformity

# Versions of the MOVES Model

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MOVES



## MOVES2010

- Released December 2009
- Approved in March 2010 for use in SIPs and regional conformity analyses (with a 2-year conformity grace period)
- Significant improvements over Draft MOVES2009
- **5/15/2010 database**
  - Updated MOVES database that corrects several minor errors in the original MOVES2010 default database

## MOVES2010a

- Released in September 2010
- Added features, improved performance and corrected errors
- Not considered a new emission models for SIP and conformity purposes
  - Impact on criteria pollutants is small
  - SIP/conformity policy: users can choose to continue significant work with 2010 or switch to 2010a
  - Approved for project-level conformity in Dec. 2010 with separate, 2-year grace period

## Updates Included in MOVES2010a

- **Allowed users to easily estimate emissions that incorporate new car and light truck energy and greenhouse gas rates.**
  - Includes new car and light truck GHG standards for model years 2012 and later
  - Corrects impacts of CAFE standards for model years 2008-2011
- **Also...**
  - Improved methane algorithm
  - Improved ramp algorithm
  - Code modified to make more compatible with LINUX operating systems
  - Includes 5/15 database in installation package
  - Other improvements

## MOVES2010b

- Released April 2012
- No significant changes in criteria pollutant or GHG emissions
- Not considered a new emission models for SIP and conformity purposes
  - No new grace period
  - SIP/conformity policy: users can choose to continue significant work with 2010 or 2010a, or switch to MOVES2010b
  - Recommend use of MOVES2010b for new work

## MOVES2010b

- **Some changes in air toxics**

- Some updates to factors used to calculate existing air toxics in MOVES based on new data
- Addition of air toxics previously available for MOBILE/NMIM, but not in MOVES2010 or MOVES2010a
- Needed for National Emissions Inventory (NEI)

- **Performance improvements**

- New debugging features and better error recovery
- Updated to latest versions of JAVA and MySQL

- **New features**

- Easier to do multi-county runs at county scale
- Better functionality for rates option
- Many other small improvements



## MOVES2013: What's Next?

- **A major upgrade to MOVES**
- **New data**
  - Heavy duty
    - Two new studies
  - Evaporative emissions
    - New studies
    - Adding multi-day diurnals
  - Cold temperature data for new vehicles
  - New fuel effects and fuel supply information
  - Activity
    - New sales, population, and VMT data
    - New studies on VMT and starts
  - New speciation data for VOC and PM

## MOVES2013: What's Next?

- **New Rules**

- Heavy Duty (HD) Greenhouse Gas MY 2014-2018
- Light Duty Greenhouse Gas MY 2017-2025
  - Not yet finalized
- Tier 3
  - Not yet proposed
  - Inclusion is dependent on timing of MOVES 2013 and timing of Tier 3

- **Addition of draft NONROAD emissions**

- Will finalize in a later version

## MOVES2013: What's Next?

- **Other potential improvements**
  - Better Performance
  - Upgraded support for Cloud Computing
  - Improved evaporative emission processing (e.g. multi day diurnal)
  - Improved diesel “retrofit” processing
  - Incorporating VOC and PM speciation
  - Major upgrade for technical documentation (Software Development Reference Manual and User Guide)
  - Improved error and warning messages
  - Inclusion of features that will allow MOVES to be used internationally
- **Tentative release mid-2013**

# How Does MOVES Work?

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MOVES



## Geography and Time in MOVES

- **Modeling domain is entire U.S.**
  - 50 states plus Washington, D.C., Puerto Rico, & U.S. Virgin Islands
  - Data for all 3222 counties as of CY 1999
- **Can provide estimates for calendar years 1990 and 1999-2050**
  - 12 months of the year
  - Weekdays and weekend days
  - 24 hours of the day

# MOVES Analysis Scales

- **National scale**

- Do not use for SIPs and conformity analyses
- Uses national default data and allocation factors for local fleet and activity inputs
- Can be used to make rough estimates

- **County scale**

- Use for SIPs and regional conformity analysis
- Requires input of county level data
- Includes County Data Manager to simplify creating and importing tables of local data

- **Project scale**

- Use for analyses of highway, transit, and freight projects
- Requires input of link level activity information (and some county level data)

## MOVES Emissions Processes

- Running Exhaust
- Start Exhaust
- Extended Idling
- Evaporative Processes
  - Permeation, Vapor Venting, Leaks, Refueling Displacement, Refueling Spillage
- Crankcase
- Tire wear
- Brake wear

## MOVES Source Types

HPMS Vehicle Type	MOVES SourceType
Motorcycle	Motorcycle
Passenger Car	Passenger Car
Other 4-tire, 2-axle	Passenger Truck
	Light Commercial Truck
Bus	Intercity Bus
	Transit Bus
	School Bus
Single Unit Truck	Refuse Truck
	Short-haul Single Unit
	Long-haul Single Unit
	Motor home
Combination Truck	Short-haul Comb. Truck
	Long-haul Comb. Truck

Sub-categories (like refuse trucks and motor homes) are discussed in guidance; EPA does not expect areas to have local data for all subcategories.



## MOVES Road Types

- **For running emissions, county-level VMT is distributed to four road types:**
  - Rural restricted access (freeways and Interstates),
  - Rural unrestricted access,
  - Urban restricted access (freeways and Interstates),
  - Urban unrestricted access
- **A fifth road type, “off-network”, is included to capture start, evaporative and extended idle emissions**
  - This is not the same as “off-network” vehicle activity in the travel modeling world.

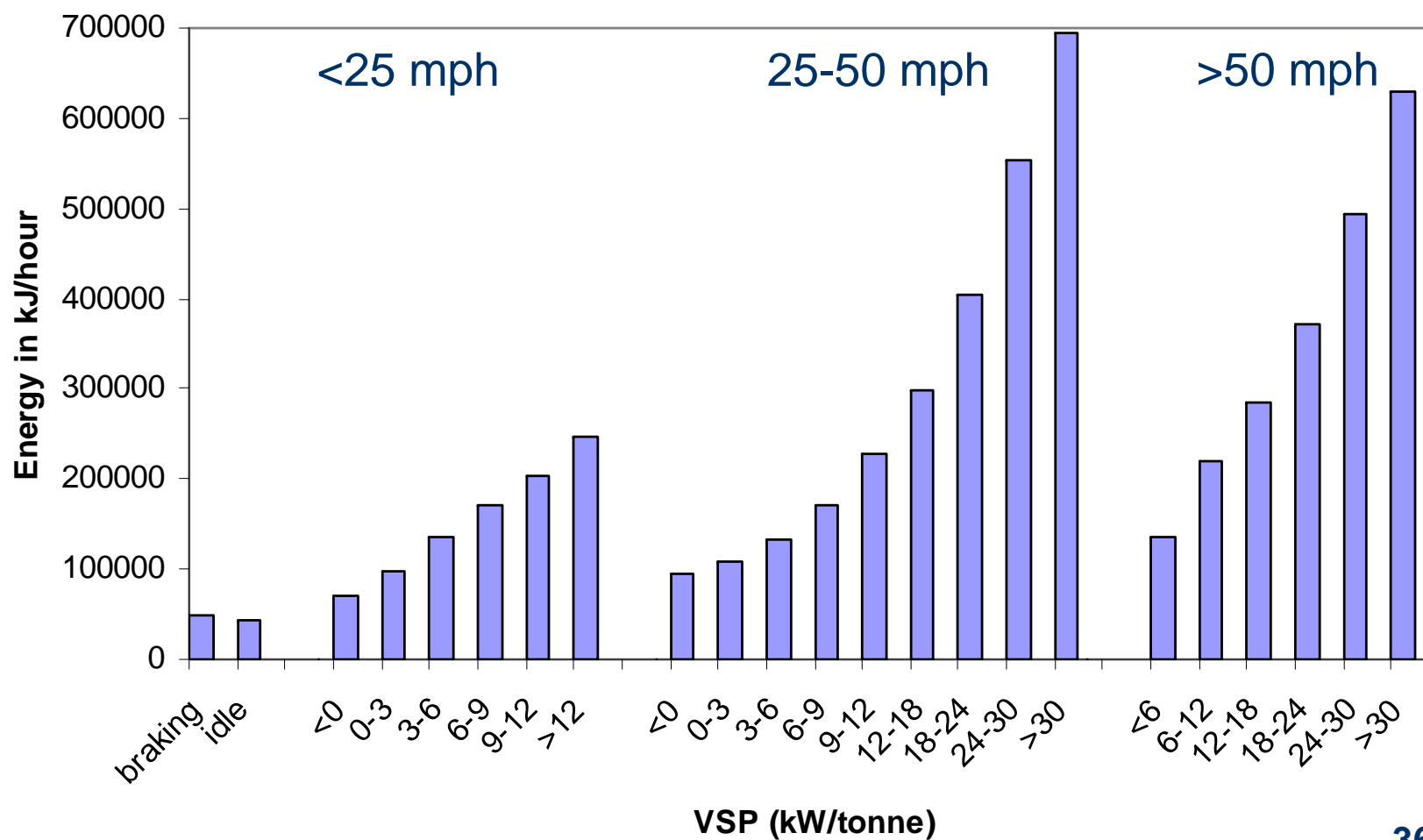
## MOVES Vehicle Ages

- Emission rates can vary by age as well as model year; activity also varies by age
- MOVES models vehicles 0-29 and 30+ years old
- Age groups used for emissions calculations:
  - 0 to 3 years old
  - 4 or 5 years old
  - 6 or 7 years old
  - 8 or 9 years old
  - 10 to 14 years old
  - 15 to 19 years old
  - 20 or more years old

