

Introduction to MOVES2014a for Modelers



Course Goals

- Provide an overview of MOVES2014a
 - 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 MOVES2014a 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 MOVES2014a input files
 - Using MOVES2014a in the inventory and rates modes
 - Reviewing output using MySQL
- Hands-on experience using the MOVES2014a 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
 - Understanding converters (using Daily VMT converter)
 - 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 MOVES2014a?

- The MOtor Vehicle Emission Simulator (MOVES) is a state-of-the-art modeling framework
- Designed to allow easier incorporation of large amounts of in-use data from a variety of sources
- A minor update to MOVES2014, which replaces MOVES2010 (including MOVES2010, MOVES2010a, and MOVES2010b)

When do I use MOVES?

- EPA *Federal Register* notice of October 7, 2014 (79 FR 60343) approved MOVES2014 and subsequent minor revisions (MOVES2014a) for:
 - New State Implementation Plans (SIPs)
 - Use MOVES2014a now for any new SIPs
 - If significant work on a SIP with MOVES2014 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, use either MOVES2010 or MOVES2014 or MOVES2014a
 - After that, use only a version of MOVES2014 (MOVES2014a recommended)

Previous MOVES Versions

- Draft MOVES2009 - not an official version (4/2009)
- MOVES2010: major release (new grace period)
 - Released December 2009 and approved March 2010 for SIPs and regional conformity analyses
- MOVES2010a: minor release (no new grace period)
 - Released September 2010; incorporated GHG standards for cars and light trucks; did not significantly change emissions
- MOVES2010b: minor release (no new grace period)
 - Released April 2012; improved functionality
 - MOVES2010b corrected database released October 2012

MOVES2014

- 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

- 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

EPA MOVES Guidance

- MOVES2014 SIP and Conformity Policy Guidance
 - Published July 2014
 - www.epa.gov/otaq/models/moves/index.htm#sip-2014a
 - Guidance on when MOVES should be used in SIPs and transportation conformity analyses
- MOVES2014a Q&A document
 - Published November 2015
 - www.epa.gov/otaq/models/moves/index.htm#generalinfo-2014a
- MOVES2014 and MOVES2014a Technical Guidance
 - Published November 2015
 - www.epa.gov/otaq/models/moves/index.htm#sip-2014a
 - 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

www.epa.gov/otaq/stateresources/ghgtravel.htm

- Transportation Conformity Guidance for Quantitative Hot-spot Analyses in PM_{2.5} and PM₁₀ Nonattainment and Maintenance Areas

www.epa.gov/otaq/stateresources/transconf/policy.htm#project

- Using MOVES in Project-Level CO Analyses

www.epa.gov/otaq/stateresources/transconf/policy.htm#project

Other MOVES2014a Documentation

- MOVES User Guide: A step-by-step guide for users based on this training. Topics include:
 - Graphical user interface (GUI)
 - Using MOVES at the County and Project scales
 - Generating rates
 - Processing output
- MOVES User Interface Reference Manual
 - Includes detailed description of the function of every menu item, panel, and importer in MOVES
- MOVES Module Reference
 - On-line reference of algorithms in MOVES
- The Software Design and Reference Manual (SDRM)
 - Hardware and software requirements
 - Software design components
 - Overview of processing, data and control flow
 - Functional design
 - Input and output database tables and design

Other MOVES Information

A screenshot of the EPA's MOVES website. The header features the EPA logo and navigation links for 'LEARN THE ISSUES', 'SCIENCE & TECHNOLOGY', 'LAWS & REGULATIONS', and 'ABOUT EPA'. A search bar and 'A-Z Index' link are on the right. The main content area is titled 'Modeling and Inventories' and includes a breadcrumb trail: 'You are here: EPA Home » Transportation and Air Quality » Modeling and Inventories » MOVES (Motor Vehicle Emission Simulator)'. The title 'MOVES (Motor Vehicle Emission Simulator)' is prominently displayed. Below it, a paragraph describes the simulator's purpose. A large, semi-transparent text overlay reads 'Visit: www.epa.gov/otaq/models/moves/'. To the right of this, a box provides information on how to access earlier versions of the software. The left sidebar contains a list of links related to MOVES, including 'Home', 'Previous MOVES versions', 'Reports', 'Presentations', 'Training', 'Tools', 'Frequent Questions', 'Fuel Effects on Vehicle Emissions', 'MOBILE6.2 Model', 'NONROAD Model', 'NMIM (National Mobile Inventory Model)', and 'Listserv Information'. The main content area also includes a list of links for 'General Information about MOVES2014', 'MOVES2014 User Documents and Tools', and 'Downloading MOVES2014'. A section titled 'For further information:' lists links to 'MOVES Technical Reports', 'MOVES Training Sessions', and the 'Federal Advisory Committee Act (FACA) MOVES Model Review Work Group'.

