

# Introduction to MOVES2014b for Modelers



# Course Goals

- Provide an overview of MOVES2014b
  - Understanding capabilities and input data needs
  - Deciding on a modeling strategy
  - Using MOVES to estimate both onroad and nonroad emissions
  - Obtaining relevant EPA guidance
- A detailed look at MOVES2014b at the County scale for SIPs and regional conformity analyses based on EPA MOVES Technical Guidance
  - Setting up a RunSpec
  - Creating a county database using the County Data Manager
  - Developing MOVES2014b input files
  - Using MOVES2014b in the inventory and rates modes
  - Reviewing output using MySQL
- Hands-on experience using the MOVES2014b model

# Course Outline: Day 1

- Module 1: Introduction
  - General MOVES overview and strategies for running MOVES
- Module 2: Getting Acquainted
  - Preview of menu items and creating a RunSpec
  - Hands-on National scale exercise
- Module 3: Generating Inventories at the County Scale
  - Creating a RunSpec for an inventory run
  - Using the County Data Manager to create an input database
  - Running MOVES

# Course Outline: Day 1, continued

- Module 4: Processing MOVES Outputs
  - What's in MOVES output tables?
  - Post Processing menu
  - Using MySQL scripts and Workbench
- Module 5: Review and Best Practices
  - Best practices for managing files
  - What to look for when reviewing MOVES runs

# Course Outline: Day 2

- Module 6: Using the Custom Domain Option
  - Relevant inputs
  - Dividing the activity using zones
  - Hands-on exercise: modeling a multi-county area with a custom domain
- Module 7: Emission Rates at the County Scale
  - Types of rates
  - Building a rates look-up table
  - Creating a RunSpec and input database for a rates run
  - Hands-on exercise: create an inventory using rates

# Course Outline: Day 2, continued

- Module 8: Project-level Analyses
  - Overview
  - Class demonstration: how to run MOVES for a small project
- Module 9: On-Your-Own Class Exercise
  - Develop a county level CO inventory starting with input data
- Module 10: Modeling Nonroad Emissions
  - Options for modeling nonroad emissions
  - Hands-on demonstration

# Module 1

## Introduction to MOVES



# Module 1 Overview

- Overview of MOVES
- Available documents
- Modeling options



# What is MOVES?

- The MOtor Vehicle Emission Simulator (MOVES) is a state-of-the-art modeling framework for onroad and nonroad emissions inventory development
- EPA's official model for state implementation plans (SIPs) and transportation conformity analyses
- Current version is MOVES2014b
  - Second update in MOVES2014 series

# MOVES2014

- Major release (10/2014)
- New OTAQ rules
  - Tier 3
  - HD GHG phase 1
  - LD GHG
- New science
  - Relied on dozens of new test programs and scientific studies
  - Future forecasts (VMT, population, sales)
- Improved functionality
  - Improved integration with air quality models
  - More features for local inputs
  - GUI improvements
  - Adds existing NONROAD model

# MOVES2014a

- Minor release (11/2015)
- Nonroad toxics and speciation
  - No longer just “total hydrocarbons”
    - Now also VOC, TOG, NMHC, NMOG
  - About 60 air toxics
- New flexibility for local VMT input
  - Users can now enter VMT either by HPMS class or MOVES Source Type
  - Users can now enter either annual VMT or average daily VMT
- More nonroad output aggregation options
  - Adds output flexibility similar to NONROAD2008
- Updated nonroad gasoline supply to match onroad
- Numerous bug fixes
- New installation suite reduces installation problems

# MOVES2014b

- Minor release (8/2018)
- Updates equipment growth estimates for every sector
  - Most sectors now have region-specific growth factors
- Updates diesel Tier 4 emission rates
  - Includes specific rates for various combinations of aftertreatment technologies
- Improves post processing scripts
  - Emission factor scripts are faster, more flexible, and easier to use
- Updates and adds chemical mechanisms:
  - CB05
  - CB6CMAQ
  - SAPRC07T

