

Massachusetts 2011 Periodic Emissions Inventory of VOC, NO_x, CO, SO₂, PM₁₀, PM_{2.5} and NH₃

February 2018

SECTION 4 ON-ROAD MOBILE SOURCES

- 4.1 INTRODUCTION
- 4.2 MOVES MODELING
 - 4.2-1 MOVES INPUTS
- 4.3 TRANSPORTATION DATA
 - 4.3-1 DAILY VEHICLE MILES TRAVELED
 - 4.3-2 VEHICLE SPEEDS
- 4.4 MOVES RUN SPEC
- 4.5 MOVES EMISSIONS POST-PROCESSING

SECTION 4

ON-ROAD MOBILE SOURCES

4.1 INTRODUCTION

This section provides an estimate of on-road mobile source emissions of volatile organic compounds (VOC), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO₂), particulate matter (PM₁₀ & PM_{2.5}), and Ammonia (NH₃). Off-road mobile sources (such as industrial and commercial equipment, farm equipment, trains, and boats) are inventoried as part of Section 5 Non-Road Mobile Emission Inventories.

EPA estimated annual emissions nationwide (including Massachusetts using inputs from MassDEP). MassDEP adopted EPA's annual 2011 NEI Version 1¹ onroad mobile emissions as estimated by the Motor Vehicle Emissions Simulator model (MOVES).² To estimate annual emissions EPA ran MOVES for all 12 months, which was very time-consuming. MassDEP, however, was required to do one MOVES run to obtain estimates for a typical ozone summer day. MassDEP used EPA annual emissions to estimate CO winter day emissions for CO Maintenance SIP purposes.

MassDEP submitted the 2011 MOVES input files to EPA-NEI in the required NMIM³ format in order for EPA to run the MOVES and NONROAD models (see Appendix 4.1 for input files). MassDEP's submittal of the MOVES model inputs satisfied the requirements of EPA's Consolidated Emissions Reporting Rule (CERR)⁴ and the Air Emissions Reporting Requirements (AERR) rule.⁵

Section 4.2 provides an explanation of the input parameters for MOVES used for this inventory. The input files are presented in Appendices 4.2 to 4.4. The 2011 DVMT values used in these inventories were based on the statewide traffic counting network and roadway link data maintained by the Massachusetts Department of Transportation (MassDOT). Section 4.3-1 describes the procedures MassDOT followed in developing the daily vehicle miles traveled (DVMT) for Massachusetts. Section 4.3-2 describes the DVMT collection from MassDOT.

4.2 MOVES MODELING

4.2-1 MOVES INPUTS

Two separate Excel workbooks contain state specific input files required to run the MOVES model for Massachusetts (see Appendices 4.2 to 4.4). These are Appendices 4.2 MIDDLESEX_MASTER_2011 and 4.3 HAMPDEN_MASTER_2011. The input data and MOVES runs for Middlesex and Hampden

¹ EPA 2011 NEI website: <http://www.epa.gov/ttn/chief/net/2011inventory.html>

² EPA Motor Vehicle Emissions Simulator (MOVES) currently estimates emissions from cars, trucks & motorcycles. MOVES-2014 incorporates new car and light truck energy and greenhouse gas rates and a number of other improvements. <http://www.epa.gov/otaq/models/moves/index.htm>

³ EPA National Mobile Inventory Model (NMIM) is used for formatting inputs for running MOVES. <http://www.epa.gov/otaq/nmim.htm>
EPA National Mobile Inventory Model (NMIM) is used for formatting inputs for running MOVES. <http://www.epa.gov/otaq/nmim.htm>
Regulations p.39602-39616. <http://www.epa.gov/ttnchie1/cerr/index.html>

⁵ EPA "Air Emissions Reporting Requirements" (AERR) <http://www.epa.gov/ttn/chief/aerr/> (73 Federal Register 76539). December 2008.

counties represent eastern and western Massachusetts, respectively. The following paragraphs describe the inputs, the source of the data, and any assumptions that were made.

hpmsVTypeVMT. This table contains VMT by Highway Performance Monitoring System (HPMS) vehicle classes. MassDOT does not track VMT by vehicle class so Massachusetts-specific data could not be used. Instead, VMT fractions by vehicle class from Connecticut were used. These fractions were multiplied by the total Massachusetts VMT by county to obtain the VMT for each vehicle class.

sourceTypePopulation. This table contains counts of vehicles by MOVES vehicle class. Counts were obtained from Massachusetts Registry of Motor Vehicles (RMV) vehicle registration data by county and vehicle class.

