Emissions Inventory and Conformity Data Primer

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PURPOSE OF THIS PRIMER

The aim of this document is to provide Texas' transportation practitioners with an overview of key concepts pertaining to emissions inventories and to demonstrate the impact of using local data inputs in the emissions inventory development process. Mobile source emissions inventories are commonly required for transportation conformity demonstration in nonattainment areas, as part of the regional emissions analysis. Most commonly, the transportation network emissions are compared against a motor vehicle emissions budget (MVEB) in the State Implementation Plan (SIP)[1].

This primer provides a brief overview of the following:

- Overview of what an emissions inventory is
- Description of the MOVES model and its application for emissions inventories
- Data and tools used to develop inventories in Texas
- Case study application to demonstrate the impact of local data on inventory development

This primer on data for transportation conformity was developed by the Texas A&M Transportation Institute (TTI), using detailed technical materials and documents developed as part of an interagency support contract with TxDOT. Some key references used in the development of this primer, which may be referred to for further details, include TTI's guidebooks on emissions analysis methods and procedures (*1*) and on the development of emissions inventory estimation utilities (*2*). The work presented in this primer also follows up on an assessment conducted by TTI to understand and map out the various data used in the conformity process (*3*).

WHAT IS AN EMISSIONS INVENTORY?

Emission inventories are developed by state and local air quality and transportation agencies to help determine significant sources of air pollutants and to support regulatory actions (*4*). An emissions inventory includes estimates of the emissions from various pollution sources in a geographical area, including mobile source, non-road

[1] Before a SIP is available, interim emissions test are used for conformity determination (*15*). For project-level conformity, the determination shows that the project is consistent with the regional conformity determination and that potential localized emissions impacts are addressed.

source, area source, and point source emissions (*5*). It serves as an essential input for air quality modeling. For transportation conformity purposes, local governments and agencies in nonattainment areas are required to develop regional transportation plans and generate mobile source emission inventories to estimate the contribution of on-road transportation activities to regional air quality (*6*). These emission inventories are then compared to statewide budgets or targets outlined in the SIP to ensure that regional transportation plans are consistent with statewide air quality improvement plans.

WHAT IS THE MOVES MODEL AND HOW IT IS USED TO DEVELOP INVENTORIES?

MOtor Vehicle Emission Simulator (MOVES) is an emissions model developed by the United States Environmental Protection Agency (EPA), required to be used to prepare regional mobile source emission inventories for SIP and transportation conformity analysis in all states outside of California (*7*). On January 7th, 2021, the United States Environmental Protection Agency (EPA) issued a Federal Register (FR) notice on the availability of the new MOVES3 for use in State Implementation Plans and transportation conformity, replacing the previous version MOVES2014b (*8*). State and local agencies are currently undergoing a two-year grace period for using MOVES3 for regional transportation conformity and project-level conformity purposes.

The MOVES model requires various scenario and vehicle activity inputs to calculate emissions. Typical inputs including information about vehicle miles traveled (VMT) by vehicle type, the population of vehicles, vehicle age distributions, fuel information, meteorological data, etc. For most inputs, EPA recommends that users provide local data to enhance the accuracy of emissions estimates (*7*), which creates the need for state and local agencies to develop local data application plans for environmental analysis.

MOVES allows two modeling options - inventory approach and emission rate approach (*9*):

- Inventory approach -

  Users upload local activity data to MOVES input database tables, and these activity data are then multiplied by the appropriate emission rates within the MOVES model. .

- Emission rates approach: MOVES is used to calculate emissions rates per unit of activity (e.g., per mile, or per hour of vehicle activity). The rates are extracted from MOVES, and combined with traffic activity estimates to calculate total emissions.

Depending on the modeling option selected, users may adopt different processes to prepare inputs. The major inputs required for generating an emission inventory using MOVES are summarized below (*10*).

- VMT by different vehicle types
- Speed Distribution of vehicles
- Population of operating vehicles by Source Type
- Age Distribution of operating vehicles
- Road Type Distribution
- Vehicle Starts
- Hotelling (for long-haul combination truck only)
- Fuel
- Inspection and Maintenance (I/M) Program
- Meteorology Data

HOW IS MOVES USED FOR EMISSIONS INVENTORIES IN TEXAS?