# When do I use MOVES?

- EPA *Federal Register* notice of October 7, 2014 (79 FR 60343) approved MOVES2014 and subsequent minor revisions (MOVES2014a, MOVES2014b) for:
  - New State Implementation Plans (SIPs)
    - Use MOVES2014b now for any new SIPs
    - If significant work on a SIP with MOVES2014 or MOVES2014a has already been completed, you can continue
  - Transportation conformity analyses, including
    - Regional conformity analyses
    - Project-level conformity analysis (PM & CO Hotspot)
    - *FR* notice established a two-year conformity grace period
      - Until October 7, 2016, could use a version of MOVES2010 or MOVES2014
      - Since then, must use a version of MOVES2014 (MOVES2014b recommended)

# EPA MOVES Guidance

- MOVES2014 SIP and Conformity Policy Guidance
  - Published July 2014
    - [nepis.epa.gov/Exe/ZyPDF.cgi?Dockkey=P100K4EB.txt](https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockkey=P100K4EB.txt)
    - Guidance on when MOVES should be used in SIPs and transportation conformity analyses
- MOVES2014b Q&A document
  - Published August 2018
    - [nepis.epa.gov/Exe/ZyPDF.cgi?Dockkey=P100V7H1.pdf](https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockkey=P100V7H1.pdf)
- MOVES2014, MOVES2014a, and MOVES2014b Technical Guidance
  - Published August 2018
    - [nepis.epa.gov/Exe/ZyPDF.cgi?Dockkey=P100V7EY.pdf](https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockkey=P100V7EY.pdf)
    - Detailed guidance on appropriate inputs for MOVES in SIPs and regional conformity analyses
    - Defaults vs. local information
    - Developing appropriate local inputs

# MOVES Policy and Guidance Documents

- Technical Guidance on MOVES for On-Road GHG Emissions and Energy Consumption

<https://www.epa.gov/state-and-local-transportation/estimating-road-greenhouse-gas-emissions>

- Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM<sub>2.5</sub> and PM<sub>10</sub> Nonattainment and Maintenance Areas

[www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#pmguidance](http://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#pmguidance)

- Using MOVES in Project-Level CO Analyses

[www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#coguidance](http://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses#coguidance)

# Other MOVES2014b Documentation

- [www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves#manuals](http://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves#manuals)
- MOVES User Guide: A step-by-step guide for users based on this training. Topics include:
  - Graphical user interface (GUI)
  - Using MOVES at different scales
  - Processing output
- MOVES User Interface Reference Manual
  - Includes detailed description of the function of every menu item, panel, and importer in MOVES
- The Software Design and Reference Manual (SDRM)
  - Hardware and software requirements
  - Software design components
  - Overview of processing, data and control flow
  - Input and output database tables and design
- MOVES Algorithms Reference
  - [www.epa.gov/moves/moves-algorithms](http://www.epa.gov/moves/moves-algorithms)



# Other MOVES Information



Environmental Topics

Laws & Regulations

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## MOVES and Other Mobile Source Emissions Models

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### MOTor Vehicle Emission Simulator (MOVES)

[Latest version of MOVES](#)

EPA's MOTor Vehicle Emission Simulator (MOVES) is a state-of-the-science emission modeling system that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics.

Visit:  
[www.epa.gov/moves](http://www.epa.gov/moves)

### Using MOVES

- [Latest MOVES Model](#)
- [MOVES Limited Use Models](#)
- [Tools to Develop or Convert MOVES Inputs](#)
- [MOVES Training Sessions](#)
- [Methods to Produce Emission Inventories](#)

### Understanding Algorithms & Default Data

- [MOVES Algorithms](#)
- [MOVES Technical Reports](#)
- [NONROAD Technical Reports](#)
- [Presentations and Workshops on MOVES Data](#)
- [MOVES Model Review Work Group](#)
- [Fuel Analysis Programs](#)

### Older Models

- [Previous MOVES Versions](#)
- [MOBILE Model](#)
- [NONROAD Model](#)
- [NMIM \(National Mobile Inventory Model\)](#)

Search MOVES and Other Models

Search this Site

[Contact Us](#) to ask a question, provide feedback, or report a problem.