Other MOVES Information

- To join the MOVES listserv, send a blank email to join-EPA-MOBILENEWS@lists.epa.gov
- Questions? Contact us:
MOBILE@epa.gov
www.epa.gov/otaq/models/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

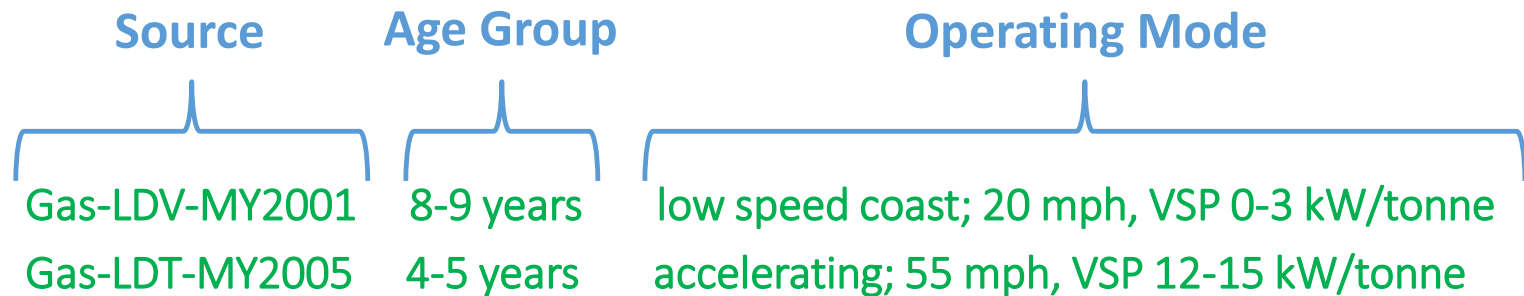
- HC (THC, NMHC, NMOG, TOG, VOC)
- CO
- NO_x (NO, NO₂)
- NH₃
- SO₂
- PM_{10,2.5} (multiple exhaust species plus brake and tire)
- GHG (CO₂, CH₄, N₂O)
- Toxics (over 50 different exhaust and evap species)
- Energy (total, petroleum, fossil)

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...



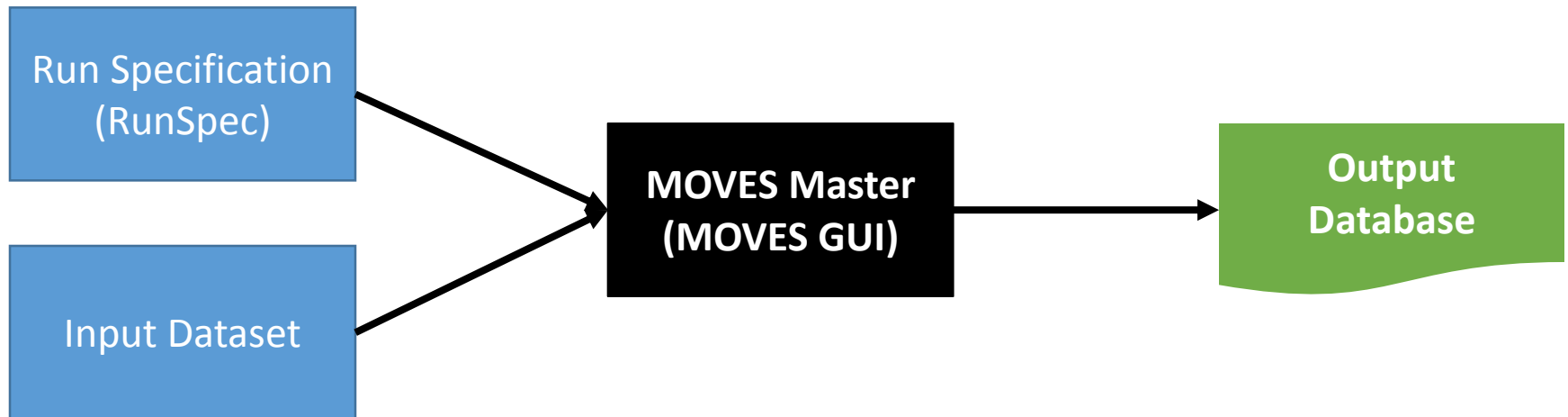
- MOVES can:
 - calculate an emission inventory internally using fleet and activity inputs, or
 - users can do this outside of MOVES by multiplying emission rates from MOVES by the appropriate activity factors

