

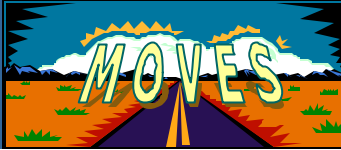
EPA's Plans to Estimate the Criteria Air Pollutant Emissions of Highway Vehicles and Off-Highway Equipment with MOVES

Harvey Michaels

US EPA Office of Transportation & Air Quality

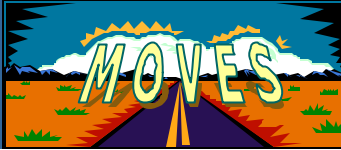
**NARSTO Emission
Inventory Workshop**

15 October 2003



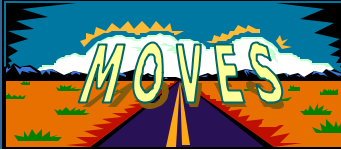
MOVES: EPA's New Mobile Source Model

- **Comprehensive in source, pollutant, scale, process**
- **Data-driven**
- **Designed for modeling at multiple analysis scales**
- **Includes uncertainty**
- **Modern software--object-oriented, modular, extendable.**
- **Includes GUI, batch mode, interface to other models.**
- **Standalone or distributed processing**



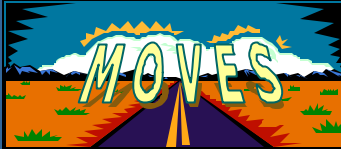
Where are we with MOVES?

- **MOVES GHG (on-road)**
 - Draft release: Early 2004
 - Energy consumption, CO₂, CH₄, N₂O
 - U.S. at county level inventories 1999 forward
 - Well-to-pump (GREET) integration
- **New implementation under consideration: 2005**
 - Add Aircraft, Commercial Marine, Locomotives
- **Full on-road implementation: Fall 2005**
 - Add HC, CO, NO_x, Toxics, PM, NH₃, SO₂
 - Microscale analysis capability
 - Will replace MOBILE6
- **NONROAD to MOVES: 2006**



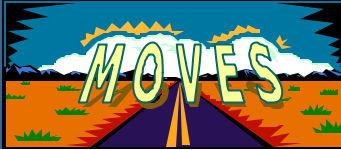
MOVES Software Framework

- **Language: Java[®]**
- **Database-driven structure**
 - **Open-source relational database (MySQL[®])**
 - **Enables modularity, easy updates with new data**
- **Graphical user interface or batch mode**
- **Designed for single or multiple computer processing**
- **Output reporting and visualization**



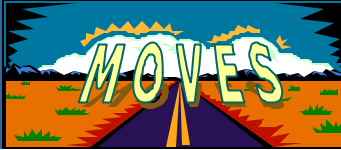
MOVES Emission Processes

- **Emission process = emission pathway with unique activity and emission characteristics**
- **Combustion Products**
 - Running exhaust, Start exhaust, Extended idle, Crankcase
- **Hydrocarbon Evaporation**
 - Diurnal, Hot Soak, Running Loss, Resting Loss, Refueling
- **Other**
 - Brake Wear, Tire Wear, Well-To-Pump, Manufacture/Disposal



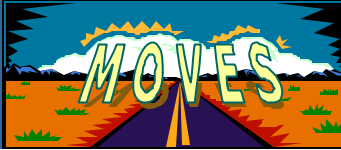
Characterizing the Fleet

- **Source Use Types** are a specific class of vehicles or equipment defined by unique activity patterns
- **Source Bins** are subcategories of use type that differentiate emission levels
 - Source bin discriminators include weight class, fuel type, engine technology, emissions standard, horsepower range, etc.
 - A particular source bin may apply to more than one use type.



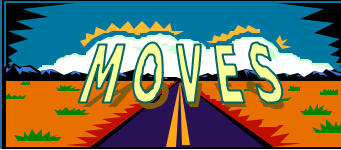
Characterizing Activity

- **Total Activity Basis** - in general, source hours, but depends on emission process
- **Operating Mode Bins** - depend on pollutant and process
 - Division of total activity into categories that differentiate emissions
 - Depends on emission process and pollutant