# Other MOVES Information

- To join the MOVES listserv, send a blank email to [www.epa.gov/moves/forms/epa-mobilenews-listserv](mailto:www.epa.gov/moves/forms/epa-mobilenews-listserv)
- Questions? Contact us:  
[MOBILE@epa.gov](mailto:MOBILE@epa.gov)  
[www.epa.gov/moves](http://www.epa.gov/moves)

# What's Inside MOVES?

- We will focus on the *onroad* portion of MOVES here
  - We will cover *nonroad* in Module 10
- Next few slides will cover:
  - Processes that yield emissions
  - Pollutants
  - Vehicle types
  - Emission rate components

# Emissions Processes in MOVES

- Running
- Start
- Extended Idle (trucks “hoteling” under load)
- Evaporative
  - Permeation, Vapor Venting, Liquid Leaks
- Refueling
  - Vapor loss, Spillage
- Crankcase
- Tire Wear
- Brake Wear

# Pollutants in MOVES

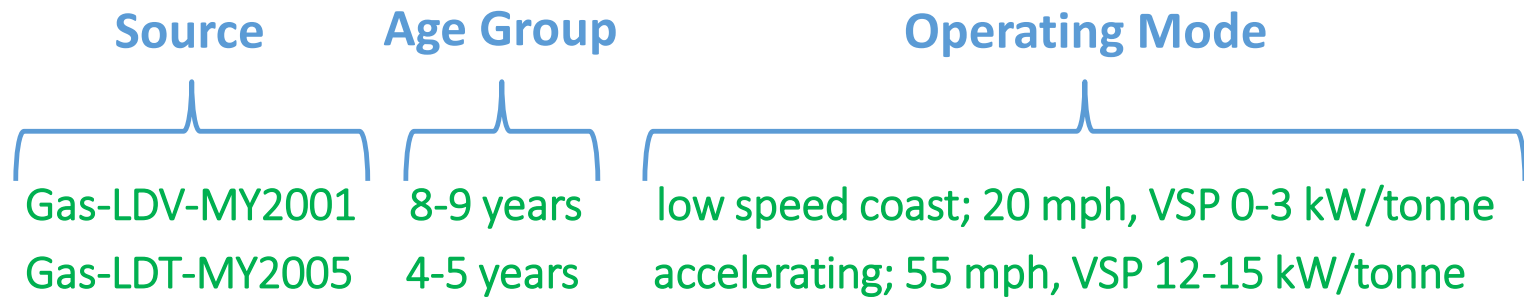
- HC (THC, NMHC, NMOG, TOG, VOC)
- CO
- NO<sub>x</sub> (NO, NO<sub>2</sub>)
- NH<sub>3</sub>
- SO<sub>2</sub>
- PM<sub>10,2.5</sub> (multiple exhaust species plus brake and tire)
- GHG (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O)
- Toxics (over 50 different exhaust and evap species)
- Energy (total, petroleum, fossil)

# Fuel and Vehicles in MOVES

- Compressed Natural Gas
  - Diesel
  - Ethanol (E-85)
  - Gasoline
  - Electricity
- +
- Passenger Car
  - Passenger Truck
  - Motorcycle
  - Light Commercial Truck
  - Intercity Bus
  - Transit Bus
  - School Bus
  - Refuse Truck
  - Single Unit Short-haul Truck
  - Single Unit Long-haul Truck
  - Motor Home
  - Combination Short-haul Truck
  - Combination Long-haul Truck

# MOVES Emission Rates

- MOVES includes different emission rates for each combination of...



# MOVES Emission Rates

- Core rates vary by:
  - Source type – different standards for different vehicle types
  - Model year/vehicle age – standards change over time, age of vehicle affects deterioration of emission controls
  - Fuel type – different rates for gasoline, diesel, CNG vehicles
  - Operating mode – speed and acceleration for running, soak time for start and evap emissions
    - Road type and speed distribution inputs determine fraction of time in different operating modes
- Further adjustments to rates for:
  - Temperature and humidity
  - Differences in fuel composition
  - I/M programs



# What output does MOVES provide?

- MOVES can:
  - provide emission rates which users can multiply by appropriate activity factors outside of MOVES, or
  - calculate an emission inventory internally using fleet and activity inputs