Nonroad in MOVES2014a

- 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)
- For SIPs, recommend states use MOVES2014a
- Technical documentation can be found at:
www.epa.gov/otaq/nonrdmdl.htm

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.: ClarkCounty_CO_2020.mrs
Input Database	Provides data necessary for the run	At County & Project scales: User names it and populates it with local information Ex. ClarkCounty_CO_2020_in 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. ClarkCounty_CO_2020_out

Locating Your Data Folder

- The data folder stores the MOVES2014a 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

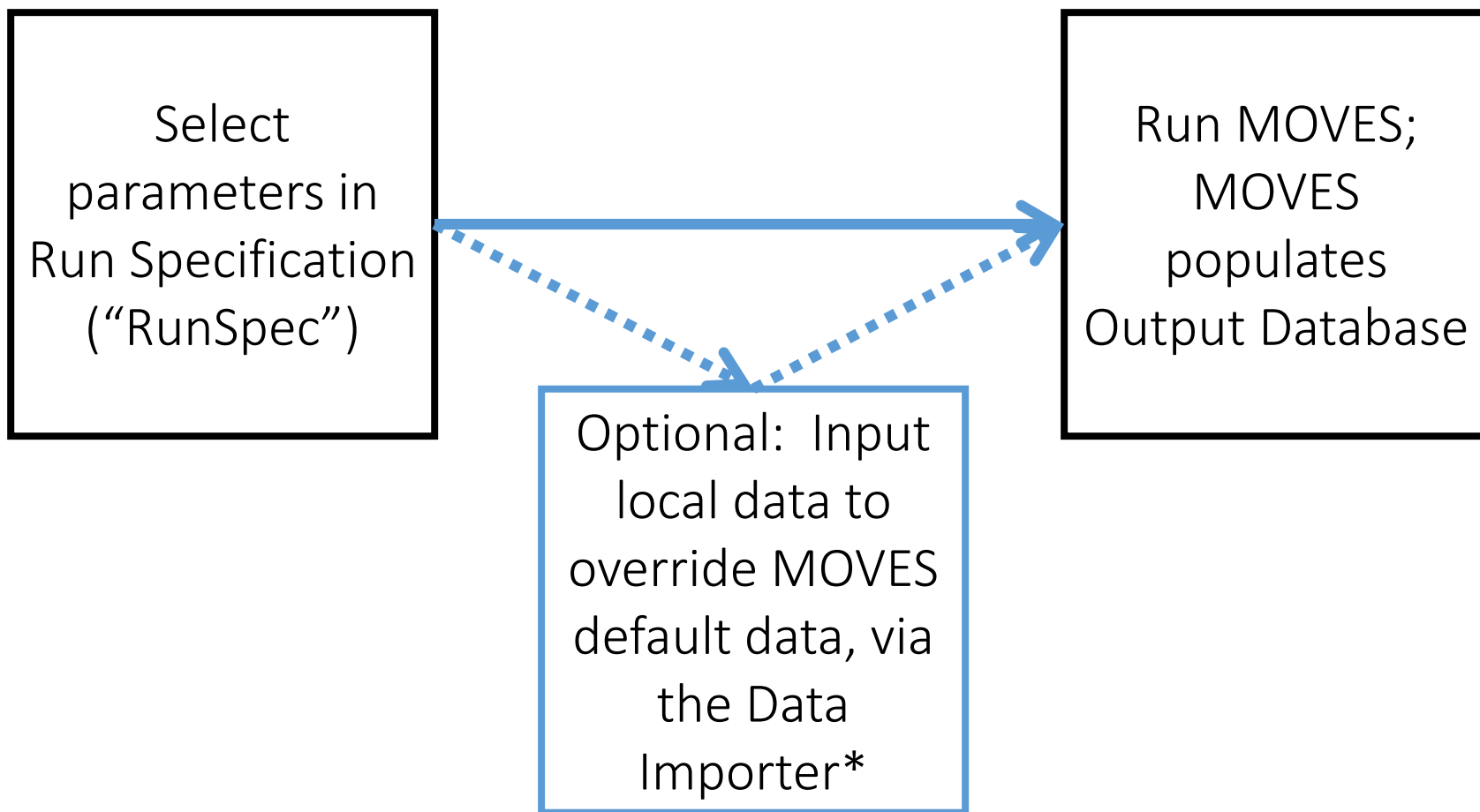