MOVES is a database processing system

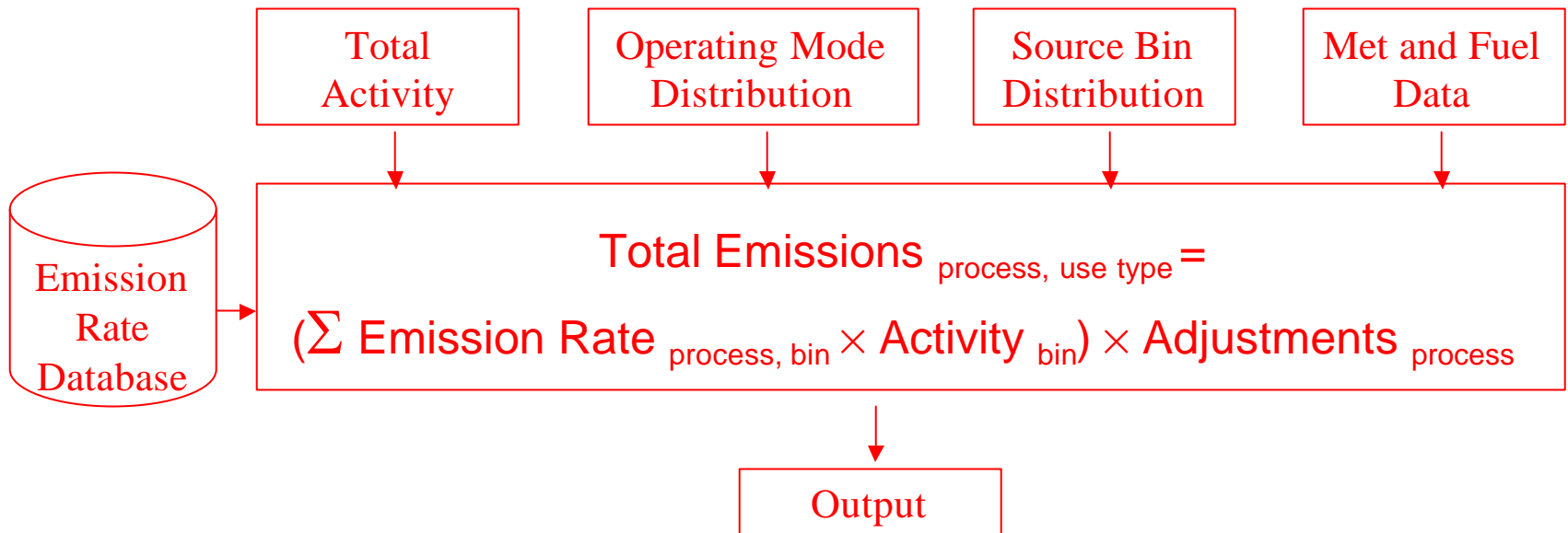
- All fleet, activity, and emission rate information is stored in a database
- Default data allow calculation of county-level inventories for entire U.S.
- Users can supply all data, generating inventories for any domain at any scale.
 - Finer analysis scales require user-supplied data