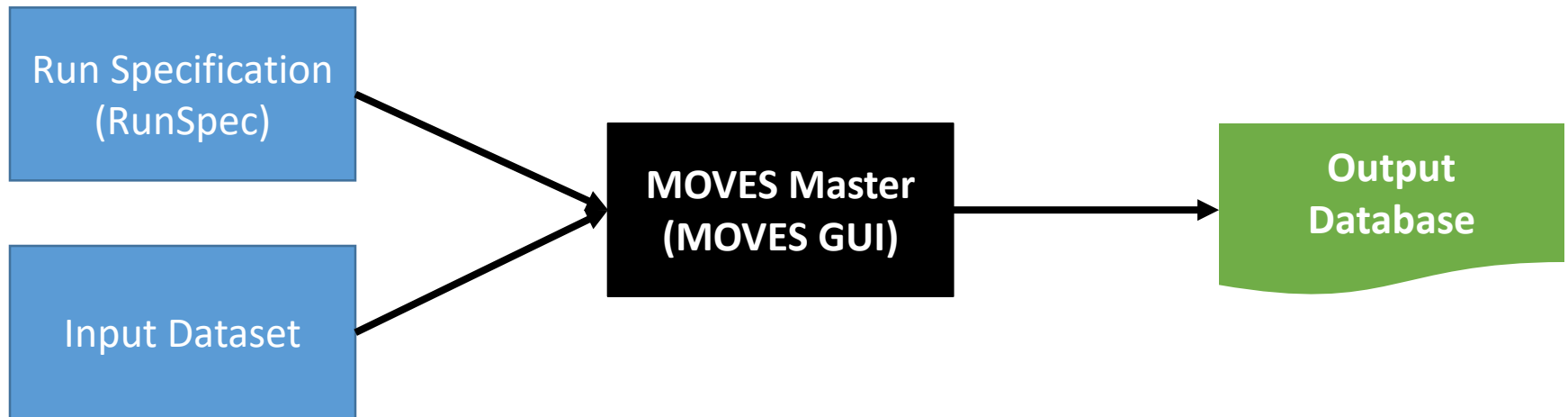
# Nonroad in MOVES2014b

- MOVES2014 incorporates existing NONROAD2008 model
  - Produces same results, but has more limited output options
- MOVES2014a updates nonroad gasoline fuels
  - Emission results change (slightly lower VOC and CO, slightly higher NOx)
- MOVES2014b updates growth rates and diesel Tier 4 rates
  - Emission results change (magnitude and direction vary by location)
- For SIPs, recommend states use MOVES2014b
- Technical documentation can be found at:

[www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles](http://www.epa.gov/moves/nonroad-model-nonroad-engines-equipment-and-vehicles)

# Files and Databases

- To run MOVES, users must provide or create
  - A run specification, a.k.a. a “RunSpec” and
  - Input databases (county and project scales)
- MOVES creates an output database



# Files and Databases

- A database is a set of tables
  - Databases are not “files” with an extension
  - User names them, but does not need to save them
  - Can be viewed and manipulated in MySQL; information can also be exported to another program (e.g., Excel)
- User provides names for all three items -- RunSpec file and two databases, and names should relate to one another
  - Ex: a MOVES run for CO emissions in Las Vegas, NV in 2020:
    - RunSpec: ClarkCounty\_CO\_2020.mrs
    - Input database: ClarkCounty\_CO\_2020\_in
    - Output database: ClarkCounty\_CO\_2020\_out

# Summary: Files and Databases

Item	Purpose	Where does it come from?
RunSpec	Describes what is being modeled, where, and when	User creates this file by making selections in Navigation Panel  Ex.: <a href="#">ClarkCounty_CO_2020.mrs</a>
Input Database	Provides data necessary for the run	At County & Project scales: User names it and populates it with local information Ex. <a href="#">ClarkCounty_CO_2020_in</a>  At National scale: MOVES relies on the default database (no action needed by user)
Output Database	Stores results of the run	User names it, and MOVES stores results in it Ex. <a href="#">ClarkCounty_CO_2020_out</a>

# Locating Your Data Folder

- The data folder stores the MOVES2014b default database, as well as input and output databases
- This folder is used to communicate between MOVES and MySQL Workbench, the post-processing tool for MOVES database tables
- The MOVES Installer may have put a shortcut on your desktop
- If not, it can generally be found in one of two places (the folder may be hidden):
  - Windows 7 or later - C:\ProgramData\MySQL\MySQL Server 5.x\
  - Windows XP - C:\Documents and Settings\All Users\Application Data\MySQL\MySQL Server 5.x\
- **Once you locate it, create a shortcut to it on your desktop** (right-click on folder, choose “Create shortcut” and drag it to your desktop)