MOVES: Three Scales of Analysis

- 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

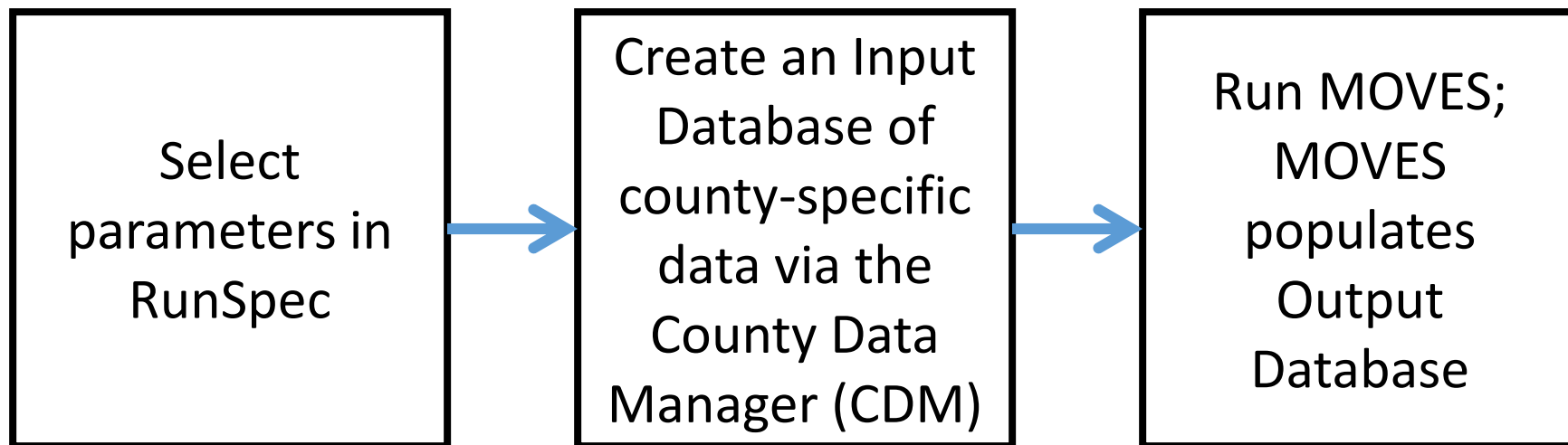


* Cannot be done with all data inputs – more later

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

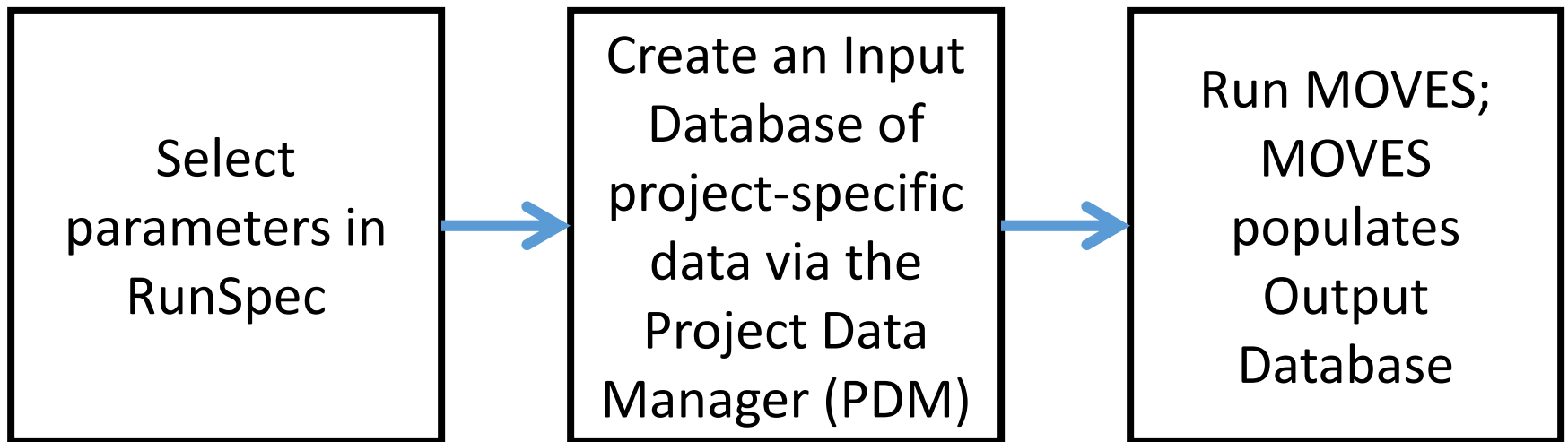


Project Scale

- 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

Project Scale Process



Summary: MOVES Three Scales

	National	County	Project
Geographic area covered	<ul style="list-style-type: none"> • Entire nation • One or more states • One or more counties 	<ul style="list-style-type: none"> • One county • A multi-county area 	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?