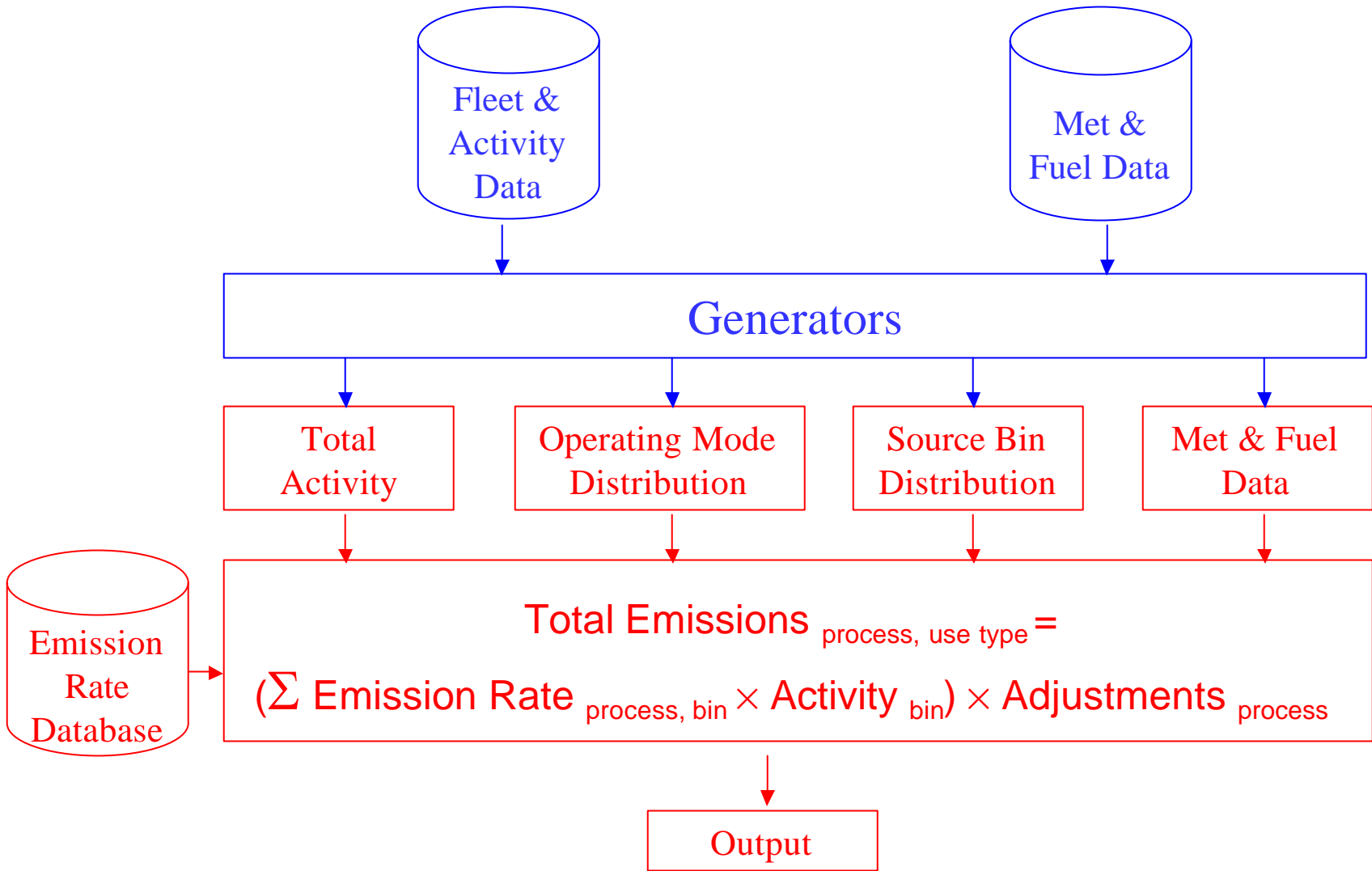


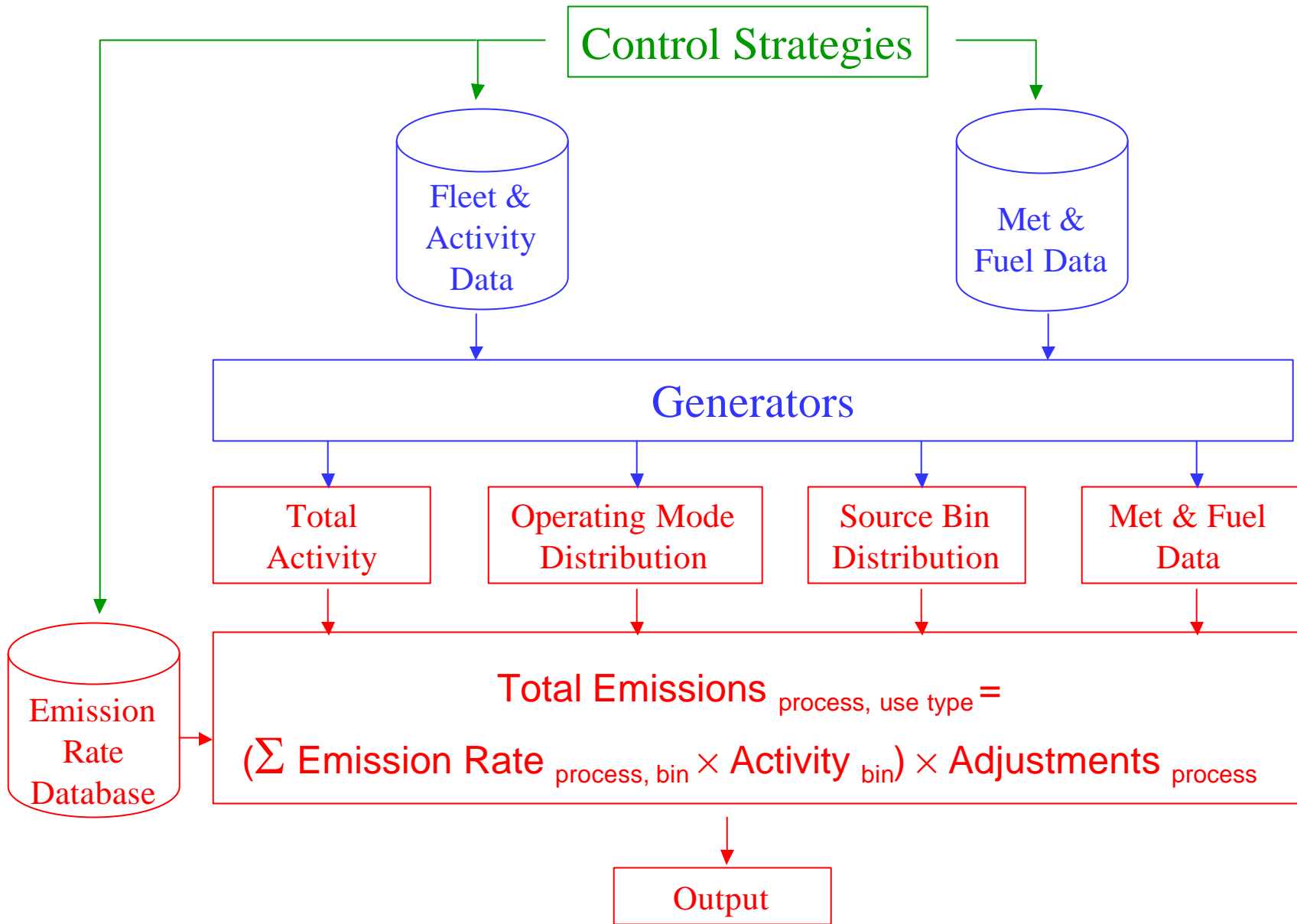
MOVES Components

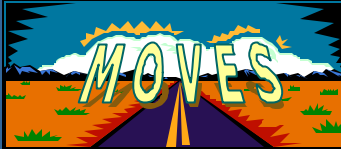
- **Core Model**
 - Generic structure applied across sources, scales, pollutants
- **Generators**
 - Produces core model inputs using available data
- **Control Strategies**
 - Modifies inputs for evaluation of policy scenarios
- **Databases - input and output**
- **Output processing**
- **User Interface**
- **Interfaces to other models**