## MOVES Operating Modes

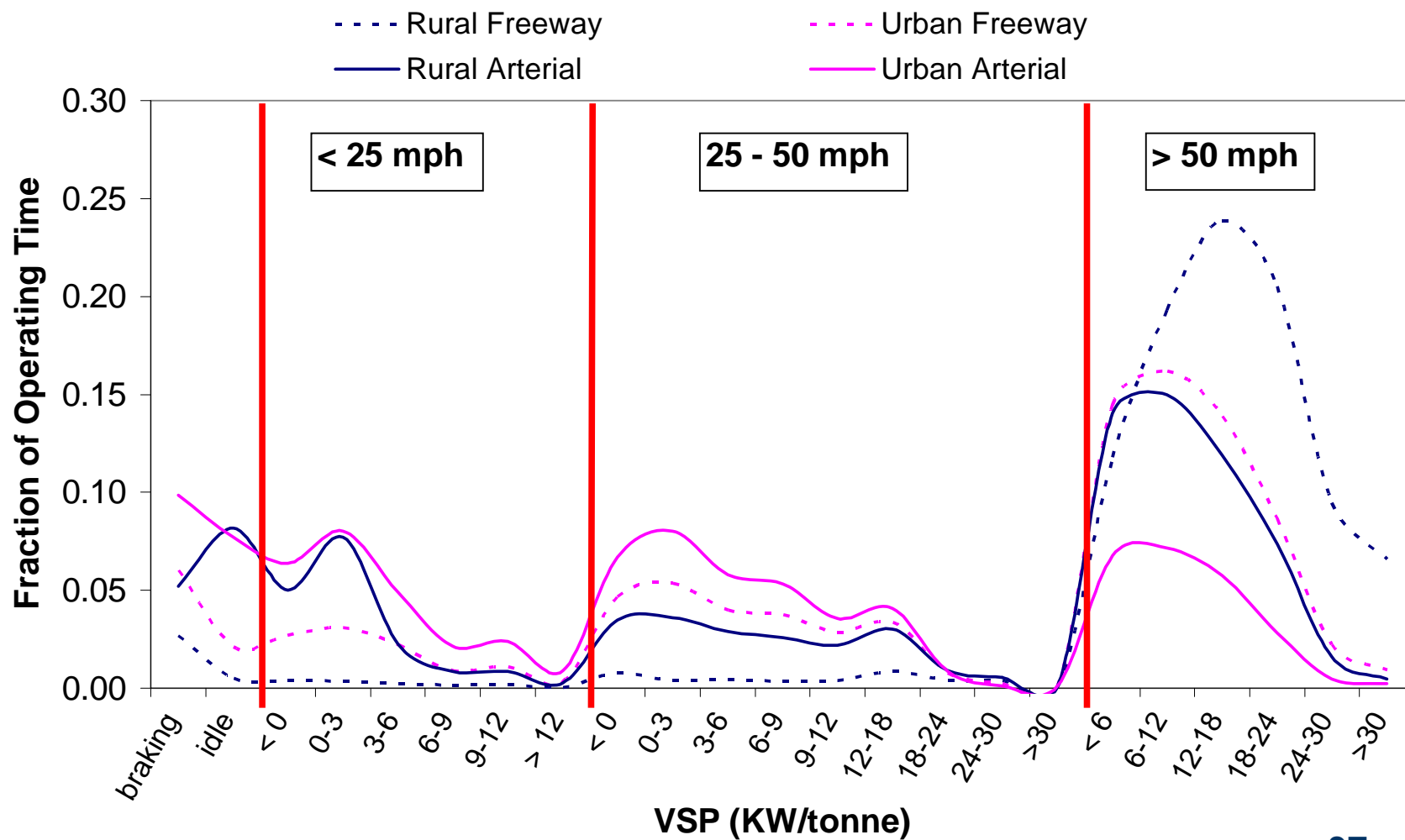
- **MOVES includes more detailed information about how emissions change with vehicle behavior**
- **Estimates are based on the amount of time vehicles spend in different “operating modes”**
  - “Operating mode” – what the vehicle is doing (e.g., accelerating, braking, cruising, idling)
  - Vehicles use different amounts of energy (“vehicle specific power” or VSP) in different operating modes
  - MOVES defines 23 operating modes for running: combinations of speed and VSP
  - In addition, includes operating modes for starts, extended idling, etc.

## Energy Consumption by Operating Mode MY 2010 Gasoline Passenger Car



## Distribution of Operating Time by Bin

Light-Duty Cars and Trucks



## MOVES Emission Rates

- MOVES includes a different emission rate for each combination of...

Source	Age Group	Operating Mode
Gas-LDV-MY2001	8-9 years	low speed coast; 20 mph, VSP 0-3 kW/tonne
Gas-LDT-MY2005	4-5 years	accelerating; 55 mph, VSP 12-15 kW/tonne

- MOVES can calculate an emission inventory internally, or users can do this outside of MOVES by multiplying emission rates from MOVES by the appropriate activity factors

## MOVES Calculation Types

- Two types: “Inventory” or “Emission Rates”
- Trade-offs in both approaches, choice depends on your area and purpose
- Recommend simplified runs each way to see which approach makes sense for your needs

## Calculation Type – “Inventory”

- **Output: total emissions in units of mass (g, kg, lbs, tons) for the time and place specified**
  - MOVES processes results (rates x activity) to get total mass
  - Results are specific to county and time
- **May be best option if modeling a small number of counties over a limited temperature range. For example, if...**
  - Developing inventories for a single nonattainment area with a limited number of counties, for a limited time period
  - Running individual counties using specific daily temperature profiles to get county-level inventory results without additional post-processing



## Calculation Type – “Emission Rates”

- **Output: a set of emission rates per mile or vehicle**
  - User must process results (e.g. multiply rates by vehicle activity data) to get an inventory
  - Requires separate runs for running, start, and evap emissions
- **May be best option if modeling many counties or a wide range of temperatures. For example, if...**
  - Developing inventories for a multi-state modeling domain over multiple seasons
  - Developing emission rates for a representative county and then apply them to many other counties
  - Modeling a full temperature range with a small number of runs
  - Using travel model post-processing software to develop inventories
  - Using the SMOKE-MOVES interface tool

## Custom Domain vs. County

- **Two options for county or project scale runs**
  - Either are acceptable for SIP and conformity purposes
- **“County”**
  - Allows access to some default county-level information
  - In Inventory mode, gives results for that specific county
- **“Custom Domain”**
  - Allows user to define a multi-county area or partial county as a single modeling domain
    - In MOVES2010b, individual “zones” can be defined
  - No direct access to default county-level information
  - In Inventory mode, results are for each defined zone

## When Should I Use “County?”

- **You could use County when you want to model**
  1. A single county, in either inventory or emission rates mode
  2. Small number of counties, and you plan to do an individual run for each one
  3. Representative county, (i.e., a county that has the same fuels and I/M program as the other counties)
    - Allows access to MOVES defaults for your representative county
    - Under this approach, use emission rates mode and post-process appropriate rates with vehicle activity data from each county

## When Should I Use “Custom Domain?”

- **You could use Custom Domain when you want to model:**
  1. Several counties with the same fuels and I/M program in one run
    - User can specify activity for each zone within the Custom Domain
    - Output will be produced for each zone (county)
    - Not typically used in emission rates mode
  2. A partial county