In Texas, TTI supports state agencies and their local partners in mobile source emissions analysis (*1*, *2*). Through this effort, TTI has developed an in-house suite of emissions inventory estimation utilities, also known as TTI MOVES Utilities. The utilities are designed to provide standardized calculations to conduct regulatory on-road emission inventories. The utilities use a detailed, MOVES rates-per-activity, travel demand model (TDM) link-based method for emissions inventories. The regional emission inventory is generated by running a series of utilities using inputs from various state and local agencies. Broadly, there are four groups of MOVES utilities that are used to process individual data sources and compute the emissions:

- **Activity utilities:** These process traffic activity data from a variety of primary data sources including TDM outputs, Highway Performance Monitoring System (HPMS) data, vehicle registration data, and statewide truck hotelling data, to generate the following activity inputs:
    - Vehicle type VMT
    - Speed distribution
    - Source type population
    - Road Type Distribution
    - Starts
    - Hoteling
- **Emission rate utilities:** These process vehicle registration data, fuel, I/M and meteorology data, to prepare the following MOVES inputs and generate emission rate per activity from MOVES:
    - Age distribution
    - Fuel
    - I/M program
    - Meteorology
- **Emission calculation utilities:** These calculate the regional emission inventory by multiplying total vehicle activities from activity utilities and emission rate per activity from emission rate utilities.
- **Miscellaneous utilities:** These are other functional parts in utilities for data assembly and data management.

Local vehicle and activity datasets from various sources are used to generate regional emission inventory using the MOVES utilities. The primary data sources adopted by TTI for transportation conformity have been reviewed in a previous report developed by TTI (*3*). The key findings are summarized in Table 1 - the TDM outputs from Metropolitan Planning Organizations (MPOs), the HPMS data from the TxDOT and the vehicle registration data from the Texas Department of Motor Vehicles (TxDMV) are the most

critical data sources for generating the inputs to emission inventories for transportation conformity.

Table 1. TTI Emission Inventory Inputs and Data Sources

Input Data Type	Input Element	Data Source
Vehicle Type VMT	• Link-level VMT and intrazonal VMT	TDM outputs from MPOs
	• VMT mix	• HPMS traffic count from TxDOT • Vehicle registration data from TxDMV
	• VMT adjustment factors (hour, day, month)	• HPMS traffic count and VMT data from TxDOT • TDM outputs from MPOs
Speed Distribution	• Link average speed	• TTI speed model • Houston speed model from Houston-Galveston Area Council (H-GAC)
Source Type Population	• Vehicle population • Fuel type	Vehicle registration data from TxDMV
Age Distribution	• Age distribution	Vehicle registration data from TxDMV
Road Type Distribution	• Link-level road type	TDM outputs from MPOs
Starts	• Vehicle population	Vehicle registration data from TxDMV
	• Engine start per vehicle	MOVES national-level results from EPA MOVES
Hotelling (for long-haul combination truck only)	• Hotelling hours	Texas truck idling study from Texas Commission on Environmental Quality (TCEQ)
	• Hoteling activity distribution	MOVES default database
Fuel	• Fuel formulation • Fuel supply • Fuel usage fraction	Local fuel data from TCEQ and EPA
IM Program	• I&M coverage	Local I/M program data from MPOs
Meteorology Data	• Hourly temperature and humidity by zone	Texas meteorology data from TCEQ

SIGNIFICANCE OF LOCAL DATA FOR DEVELOPMENT OF EMISSIONS INVENTORIES

Local data (rather than MOVES default data) are recommended for calculating emissions inventories to better represent the vehicle activity and conditions of a analysis area. Using local data instead of MOVES defaults will likely have a significant impact on inventory results (*11*). Several studies in the literature have demonstrated this. For example, one study showed VMT mix changes contributed the greatest change in emissions, with particularly large increases being observed for oxides of nitrogen (NOx) and particulate matter (PM) (*12*). Age distribution was influential particularly for hydrocarbons (HC)/volatile organic compounds (VOCs) and CO and vehicle population was the most influential for HC. A sensitivity analysis performed using a county-level database submitted to National Emission Inventory (NEI) demonstrated that MOVES total daily emissions can change fundamentally with changes made in a single input (*13*). For example, total emissions varied up to 56% for HCs, 70% for CO, 111% for NOx, and 149% for PM while changing a single input within the range of data submitted by the states.

The level of impacts of some activity inputs on emission inventory demonstrated by previous studies are also summarized in Table 2[2] (*14*).