Core Model





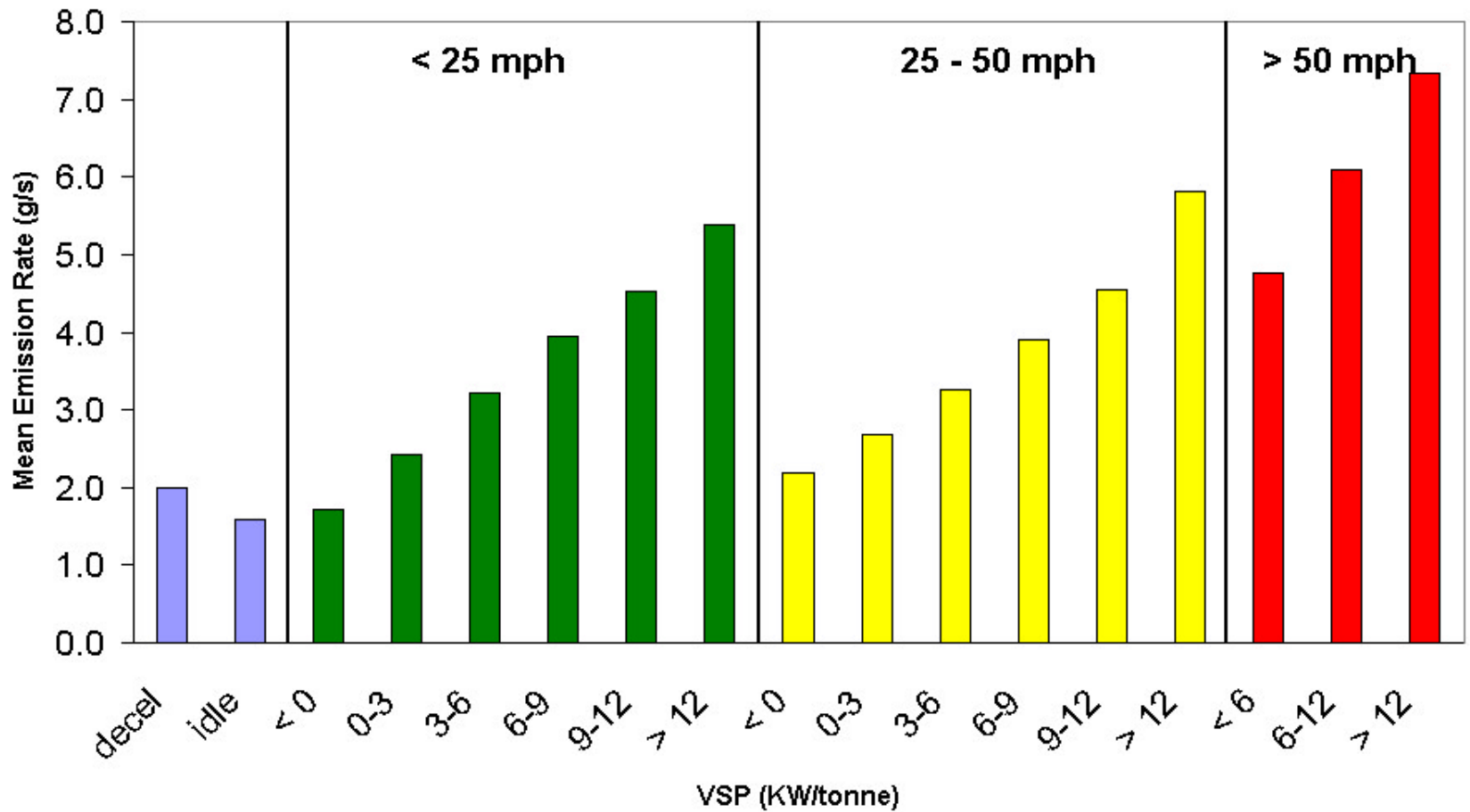




Emission Rates: Binning Approach

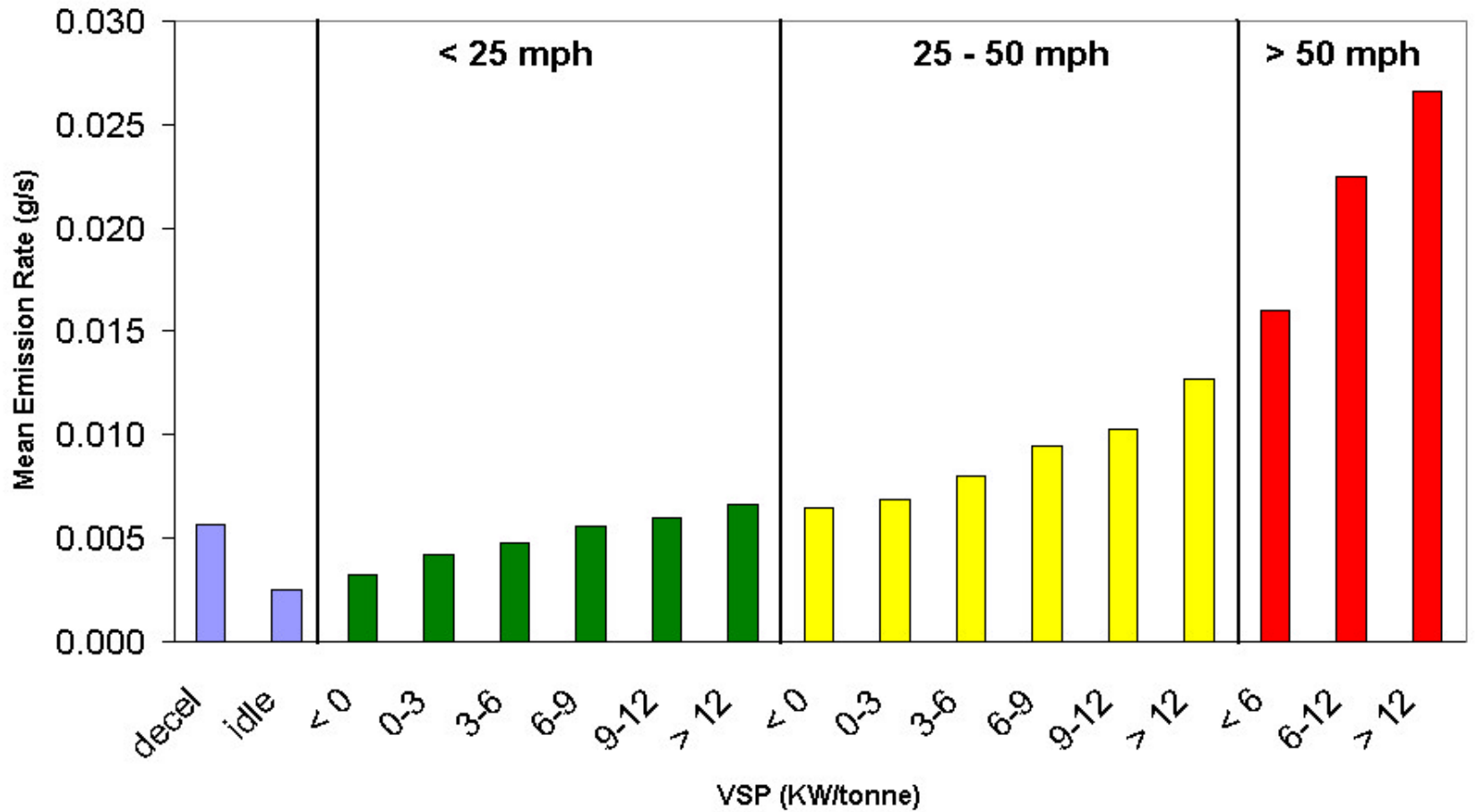
- **Group activity and emissions into “Bins”**
 - Vehicle Specific Power (VSP) & Speed
 - Accounts for speed, acceleration, grade, road load
- **Any driving pattern can be modeled based on distribution of time spent in bins**
 - Adds major flexibility compared to MOBILE
- **Provides common emission rates for macroscale, mesoscale, microscale**