# Modeling Options Overview

- MOVES gives the user an array of input & output options
- Users need to consider their modeling approach, e.g.,
  - *Scale/Domain*
  - *Inventory vs. Emission Rates*
- Your modeling approach will affect
  - Number of runs
  - Amount of post-processing necessary
  - Input data required
- Next few slides give an overview
- See also Section 2 in the Technical Guidance

# MOVES: Three Scales of Analysis

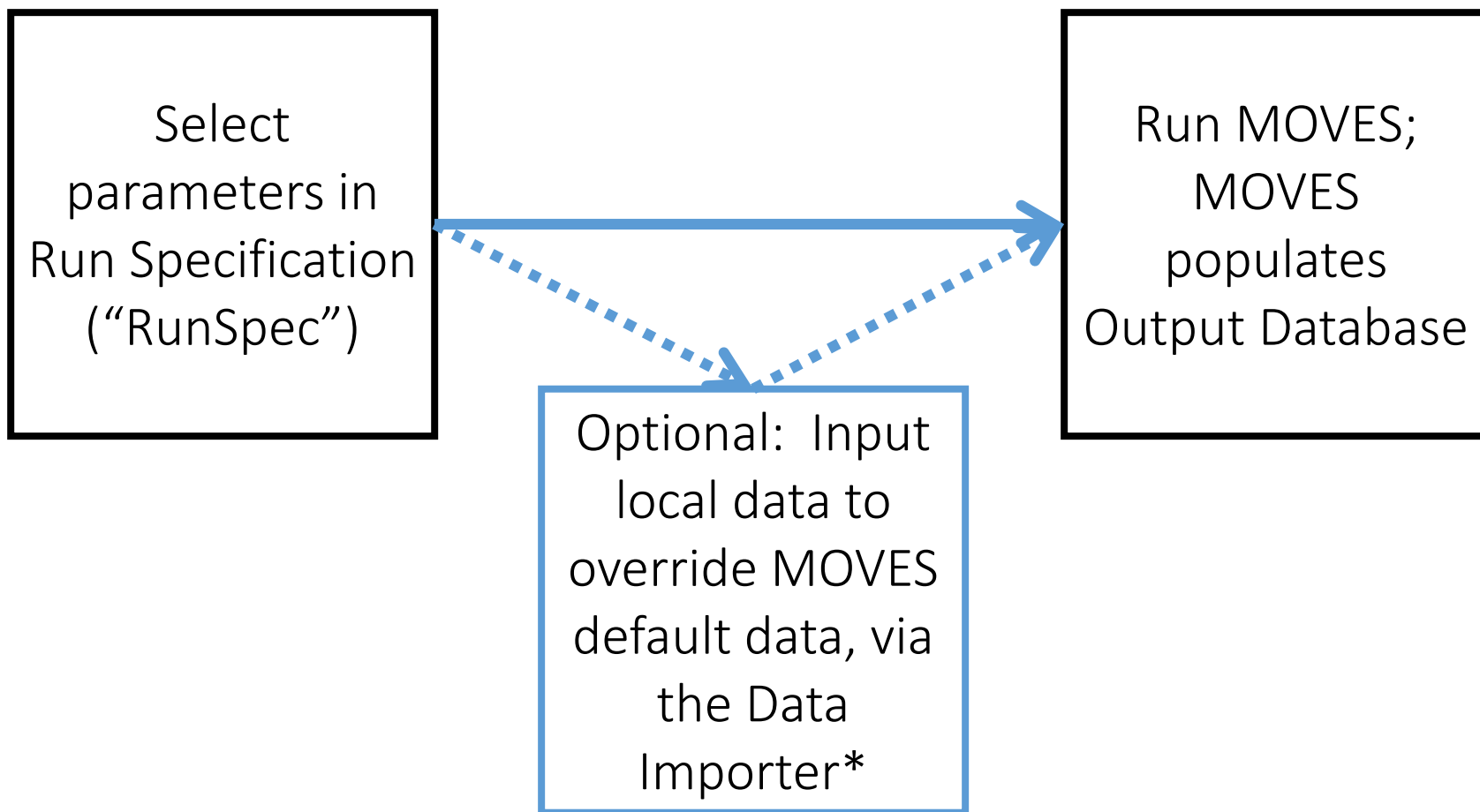
- Three scales: National, County, or Project
- All three scales have the same underlying MOVES emission rates and adjustment factors
- RunSpec file: needed for all three scales
- Input database: optional for National scale, needed for County and Project scales
- Output database: needed for all three scales