Table 2. Impact of MOVES Inputs on Emission Results (*10*, *14*)

Input Data Type	VOC	NOx	PM
Vehicle Type VMT	Very Substantial	Substantial	Substantial
Speed Distribution	Substantial	Substantial	Substantial
Source Type Population	Substantial	Substantial	Very substantial
Age Distribution	Very Substantial	Substantial	Substantial
Road Type Distribution	Modest	Modest	Moderate
Meteorology Data	Substantial	Substantial	Very substantial

*Level of impact (% of difference in emission inventories): Modest = <5%; Moderate = 5-15%; Substantial = 15-50%; Very Substantial = >50%. N/A indicates those factors have not been investigated in the reference.

Given the importance of local data and its impact on emissions inventories using MOVES, different agencies adopt different approaches in terms of local data preparation. According to a survey of state transportation and air quality agencies, most agencies adopt TDM and HPMS data to prepare VMT, speed and road type inputs (*14*). MOVES default and vehicle registration data are popular data sources for vehicle source type population and age distribution. In terms of modeling approaches, nearly half of

[2] For a single factor, the sensitivity may vary under different intervals and combination with other factors. The table summarizes the largest emission impact under all tested case as an indicator of maximum level of impact.

agencies use a mix of the inventory and emission rate approach and about a third of agencies use inventory mode only (*14*). In addition, many agencies have developed TDM post-processors and vehicle classification algorithms to prepare emission inventory inputs from local data sources.

CASE STUDY ON IMPACT OF LOCAL DATA

To provide readers with a clearer understanding of the impact of local data on emissions inventories, a small hypothetical case study was performed in the Texas context. A conformity emissions inventory for El Paso County, for the 2020 Analysis Year, was used to provide baseline data for the hypothetical study.

Two scenarios were then compared – the "Local Data" case which used a majority of local inputs consistent with an actual emissions inventory performed with TTI Utilities, and the "MOVES Default" case in which MOVES defaults were instead used wherever possible. The intent of this analysis is to demonstrate how pollutant estimates may vary when MOVES defaults are used to the greatest extent possible versus when local data are used. The emission inventory calculation processes under each case are introduced below:

- **Local data case:** the local data sources from El Paso County listed in **Table 1** were used to generate an emission inventory consistent with how a typical conformity emissions inventory would be developed in Texas. The TTI MOVES Utilities (the emission rate approach) were used to compute the regional emission inventory for a 2020 El Paso County winter scenario.
- **MOVES default case:** MOVES default values were used to prepare county-level input database, with the bare minimum inputs consistent with the TTI conformity case. The total daily VMT by source type, vehicle population, and the number of starts from TTI conformity analysis were used as inputs. The emission inventory was generated using the MOVES inventory mode for the 2020 winter case.

Table 3 shows the results of the emission inventories using local versus default data inputs. The comparison suggests that the local data play a significant role in emission results, with differences in emission estimates greater than 10% for most pollutants. Among all pollutants, VOCs have the largest difference and is 25% higher in the case with local data compared to the MOVES default result.

Table 3. Comparison of Emission Inventory Generated from MOVES Default and Local Data

Pollutant	Moves default (gram)	TTI Utilities with local data (gram)	Difference (local – default) (gram)	Difference (local – default) (%)
NOx	12,667,765	15,241,729	2,573,964	20.3%
VOC	6,166,001	7,709,252	1,543,252	25.0%
CO	70,707,945	81,704,966	10,997,021	15.6%
PM_{10}	1,197,648	1,314,926	117,278	9.8%

The case study performed here demonstrated the impact of using local data as compared to a case with mostly MOVES default inputs. This is a relatively extreme contrast in which a case with a majority of local inputs was contrasted against one with minimal local data inputs. A more comprehensive sensitivity analysis will be needed to evaluate the impacts of individual local data sources or combinations of sources. In addition, most agencies have access to at least some of the local data sources for developing regional emission inventory, and the availability of the data depends on the local context (*14*).

ADDITIONAL RESOURCES

Some references and links are provided in this section for additional information regarding this topic.

- TTI Report – 'Addressing New Technologies and Data in Transportation Conformity: Overview and Assessment': https://server.txaqportal.org/storage/uploads/2020/11/12/5fad8ec84d027IAC-A_Task-2.1-Review-of-Conformity-Data.pdf
- MOVES training materials: https://txaqportal.org/training#/
- Transportation Air Quality Briefing: https://server.txaqportal.org/storage/uploads/2020/02/20/5e4f0403882e0TransportationAirQualityBriefing_ExecutiveBriefing_2016.pdf

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