CO2 Emission Rates By Bin ARB UCC Light-Duty Dataset

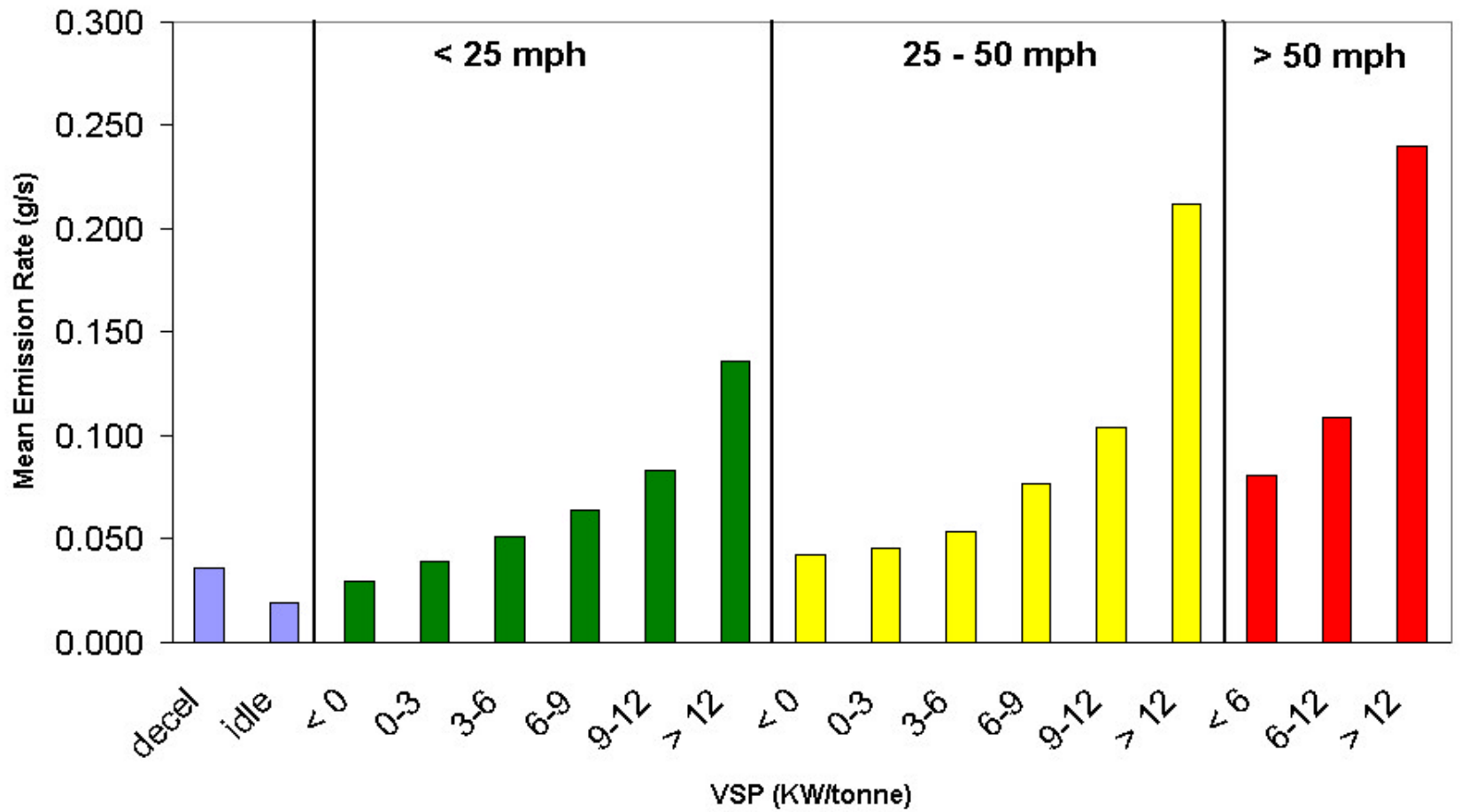


NOx Emission Rates by Bin

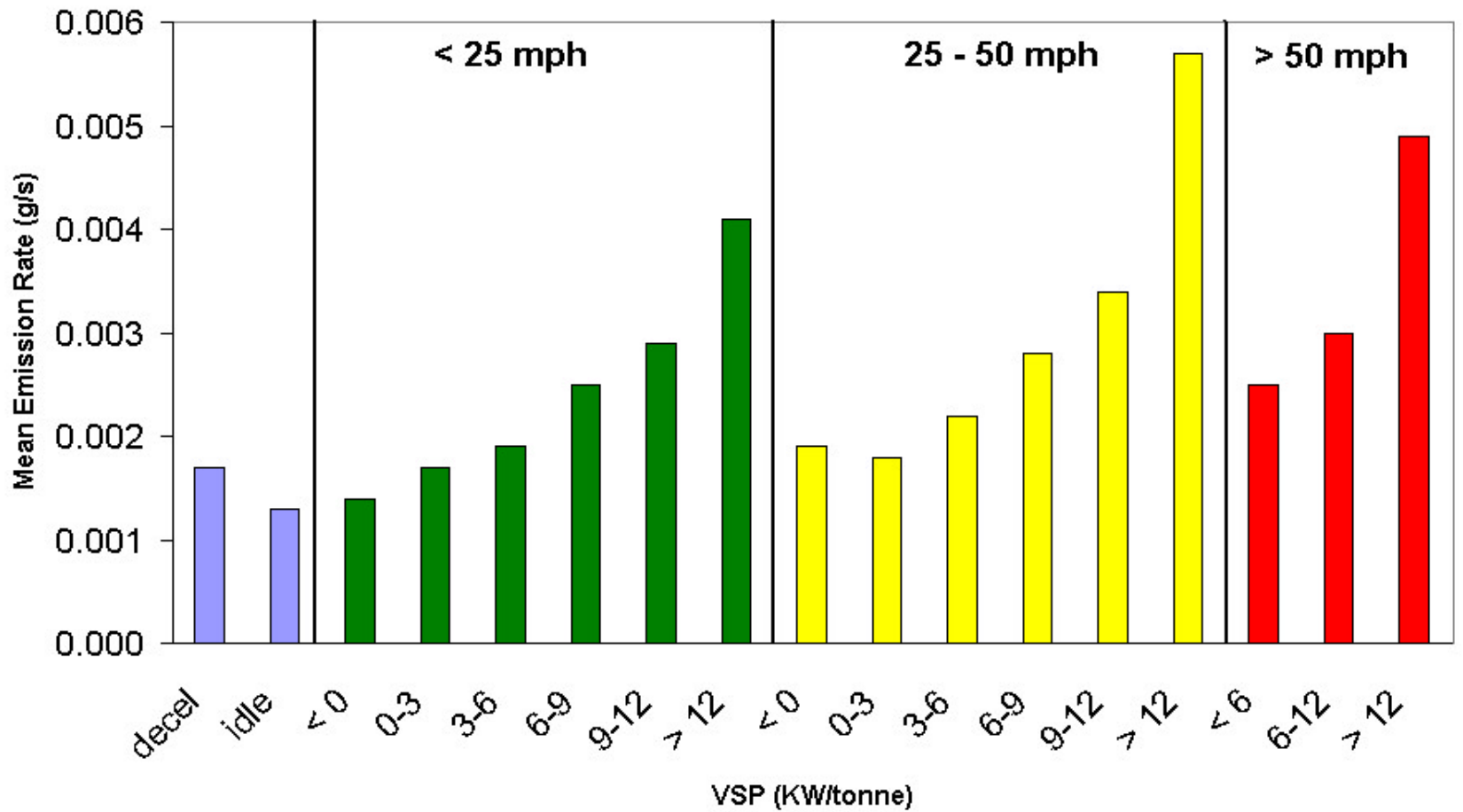
ARB UCC Light-Duty Dataset

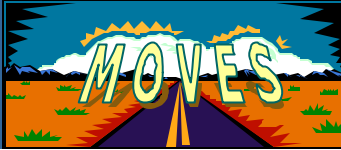


CO Emission Rates by Bin ARB UCC Light-Duty Dataset

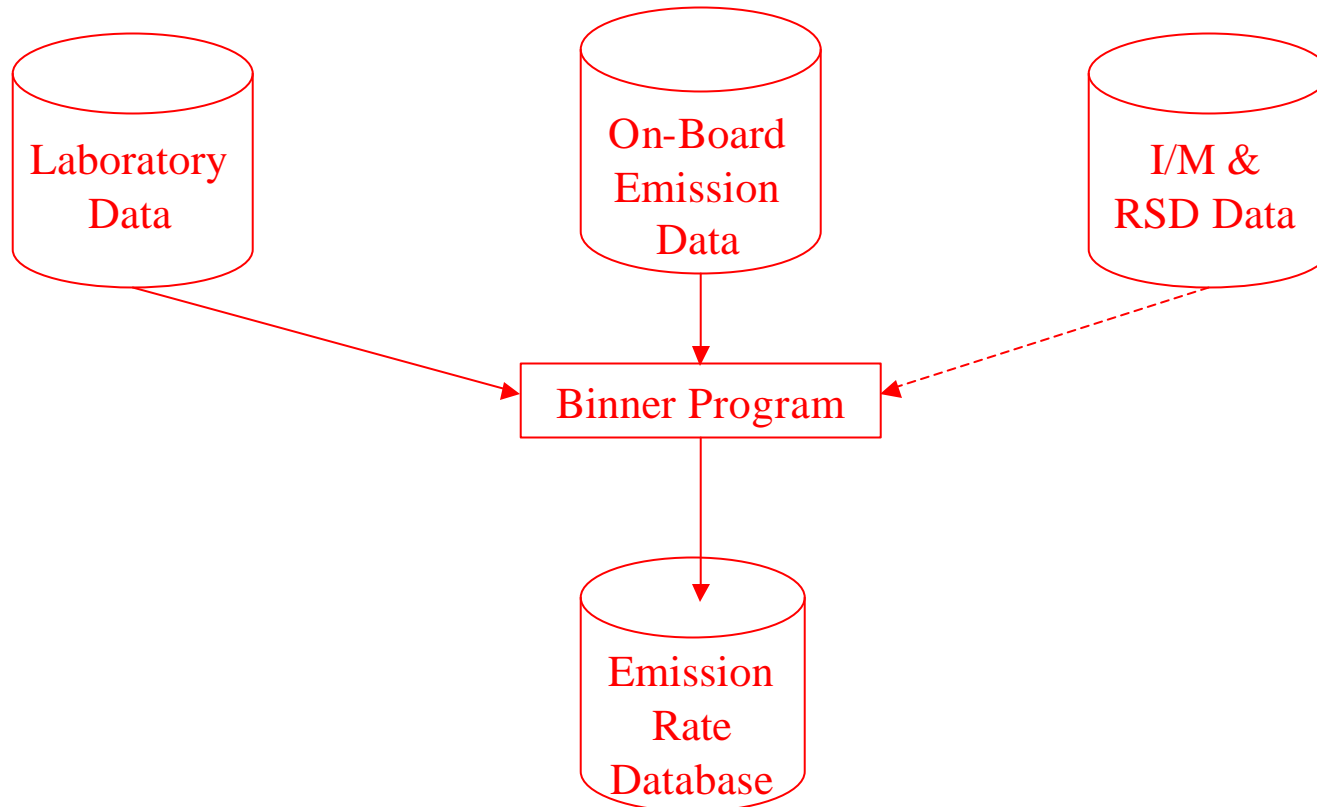


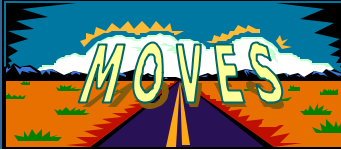
HC Emission Rates by Bin ARB UCC Light-Duty Dataset





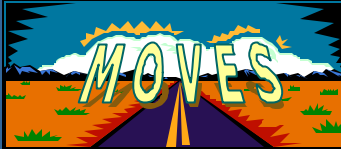
Binning Approach Broadens Usable Data





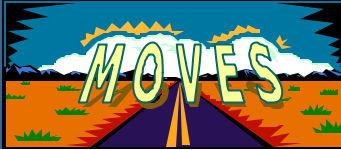
MOVES GHG Emission Data Sources

- **EPA Mobile Source Observation Database**
- **With new data from:**
 - CARB
 - Coordinating Research Council
 - UC Riverside
 - Environment Canada
 - West Virginia University
 - State of New York
 - North Carolina State University
 - University of Texas