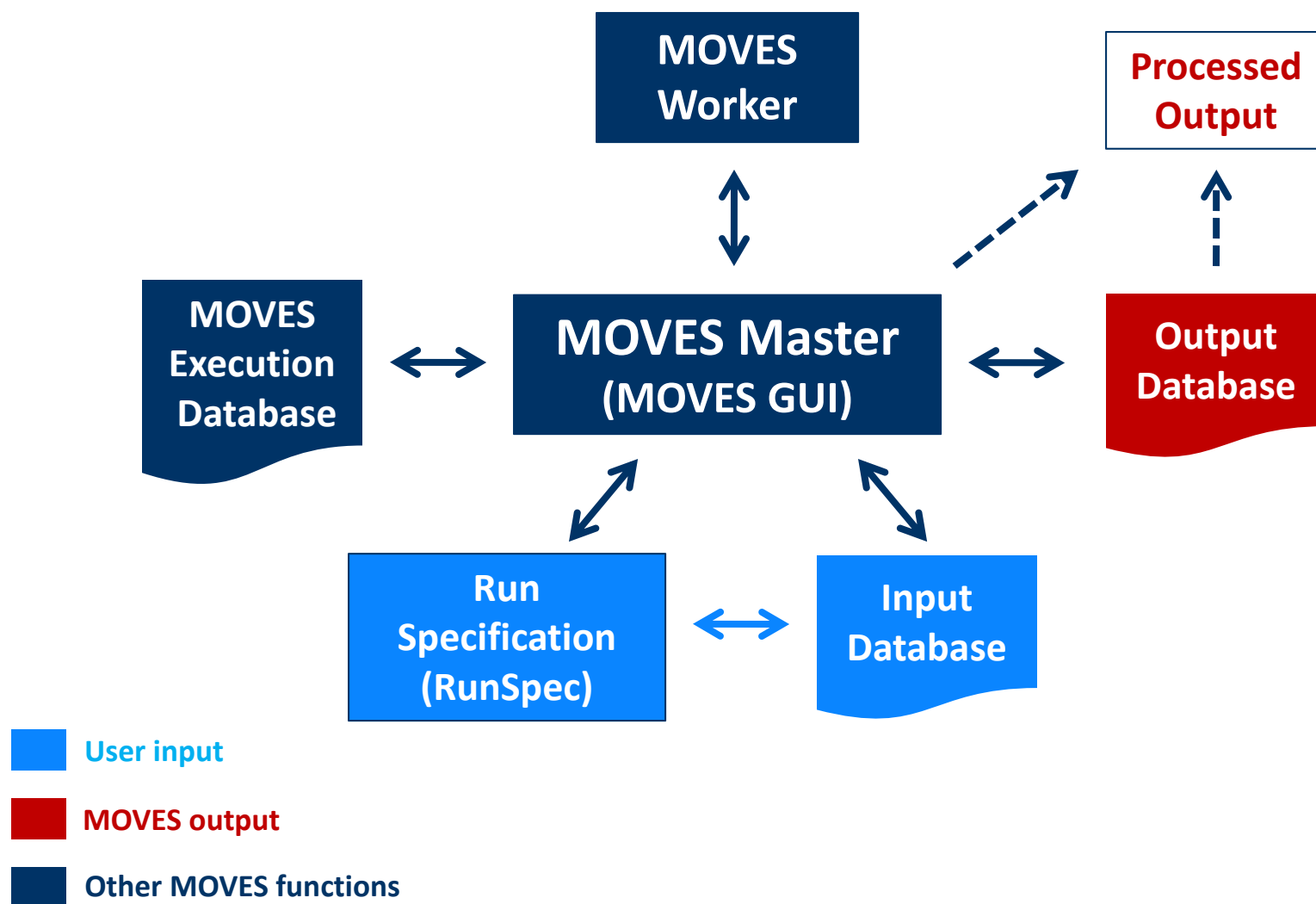
# Interacting with MOVES

- **Create a RunSpec**
  - Tells MOVES what you want included in a run
    - Scale, time span, geographic area, vehicle types, road types, pollutants
- **Create a local input database**
  - Tells MOVES details of local scenario
  - For county scale, use the County Data Manager (CDM)
    - Meteorology, VMT, vehicle population, age distribution, speed distribution, road type distribution, local fuel information, and I/M programs
  - For project scale, use the Project Data Manager (PDM)
    - Meteorology, description of links, vehicle distribution on links, activity on links, age distribution, local fuel information, and I/M programs
- **Run MOVES**
- **Review and process output database**

## MOVES Databases

- **MOVES uses MySQL databases to obtain input, process data and produce requested outputs**
- **Input Databases (default or user-created)**
  - MOVES has a default Input Database
  - Users can use some default information, but will usually have to provide local-specific data when using MOVES for regulatory purposes – see technical guidance for details
- **Execution Database (created by MOVES)**
  - Users generally do not interact directly with this database
  - Contains information needed by MOVES for a particular run
- **Output Database (created by user)**
  - User identifies a database to place results of a MOVES run
  - Also contains run data and diagnostics

# Simplified MOVES Structure



# Using MOVES at the County Scale

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MOVES





## Using MOVES at the County Scale

- **County scale required for SIP and conformity analyses**
- **County specific data must be entered when the County scale is selected**
- **Data can be exported or imported with the County Data Manager (CDM)**
- **Local data should be used for most inputs**
- **Access to default data is limited**

# MOVES Technical Guidance

Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity:

Technical Guidance for MOVES2010, 2010a and 2010b

- Key source of guidance on use of local inputs and defaults
- Some input guidance is presented in this course, but refer to Technical Guidance for more detail
- Posted on EPA's MOVES web site: [www.epa.gov/otaq/models/moves/index.htm](http://www.epa.gov/otaq/models/moves/index.htm)
- Section 2.3.3 of the MOVES User Guide is a basic reference for use of the County Data Manager

## MOVES Inputs

MOVES Input
Meteorology
Fuel inputs
I/M programs
Age distribution
Speed distribution
VMT by vehicle type
Road type distribution
Ramp fraction
VMT by hour
VMT by day and month
Vehicle (sourcetype) population

# MOVES County Data Manager

MOVES County Data Manager

Source Type Population Vehicle Type VMT I/M Programs Generic Tools

Fueltype and Technologies Fuel Meteorology Data Ramp Fraction Road Type Distribution

RunSpec Summary Database Age Distribution Average Speed Distribution

Select or create a database to hold the imported data.

Server: localhost Refresh

Database: Create Database

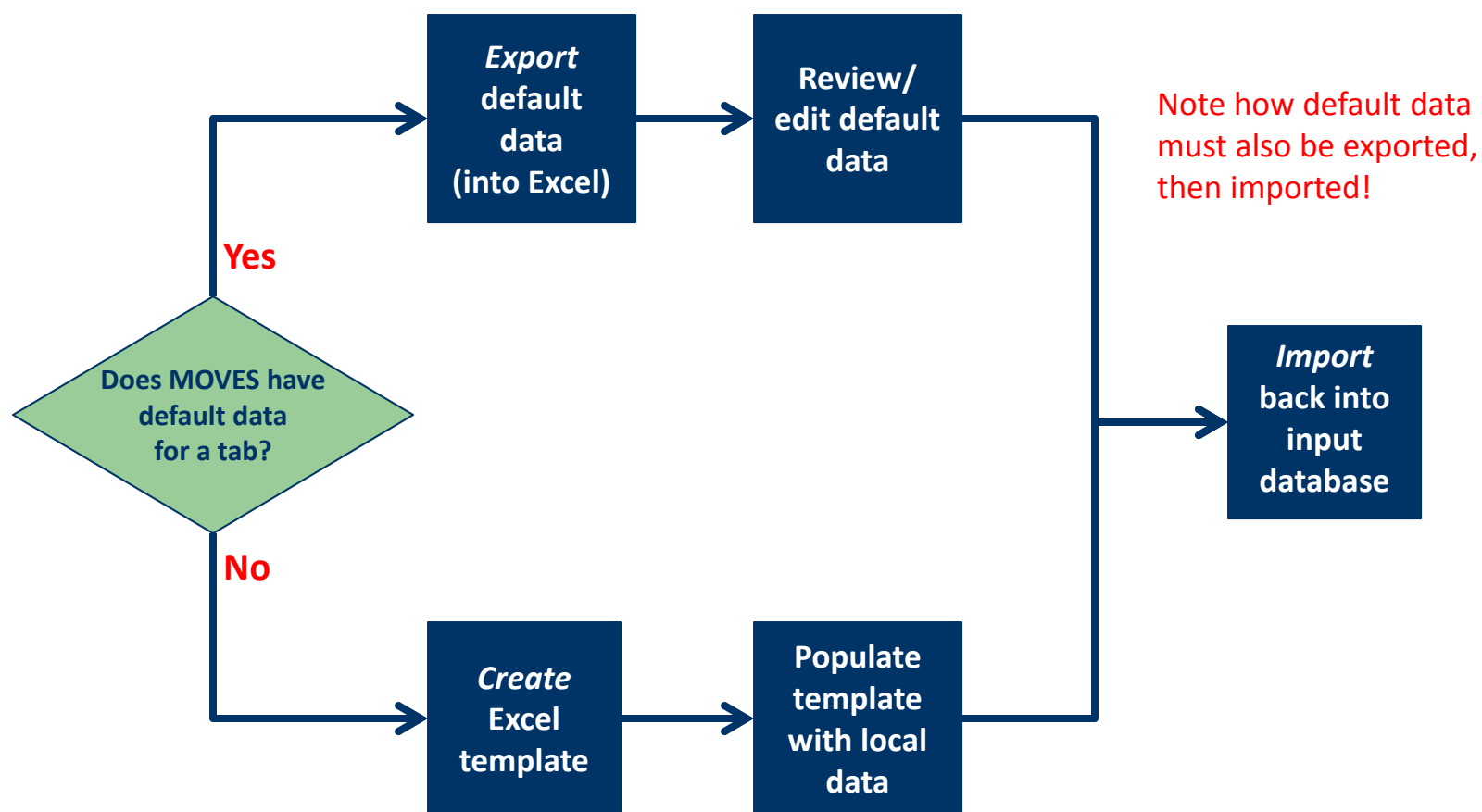
Log: Clear All Imported Data

Database

Done

Tabs used to input user-specific data to an input data

## Options for Entering Data



# Comparison of MOVES and MOBILE6 Inputs

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## MOVES v. MOBILE6 Inputs

- FHWA and EPA have heard concerns from users about the extent and complexity of MOVES inputs compared to MOBILE6 inputs
- This section compares input needs for MOVES and MOBILE6 and highlights similarities and differences
- Choice of using local data or defaults governed by MOVES Technical Guidance. This is largely unchanged from MOBILE6 Technical Guidance

## Summary of MOBILE6 & MOVES Inputs

MOVES Input	MOBILE6 Input
Meteorology	Same
Fuel inputs	Same
I/M programs	Slightly more detail
Age distribution	Essentially the same
Speed distribution	Different units
VMT by vehicle type	VMT fraction by vehicle type
Road type distribution	VMT fraction by facility
Ramp fraction	Different units
VMT by hour	Essentially the same
VMT by day and month	Applied outside MOBILE model
Vehicle (sourcetype) population	Not present in MOBILE6



## Tools Provided to Aid Transition

- **EPA has developed spreadsheets to convert certain MOBILE6 inputs into MOVES format**
  - Age distribution
  - Speed distribution
  - Converting MOBILE6 VMT fractions inputs and total VMT to appropriate MOVES format
  - Converting MOBILE6 VMT fraction “by facility” to MOVES road type distribution
  - Converting MOBILE6 VMT day and hour fractions to MOVES annual VMT input
  - Meteorology
- **EPA recommends that data eventually be obtained directly in appropriate MOVES format**

# Demonstration of MOVES2010b

Showing a County-Level Run that  
Generates an Emissions Inventory

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# Reviewing MOVES Modeling Submissions

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MOVES



## Help – I'm Just a Reviewer!

- **All elements needed to complete a MOVES scenario are usually required to complete a review (run should be able to be recreated, if needed)**
  - RunSpec
  - Input database
  - Output database
- **Review Inputs and RunSpec against guidance to ensure they are complete and correct**
  - E.g., all required pollutants and processes selected, correct age and speed distribution(s) used...
- **Outputs should appear logical and complete**
  - E.g., no missing VMT

## Checking a RunSpec

- **Scale**

- County scale for SIPs or regional conformity analysis
- Project scale for hotspot analysis
- National scale not appropriate (expect for some GHG analyses)

- **Time Span**

- Time aggregation should be “hour”
- Are the year, month, day, and hours appropriate for the analysis?