# National Scale

- Can be used to model:
  - The entire country
  - One or more states, also DC, Puerto Rico, and U.S. Virgin Islands
  - One or more counties
- Used for non-regulatory purposes only
  - **Cannot** be used for SIP or transportation conformity purposes
  - With the national scale, MOVES uses information in the MOVES default database, unless user includes local data (optional)
- **Caution:** the MOVES default database does not always have the most current or best available for any specific county or state
  - Some defaults are national but applied as-is to the geographic area chosen
  - Some defaults are national and are “downscaled” for geographic area chosen
  - Some defaults are for specific areas (e.g., type of I/M program)

# National Scale Process

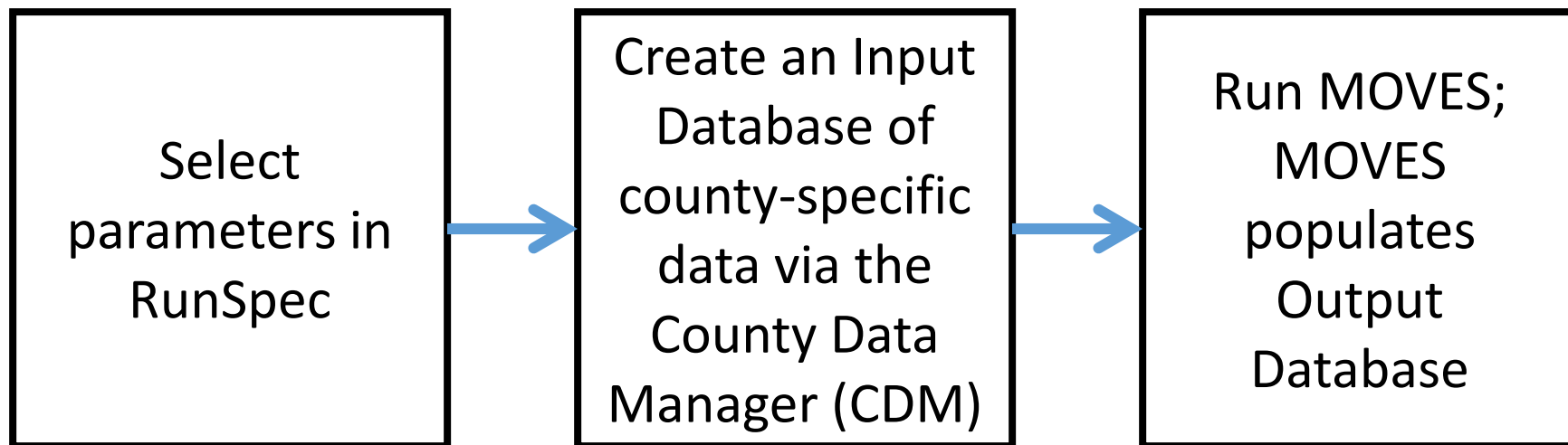


\* Cannot be done with all data inputs – more later

# County Scale

- Can be used to model:
  - An individual county
  - A Custom Domain made up of several counties (more later)
- ***Required*** for SIP and conformity analyses
- User must enter county-specific data, via the County Data Manager (CDM), for the input database
  - The CDM allows user to either:
    - export of MOVES default data, or
    - export templates, which the user completes with local data and then imports
  - Use of local data necessary for some inputs, recommended for most
  - Access to default data is limited