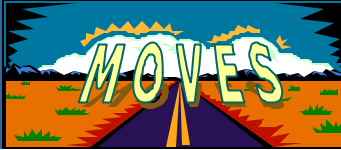
Criteria Pollutant Considerations

- **Data Sources**
 - How to use I/M and Remote Sensing Data
 - Incorporating Kansas City Gasoline PM Study
- **Characterizing High Emitters**
- **Evaporative Emissions**
- **Vehicle Deterioration**



Physical Emission Rate Estimator (PERE)

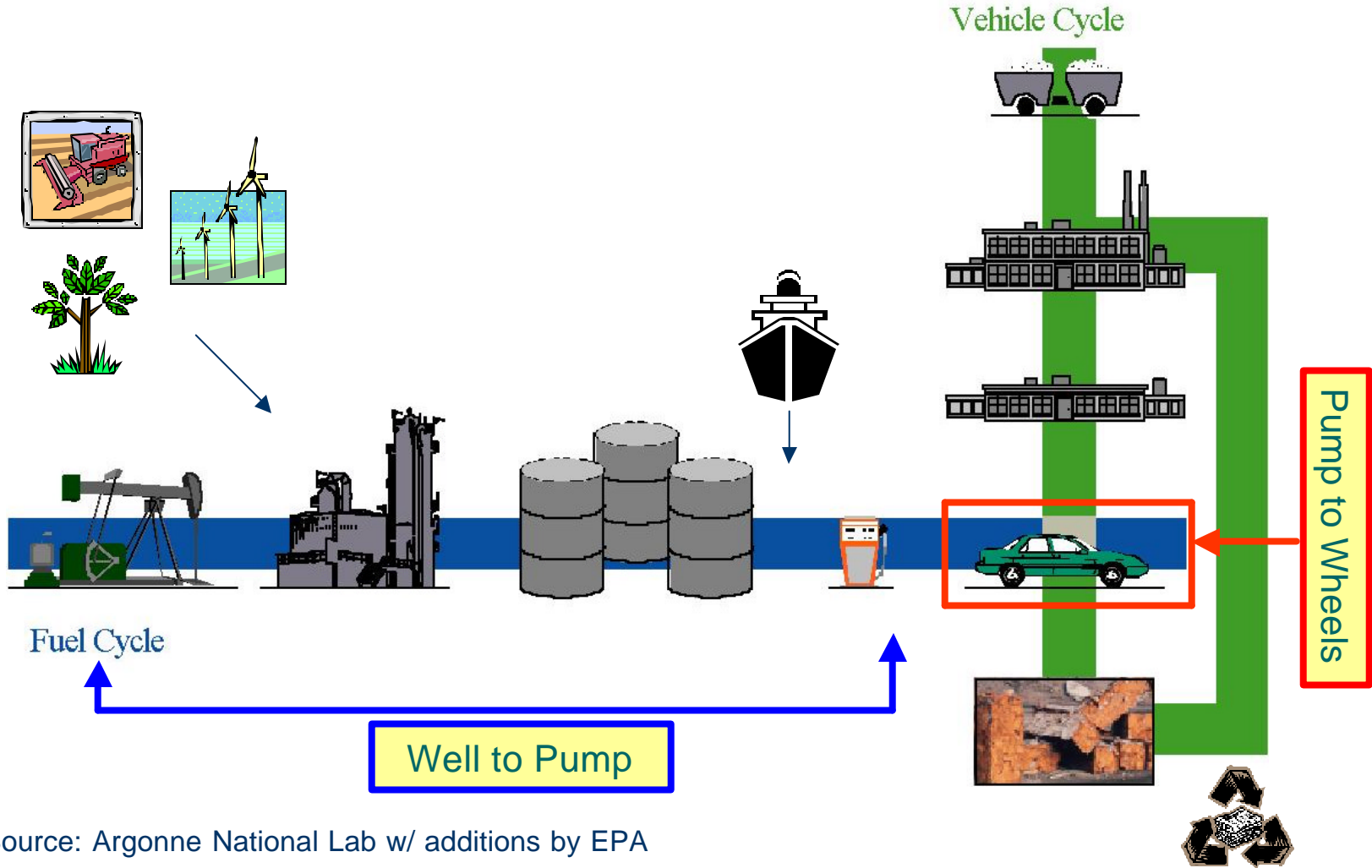
- Physically models energy, fuel use, & CO₂.
- Empirically models engine out emissions and catalyst pass fraction.
- Used to help estimate emissions from future technologies.
- May also be used to help estimate bin values for which data are sparse or missing.



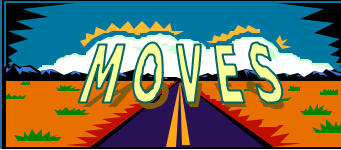
Life Cycle Analysis in MOVES

- **REET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation)** developed by Argonne National lab
- **Joint EPA/DOE effort to integrate MOVES and REET**
 - Improve time resolution of REET projections
 - Integrate REET uncertainty estimates
 - Enable update to REET inputs via MOVES GUI
 - Add several hydrogen production and storage pathways (DOE)

Life Cycle – The Big Picture



Source: Argonne National Lab w/ additions by EPA



For More Information

- **MOVES:**
 - <http://www.epa.gov/otaq/ngm.htm>
- **GREET:**
 - <http://www.transportation.anl.gov/greet/>