## Checking a RunSpec

- **Geographic Bounds**
  - Correct county?
  - If using one county to represent many in a rates analysis, is there documentation to justify that decision?
  - Does the input database name match the input database file supplied?
- **On Road Vehicle Equipment**
  - For a county level analysis, all valid combinations should be selected
- **Pollutants and Processes**
  - Have the appropriate pollutants been selected?
  - For SIP/conformity analyses, all processes associated with a given pollutant must be selected

## Checking a RunSpec

- **General Output**

- Does the output database name match the output file supplied?
- Are the units appropriate?
  - Hourly emissions should use grams, larger units may result in rounding down to zero

- **Output Emission Detail**

- Is level of detail appropriate to how the results are post-processed?
  - E.g., If hourly output, are the results properly weighted during post-processing to determine daily emissions?

## Checking an Input Database

- **An input database is more complicated than a RunSpec and more difficult to review**
- **Documentation is key**
  - Which data are defaults and which are local?
  - What is the source of the local data?
  - How recent are the local data?
- **Refer to EPA's Technical Guidance when reviewing**
  - Guidance on choice of default vs. local data
  - Guidance on sources of local data
- **In general, input database should contain the most recent and best local data available for fleet and activity inputs**



## Looking at Specific Inputs

- **Meteorology (ZoneMonthHour)**
  - Temperature and humidity inputs
  - Local data needed
    - Default data based on 30 year averages that may not be appropriate for all types of analysis
- **Source type population (SourceTypeYear)**
  - Number (“population”) of local vehicles operating in the area
  - Important for start and evaporative emissions
  - Local data needed
    - Default data likely to be inaccurate
  - Technical guidance provides suggestions for sources

## Looking at Specific Inputs

- **Age distribution (SourceTypeAgeDistribution)**
  - Age fractions of fleet by age and source type
  - Local data needed
    - Default data is a national average
    - Default data may be used for categories not locally registered, e.g., combination long-haul trucks, intercity buses
  - Vehicle registration data are best source
- **Vehicle Type VMT (HPMSVTypeYear and others)**
  - Total annual VMT by HPMS vehicle type
  - Also month, day and hour VMT fractions
  - Local data needed
    - Default data likely to be inaccurate
  - Transportation demand models and HPMS are sources

## Looking at Specific Inputs

- **Average Speed Distribution (AvgSpeedDistribution)**
  - Speed distribution by road type, hour and source (vehicle) type
  - Local data needed
    - Default is a national average, not appropriate for local conditions
  - Recommended source is post-processed output from a travel demand model
- **Road Type Distribution (RoadTypeDistribution)**
  - Fraction of source type VMT on different road types
  - Local data needed
    - Default is a national average, not appropriate for local conditions

## Looking at Specific Inputs

- **Ramp Fraction (RoadType)**
  - Fraction of freeway VHT occurring on ramps
  - Local data optional, but recommended if available
  
- **Fuels (FuelSupply and FuelFormulation)**
  - Market share and composition of fuel blends
  - Defaults available by county and recommended
    - Change RVP if necessary to reflect ethanol content
    - Other changes only if local volumetric fuel property data are available

## Looking at Specific Inputs

- **Fuel Type and Technology (AVFT)**

- Fractions of vehicles by fuel type and vehicle technology
- Use defaults unless good local data are available
- Special concern for transit buses
  - Default is based on national sales data, which includes a mix of diesel, CNG, and gasoline buses
  - Local transit bus fleets are likely to have a different mix, e.g. 100% diesel or 100% CNG
  - If the VMT fraction is not changed, MOVES will allocate bus VMT using the default VMT fractions, even if only one fuel type is selected in the RunSpec

- **I/M Programs (IMCoverage)**

- Data on I/M programs at the county level
- Check to make sure defaults are accurate, change if not

## Reviewing Inventory Output

- **Output database contains multiple tables**
- **Will need to review user documentation to understand how results were postprocessed**
- **Movesrun**
  - Run ID
  - Distance and mass units
  - RunSpec file name
  - RunSpec description
  - Default database used
  - MOVES version date
  - Domain database name (input database used)

## Reviewing Inventory Output

- **Movesactivityoutput**

- Activity type ID
- Activity
  - VMT or vehicle population

- **Movesoutput**

- Run ID
- Emission Quant
  - Broken down by whatever detail was specified in the RunSpec
  - Units are specified in the RunSpec and echoed in the movesrun table

## Reviewing Rates Output

- **Rates output is in three separate tables**
- **Rateperdistance**
  - Running emission processes (including some evap)
  - Activity measure is VMT
- **Ratepervehicle**
  - Starts, extended idle (long haul combination trucks only), some evap processes
  - Activity measure is vehicle population
- **Rateperprofile (HC only)**
  - Vapor venting from parked vehicles
  - Activity measure is vehicle population



## Reviewing Rates Output

- Will need to review user documentation to understand how results were postprocessed
- Make sure all tables and processes are accounted for

## Some Common MOVES Mistakes

- **Output has “missing VMT”**
  - VMT reflected in MOVES output does not match input
  - One possible cause: not adjusting transit bus fuel fractions in Alternative Vehicle Fuels and Technology (AVFT) panel to match local data
- **Not selecting all required/applicable pollutants and processes when developing the RunSpec**
- **When doing an “emission rate” run, incorrectly post-processing emission rates**
  - Example: multiplying starts emission rate by number of starts instead of vehicle population

# Using MOVES at the Project Scale

The MOVES logo is displayed in a metallic, three-dimensional font with a brushed metal texture and a slight glow, set against a dark rectangular background.

MOVES



## Using MOVES at the Project Scale

- The National Academy of Sciences suggested that EPA add a ‘microscale’ model domain to its emission modeling ‘toolkit’
- Project Scale allows MOVES modeling at the ‘Link’ level
  - Roadway links
  - Off-network link
- Project Scale models the ‘average’ conditions on one or more links... It does not perform traffic simulation modeling

## Using MOVES at the Project Scale

- **Project scale appropriate for link level analysis**
  - CO and PM “Hot-spot” analysis for conformity
  - NEPA
  - Roadway/Intersection level energy and GHG analysis
- **Link-specific data must be entered when the Project scale is selected**
- **Data can be exported or imported with the Project Data Manager (PDM)**
- **Access to default data is limited**

## Using MOVES at the Project Scale

- Utilizes same MOVES emission rates and correction factors as county and national scale
- It does NOT utilize the default MOVES growth, VMT or population data
  - These must be supplied by the user.
- It allows the user to specify only one combination of ... per run
  - County
  - Year
  - Month
  - Hour

## Available Guidance Documents

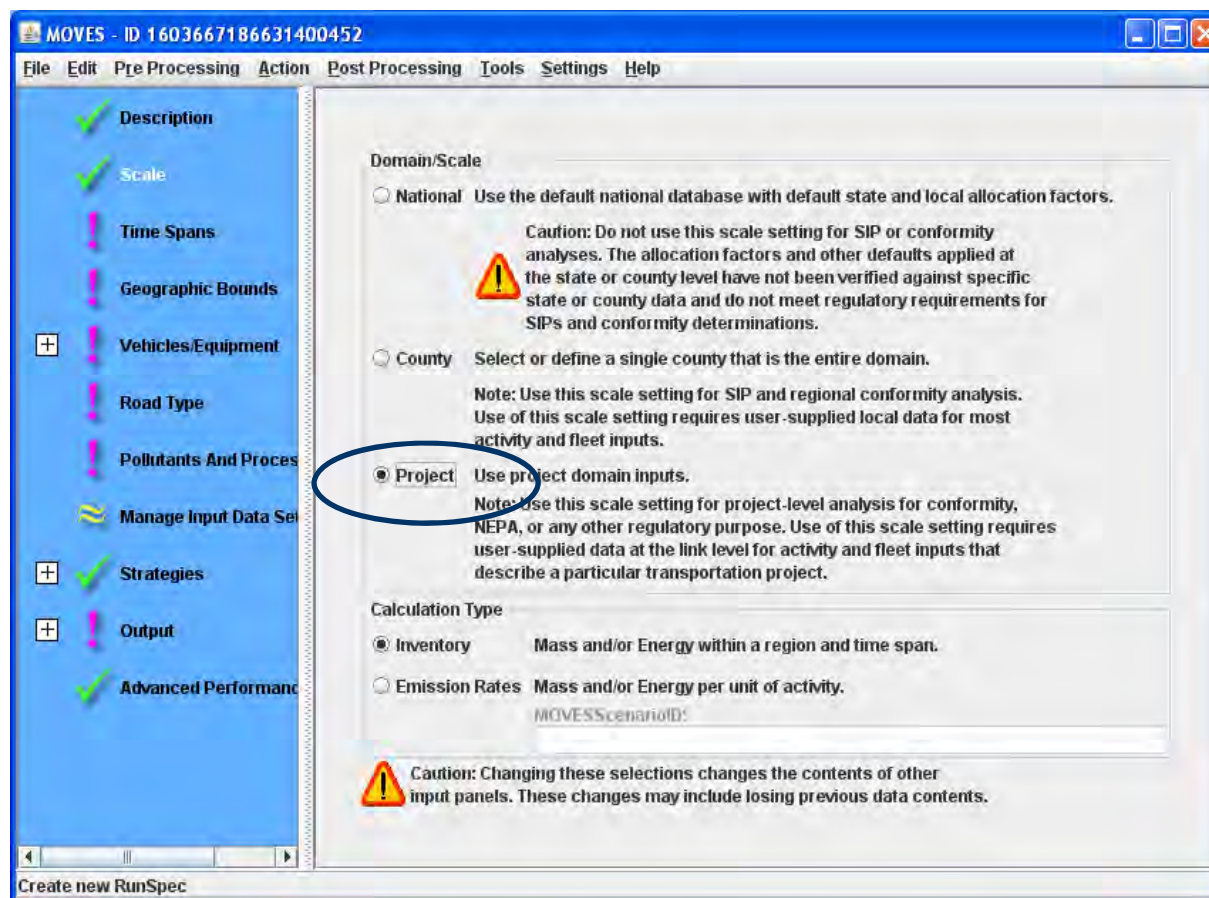
- **EPA has developed guidance for:**
  - Quantitative PM hot-spot analyses for transportation conformity (includes PM project scale MOVES guidance)
  - Using MOVES for CO project scale analyses
  - Both documents located here:  
<http://www.epa.gov/otaq/stateresources/transconf/policy.htm>