# County Scale Process

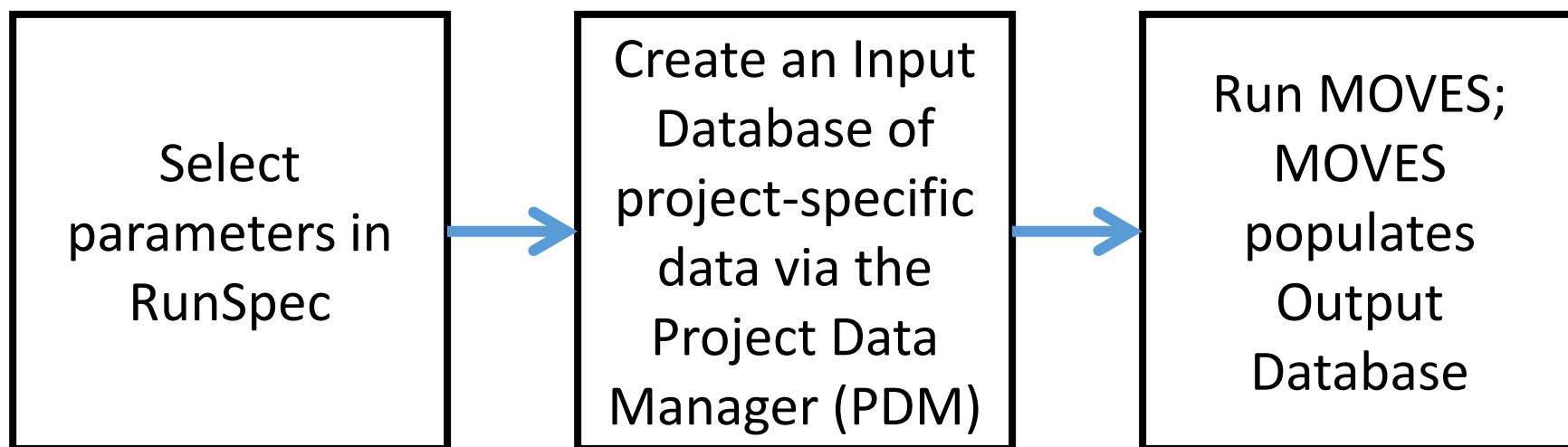


# Project Scale

- Link level modeling of specific transportation projects
  - Highways, intersections, interchanges, transit projects, parking lots
- Required for quantitative hot-spot analyses for conformity
- User must enter project-specific data, via the Project Data Manager (PDM), for the input database
- Also covered in EPA and FHWA's 3-day quantitative PM hot-spot analysis course:

[www.epa.gov/otaq/stateresources/transconf/training3day.htm](http://www.epa.gov/otaq/stateresources/transconf/training3day.htm)

# Project Scale Process



# Summary: MOVES Three Scales

	National	County	Project
Geographic area covered	<ul style="list-style-type: none"> <li>• Entire nation</li> <li>• One or more states</li> <li>• One or more counties</li> </ul>	<ul style="list-style-type: none"> <li>• One county</li> <li>• A multi-county area</li> </ul>	An individual transportation project (e.g., a highway, intersection, or transit project)
Purpose	Non-regulatory only	Required for SIP and regional conformity analyses	Required for project-level conformity analyses
Input database	User does not need to create, use of Data Importer is optional*	User creates with local data, through the County Data Manager	User creates with local data, through the Project Data Manager
Default data	Used unless overridden	Access to default data is limited	Access to default data is limited

\* User cannot provide information for certain inputs at the National scale

# Calculation Type

- Two types: **Inventory** or **Emission Rates**
  - Either are acceptable for SIP and regional conformity analyses
  - Either option can be used with any of the three scales
- Advantages and trade-offs in both approaches
- Choice depends on the area and purpose
  - In many cases, Inventory is the appropriate calculation type



# Calculation Type: Inventory

- Inventory: Output is emissions in units of mass (e.g., grams, kg, lbs, tons) for the time and place specified
  - Shorter run times than Emission Rates
  - MOVES processes results (rates x activity) to yield total mass of emissions
    - Minimizes user post-processing and therefore inadvertent errors
  - Results are specific to county and time
    - A daily run produces a county inventory for one day with a specific 24-hour temperature profile
- Inventory typically used when modeling a small number of counties, over a limited time period

# Calculation Type: Emission Rates

- Emission Rates: Output is a set of emission rates, e.g., rate per mile, rate per vehicle
  - Longer run times and larger output files than Inventory
  - User must post-process results by multiplying rates by vehicle activity data to get inventory
  - Could cover wide range of conditions with fewer runs than inventory
- Emission Rates typically used to:
  - Model a full range of temperatures with a small number of runs
  - Model a multi-state domain over multiple seasons
  - Create inventories with travel model post-processing software
  - Develop emission rates for a representative county and then apply them to many other counties
  - Used with the SMOKE-MOVES interface tool for air quality modeling
    - More information on SMOKE-MOVES on the MOVES web page

# County vs. Custom Domain

- Two options in Geographic Bounds panel for county scale runs
  - Either acceptable for SIP and conformity purposes
- **County**
  - 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
- More information later, in Module 6

# Questions?