## 3-day training for PM Hotspot Guidance

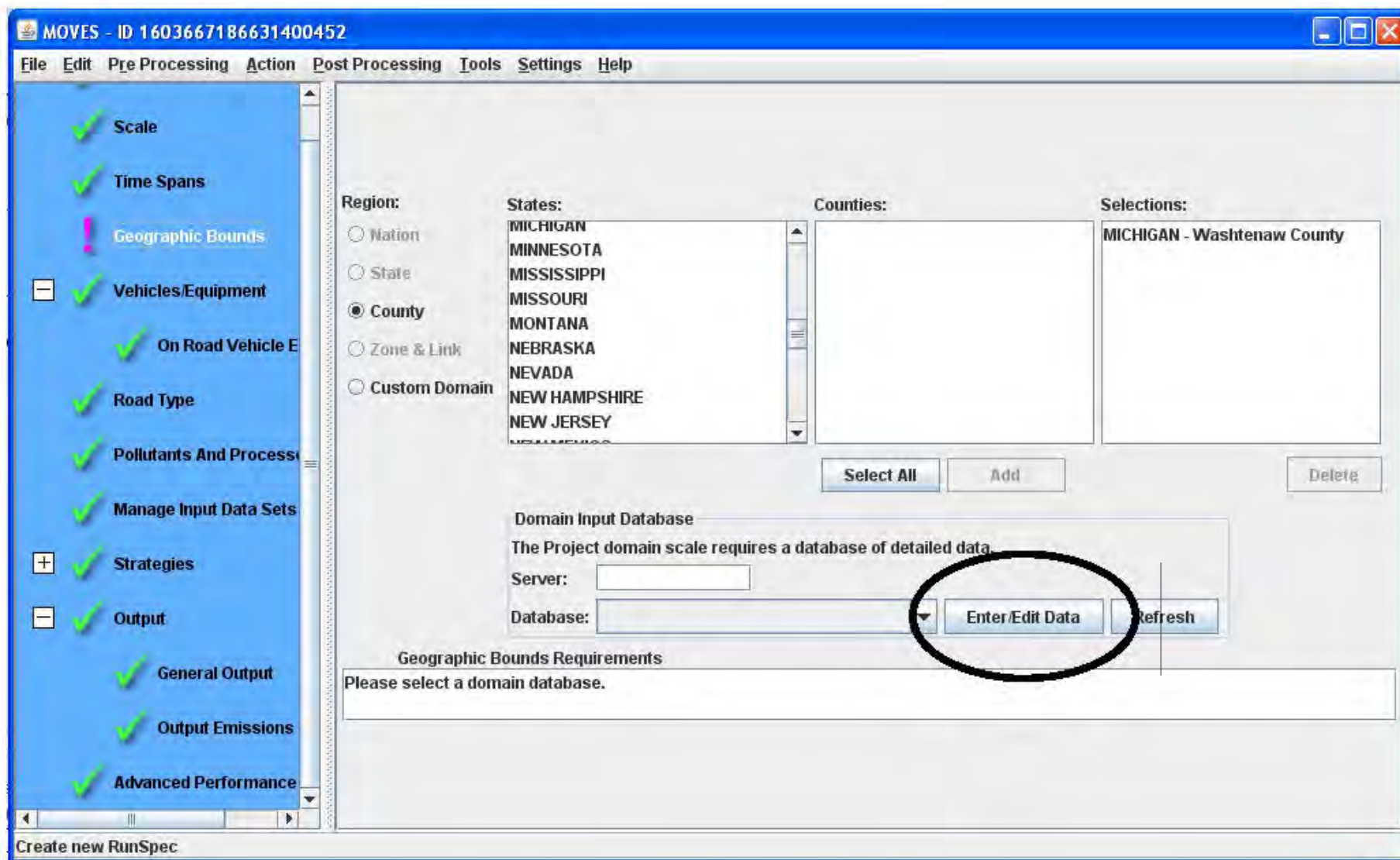
- EPA has developed a course specific to the PM hotspot requirement in the conformity rule
- Training covers using MOVES consistent with EPA guidance
- Also covers air quality modeling, background concentrations, design values, and other topics
- For training materials and updated training dates/locations, see EPA's website:  
<http://www.epa.gov/otaq/stateresources/transconf/training3day.htm>



# Project Scale RunSpec



# Accessing Project Data Manager



## **Project Scale Inputs**

- **Links**
- **Off-Network**
- **Link Source Types**
- **Age Distribution**
- **Meteorology Data**
- **Fuel Supply**
- **Fuel Formulation**
- **Fuel Type and Technology**
- **I/M**
- **Operating Mode Distribution**
- **Link Drive Schedules**

## Project Scale Inputs

- Links
- Off-Network
- Link Source Types
- Age Distribution
- Meteorology Data
- Fuel Supply
- Fuel Formulation
- Fuel Type and Technology
- I/M
- Operating Mode Distribution
- Link Drive Schedules

Inputs  
common for  
both MOVES  
county scale  
and project  
scale  
analyses



## Project Scale Inputs

- Links
- Off-Network
- Link Source Types
- Age Distribution
- Meteorology Data
- Fuel Supply
- Fuel Formulation
- Fuel Type and Technology
- I/M
- Operating Mode Distribution
- Link Drive Schedules

Inputs unique  
to MOVES  
project scale

**MOVES Project Data Manager**

☒ Fuel Formulation   ☒ Meteorology Data   ☒ I/M Programs   Tools

☒ Off-Network   ☒ Operating Mode Distribution   ☒ Age Distribution   ☒ Fuel Supply

RunSpec Summary   **Database**   ☒ Links   ☒ Link Source Types   ☒ Link Drive Schedules

Select or create a database to hold the imported data.

Server:

Database:  ▼     

Log:

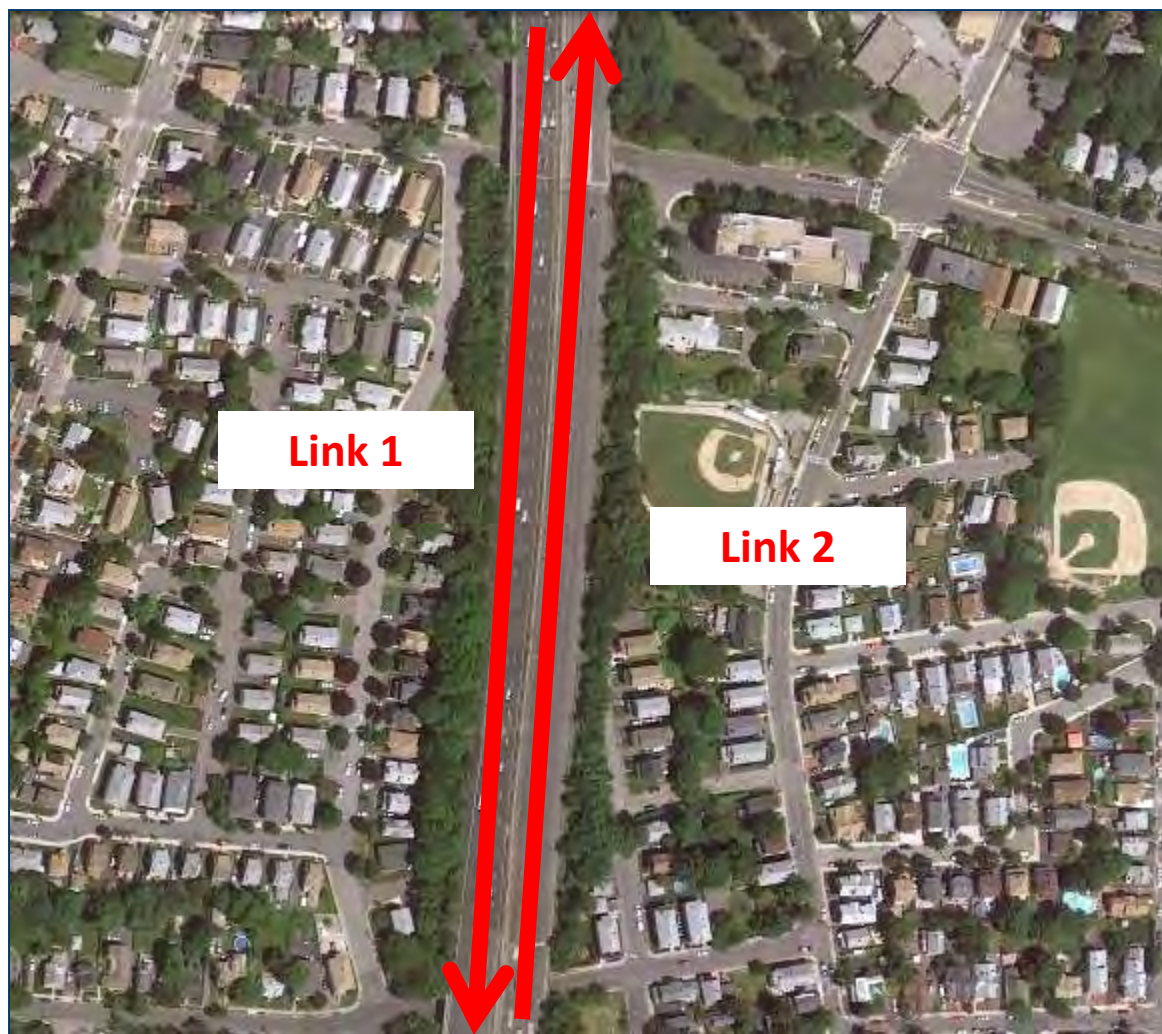
**Database**



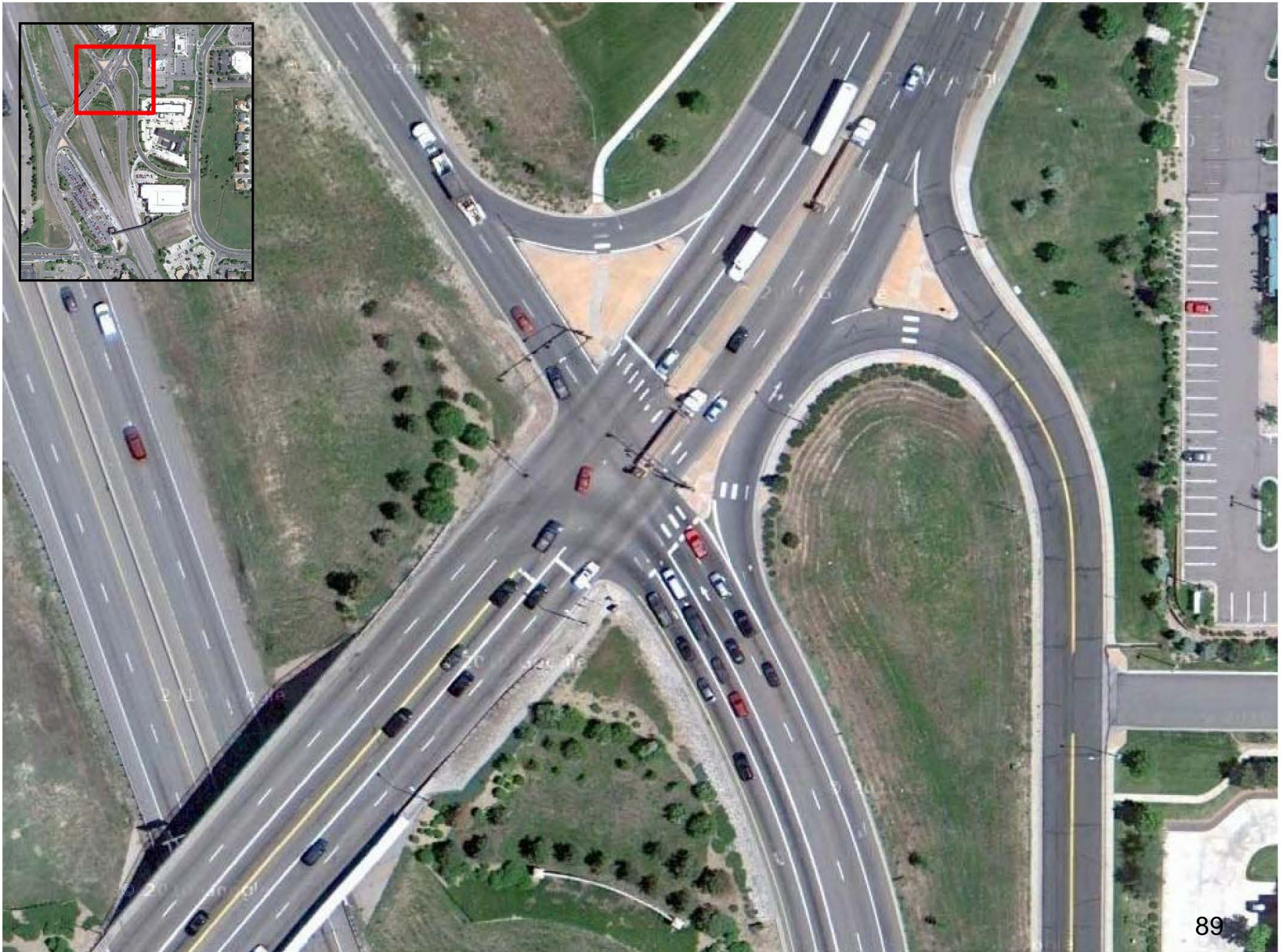
## What Is a MOVES Link?

- A segment of road or an “off-network” location where a similar type of vehicle activity occurs
- Types of links include:
  - Running Links
    - Free-flow highway and ramps
    - Intersection (cruise, deceleration, idle, and acceleration)
  - Off-Network Links
    - Start and extended idling

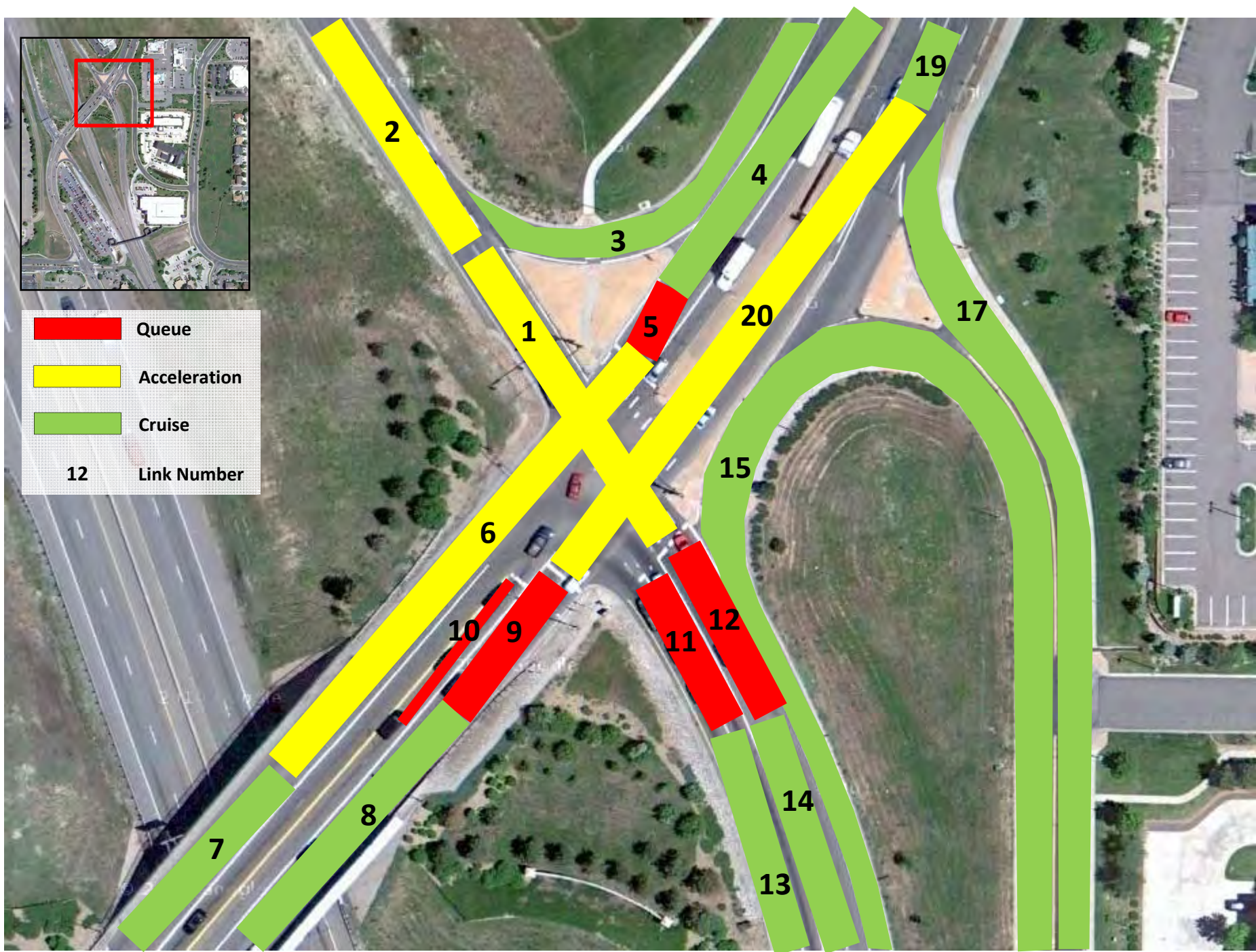
## What Is a MOVES Link?



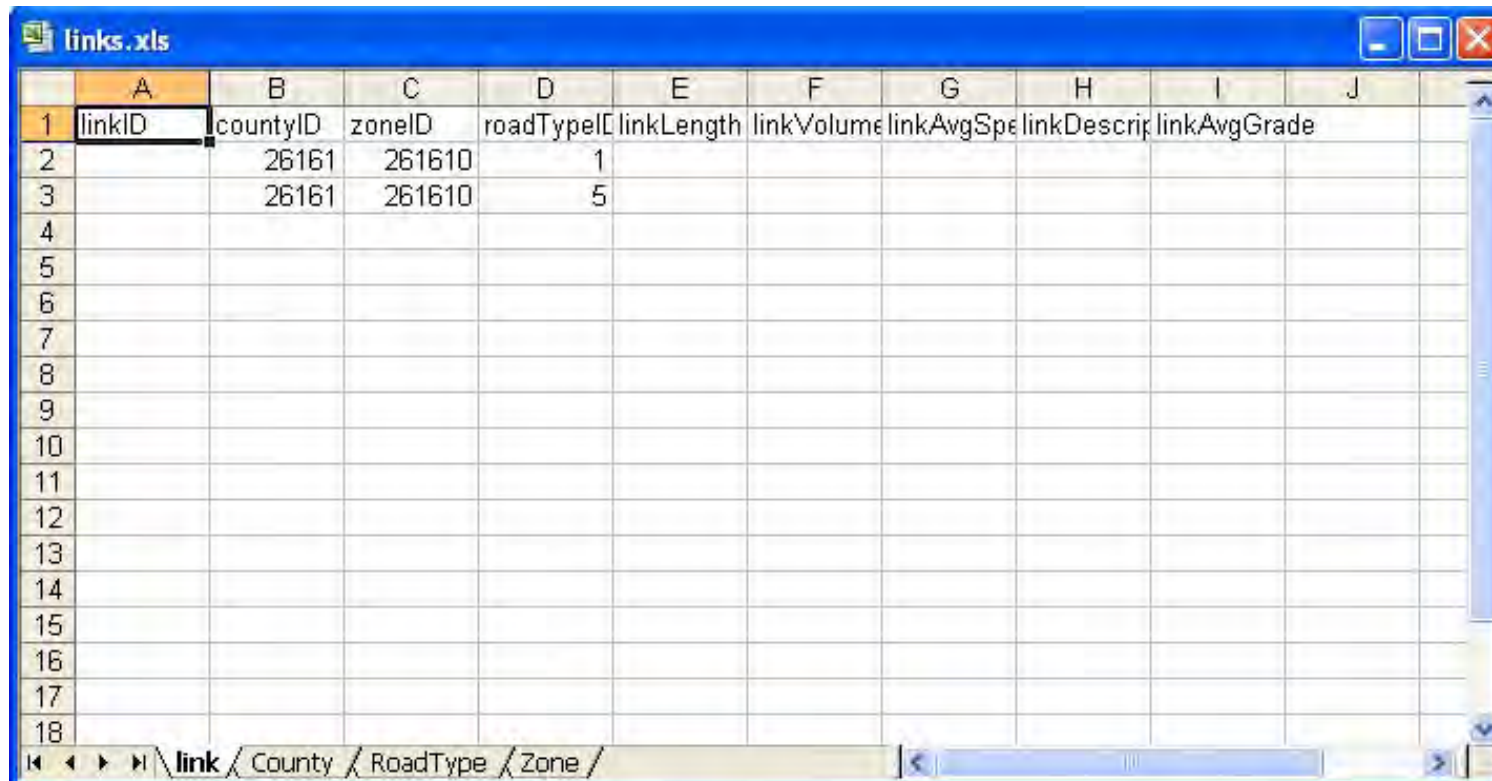






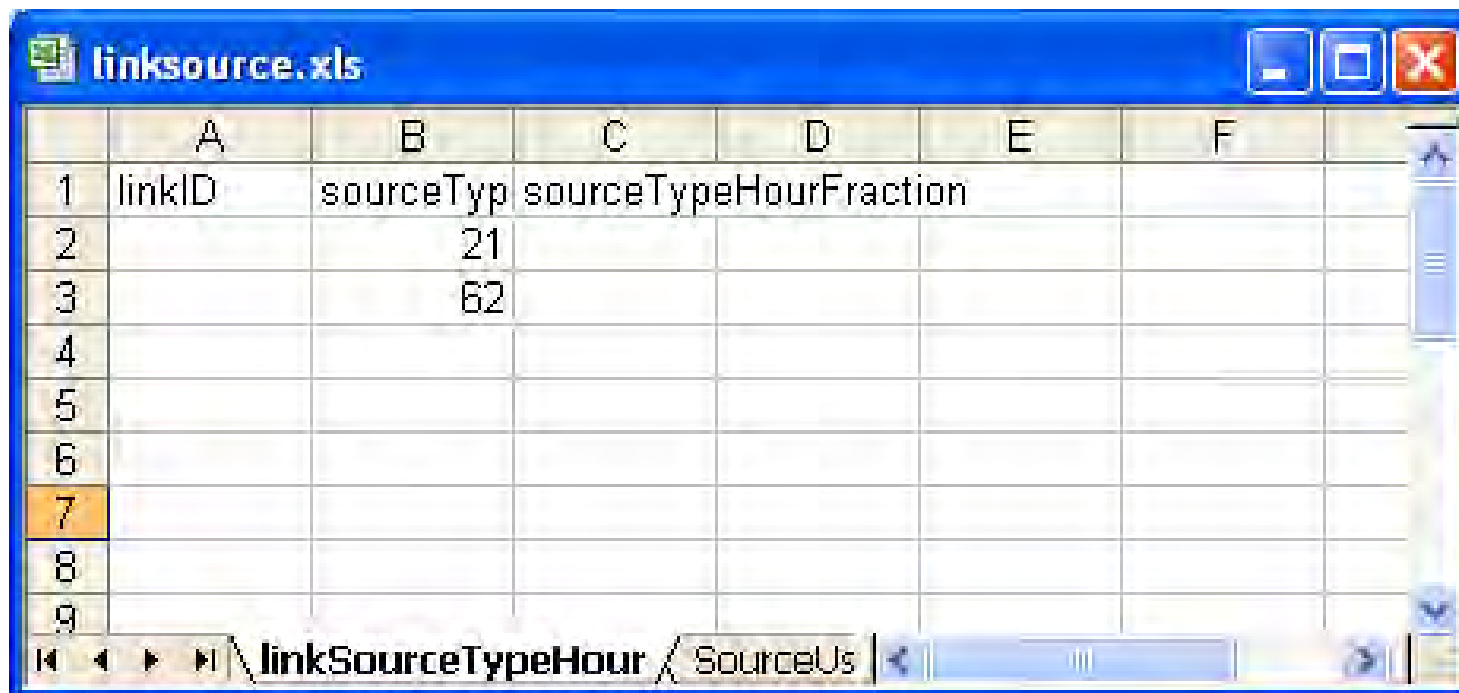


## Links Inputs



	A	B	C	D	E	F	G	H	I	J
1	linkID	countyID	zoneID	roadType	linkLength	linkVolume	linkAvgSp	linkDescrip	linkAvgGrade	
2		26161	261610	1						
3		26161	261610	5						
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										

## Link Source Type Input



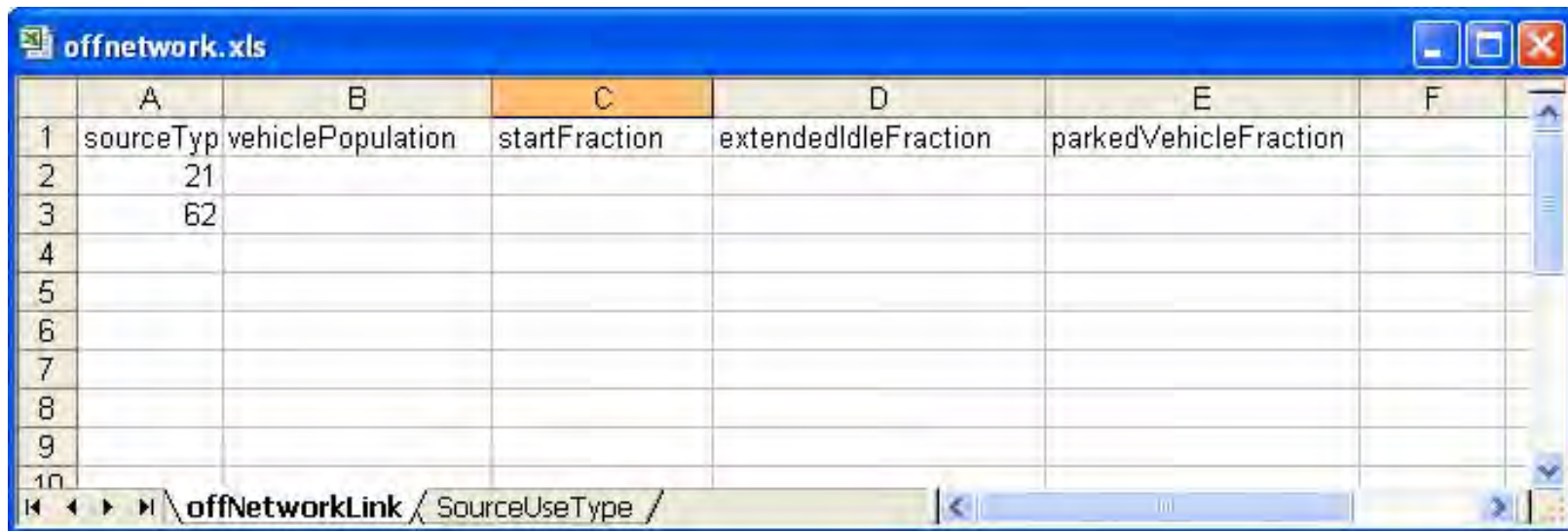
	A	B	C	D	E	F
1	linkID	sourceTyp	sourceTypeHourFraction			
2		21				
3		62				
4						
5						
6						
7						
8						
9						



# What is an Off-Network Link?



## Off-Network Input



	A	B	C	D	E	F
1	sourceType	vehiclePopulation	startFraction	extendedIdleFraction	parkedVehicleFraction	
2	21					
3	62					
4						
5						
6						
7						
8						
9						
10						

# Defining Vehicle Activity in MOVES

Users may choose one or more options:

1. **Define a link average speed (through the “Links table”)**
  - MOVES includes default OpMode distributions based on typical driving cycles
2. **Enter a link specific drive cycle**
  - User defines a second-by-second drive cycle for each link
3. **Directly enter a link specific OpMode distribution**
  - Precisely describes distribution of activity on a link (fraction of time spent in each OpMode bin)
  - Not a typical output from current traffic models
  - OpMode distribution is **required** if modeling an off-network link

# Project Scale Modeling: Demonstration

MOVES

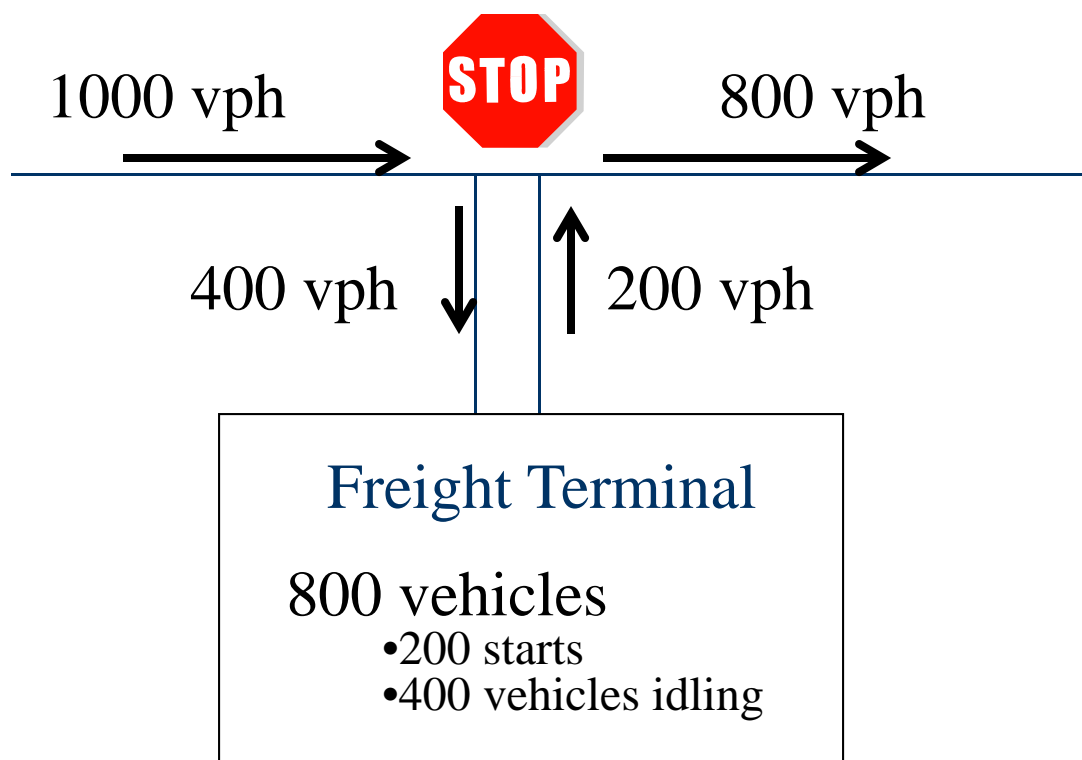




## Demonstration Goals

- Use the MOVES project scale in a practical example: modeling carbon monoxide emissions from a freight terminal and connector links
- Evaluate emissions by defining link average speeds
  - We will rely on the MOVES default drive cycles
- Produce link specific grams/hour emission factors for use in air quality modeling
- Demonstrates MOVES capabilities at the project scale, and is not intended to reflect technical or policy guidance

## Define the Project



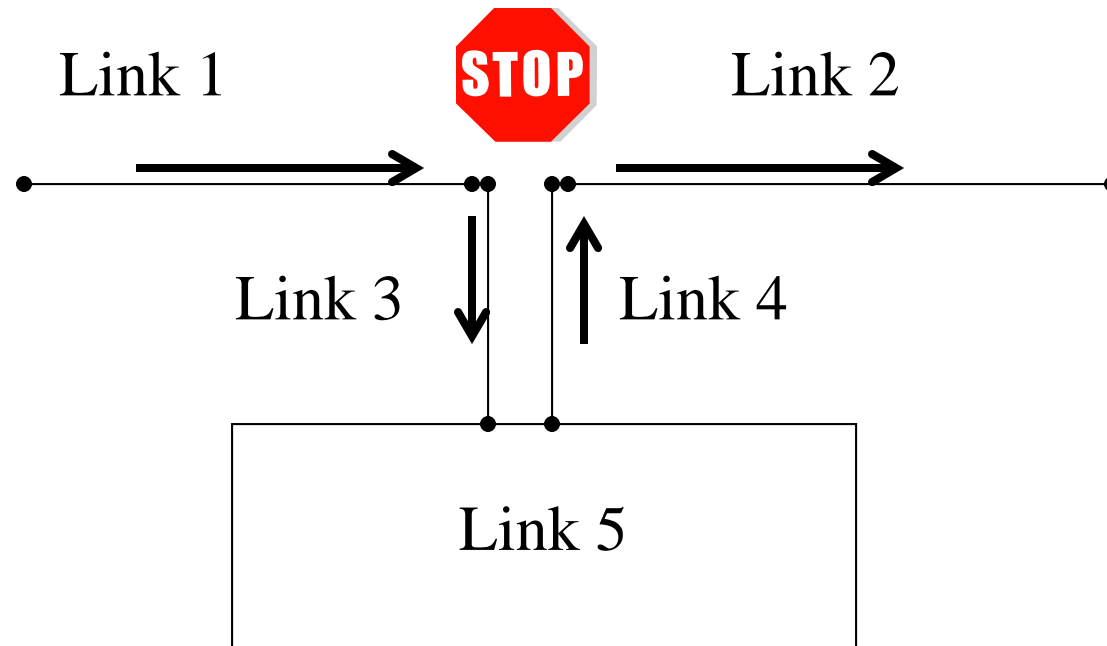
## Project Parameters and Assumptions

- Only CO emissions from running, starts, and extended idle considered (no crank-case emissions considered for simplicity)
- The on-road links consist of heavy-duty combination long-haul diesel trucks and passenger vehicles (source types 62 and 21)... not realistic, but assumed for simplicity
- The off-network link consists of only heavy-duty combination long-haul diesel trucks
- Only one hour of operation is considered (peak hour)

## Specific Project Data (parameters)

● <u>Parameter Name</u>	<u>Parameter</u>
● Location County	Washtenaw County, MI
● Calendar Year	2010
● Month	January
● Weekday/Weekend	Weekday
● Time	8:00 AM to 9:00 AM
● Temperature	20.3 F
● Humidity	70.0 %
● Roadtype of links	Urban Unrestricted Access

# Specific Project Data (link data)



Link ID	Road Type	Link Length	Link Volume	Truck Fraction	Car Fraction	Average Speed (accounting for intersection delay)
1	Urban Unrestricted	0.5 mi	1000	0.4	0.6	25 mph
2	Urban Unrestricted	0.5 mi	800	0.25	0.75	35mph
3	Urban Unrestricted	0.25 mi	400	1	0	15 mph
4	Urban Unrestricted	0.25 mi	200	1	0	15 mph
5	Off-Network	N/A	800	1	0	N/A

## Freight Terminal Data (Off-network link)

**800 Trucks: 200 starts, 400 idle hours**

- | <b>• <u>Parameter Name</u></b>      | <b><u>Parameter</u></b>   |
|-------------------------------------|---|
| • <b>Average Vehicle Population</b> | <b>800 vehicles</b>   |
| • <b>Start Fraction</b>             | <b>0.25</b>   |
| • <b>Extended Idle Fraction</b>     | <b>0.5</b>  |
| • <b>Soak Distribution</b>          | <b>0.5 soaking 90 min to 120 min</b><br><b>0.5 soaking 30 min to 60 min</b> |

# Documentation and Resources

**MOVES**



# MOVES Documentation and Resources

**Available via:** [www.epa.gov/otaq/models/moves/](http://www.epa.gov/otaq/models/moves/)

- MOVES user guide
- Guidance documents
- Software design/reference manual
- Technical documentation
- Presentations and other materials
- Frequently asked questions (FAQs)



## Policy and Guidance Documents

- **Policy Guidance on the Use of MOVES2010 and Subsequent Minor Revisions for State Implementation Plan Development, Transportation Conformity, and Other Purposes**
  - Revised April 2012
  - [www.epa.gov/otaq/models/moves/420b09046.pdf](http://www.epa.gov/otaq/models/moves/420b09046.pdf)
  - Provides detailed guidance on when MOVES2010/2010a should be used in SIPs and transportation conformity analyses
- **Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity: Technical Guidance for MOVES2010, 2010a, and 2010b**
  - Originally published December 2009, updated April 2012
  - <http://www.epa.gov/otaq/models/moves/documents/420b12028.pdf>
  - Provides guidance on appropriate inputs for MOVES2010/2010a/2010b in SIPs and regional conformity analyses

## Policy and Guidance Documents

- **Project-level MOVES guidance documents**
  - Quantitative PM Hot-Spot Analysis Conformity Guidance
  - Using MOVES for CO Project-Level Analyses
  - <http://www.epa.gov/otaq/stateresources/transconf/policy.htm#project>
- **Federal Register notices**
  - Approving the model and establishing grace periods
  - See <http://www.epa.gov/otaq/stateresources/transconf/policy.htm>

## Training Opportunities

- **MOVES 2-day training course**
  - Provides a complete hands-on introduction to using MOVES for SIPs and regional conformity analyses
- **3-day training course on completing quantitative PM hot-spot analyses**
  - Includes how to use MOVES for PM hot-spot analyses, in addition to air quality models and other analysis aspects
  - Courses start this summer
  - <http://www.epa.gov/otaq/stateresources/transconf/training3day.htm>
- **MOVES webinars (archived on website)**
  - Introduction to MOVES; Using MOVES in batch mode

## Mobile@epa.gov

- EPA has one e-mail address for all mobile source emissions modeling questions: [mobile@epa.gov](mailto:mobile@epa.gov)
- Have responded to about 2,500 questions since release of MOVES2010
- Users can help by sending in all details of runs (RunSpec, input files, output files) with question
  - Often, recreating the run is needed to determine what happened