fuelFormulation. This table contains all the default fuel formulations programmed into the MOVES model. The fuel formulations relevant to Massachusetts are in the table titled “fuelSupply.” Per EPA’s technical guidance for MOVES *“Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity”*, the default summer RVP for the fuel formulations modeled for the counties was updated based on a 2011 local fuel survey data collected by EPA. Boston/Worcester fuel survey data were used for Middlesex County and Springfield fuel survey data were used for Hampden County.

fuelSupply. This table specifies which gasoline and diesel fuel formulations were used for each of the months of the year modeled. The values for “marketShare” indicate what percentage of the fuel formulation was used for each month.

rampFraction. This table specifies the fraction of VMT that occurs on ramps by road type. The MOVES default value of 0.03 was used.

sourceTypeAgeDistribution. This table contains fractions of vehicles by age (0 to 30+ years old) by MOVES vehicle class. Calendar year 2011 test data from the Massachusetts Inspection and Maintenance (I&M) program were used to generate the fractions. All vehicles registered in Massachusetts are required to receive an annual I&M safety test. The RMV registration dataset used for the sourceTypePopulation inputs could not be used because it did not have vehicle counts broken down by Model Year.

dayVMTFraction. This table specifies the fraction of VMT between weekdays (5) and weekend days (2) for each month. MassDOT does not collect this data so values from Connecticut were used.

roadTypeDistribution. This table specifies the fractions of VMT by road type and vehicle class. MassDOT does not collect this data so values from Connecticut were used.

monthVMTFraction. This table specifies the fractions of VMT by month and vehicle class. MassDOT does not collect this data so values from Connecticut were used.

hourVMTFraction. This table specifies VMT fractions by hour of day, type of day (weekday or weekend day), and vehicle class. MassDOT does not collect this data so MOVES defaults were used.

avgSpeedDistribution. This table specifies VMT fractions by average speed bins, hour of day, type of day (weekday or weekend day), road type, and vehicle class. MassDOT does not collect this data so values from Connecticut were used.

IMCoverage. This table describes the I&M program in calendar year 2011 and is summarized by the following:

- Inspection frequency = annual
- Compliance Rate = 96%
- Waiver Rate = 1%
- OBD Exhaust and Evaporative System testing for vehicles Model Years 1997 – 2010 up to 8,500 lbs. GVWR
- OBD Exhaust and Evaporative System testing for vehicles Model Years 2008 – 2010 8,501 to 14,000 lbs. GVWR

The Compliance Factor is determined by subtracting the Waiver Rate from the Compliance Rate and multiplying by the I&M Regulatory Class Coverage Adjustment in Table A.3 of EPA's technical guidance for MOVES "*Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity.*"

Met Data. MassDEP has always estimated the typical ozone summer day temperatures according to the EPA EIIP Volume IV guidance⁶ by obtaining the daily minimum and maximum temperatures for the 10 highest ozone value days over the last 3 years 2009 to 2011. MassDEP obtained the ozone values from EPA's Air Data "Monitor Values report."⁷ Temperatures and humidity values, were obtained from the nearest meteorological sites that represent the ozone monitors.⁸ Tables 4.1 and 4.2 present the derivation of the final 2011 minimum and maximum summer day temperatures used in the model for Eastern (70.1 °F & 92.9 °F) and Western MA (60.7 °F & 91.7 °F) together with a statewide average at 65.5 °F and 92.5 °F respectively. These values were entered into the MOVES meteorological data converter to create hourly temperature and relative humidity values for July 2011 that represent a typical summer day. Relative humidity is also presented in Tables 4.2 and 4.3.

zoneRoadType. This table contains default values from MOVES. In addition to the inputs described above, the following scripts were entered into the MOVES model.

Stage II Vapor Recovery. The following script defines the Massachusetts Stage II vapor recovery program.

refuelingVaporProgramAdjust: 0.84
refuelingSpillProgramAdjust: 0.5

Low Emission Vehicle (LEV) Program. Massachusetts adopted the LEV program for light-duty vehicles (up to 8,500 GVWR) in 1995 and for medium-duty vehicles (8,501 to 14,000 lbs. GVWR) in 2003. A LEV script created by EPA was modified for the Massachusetts program and is contained in Appendix 4.4.

4.3 TRANSPORTATION DATA

4.3-1 DAILY VEHICLE MILES TRAVELED (DVMT) 2011

MassDOT provided daily vehicle miles traveled (DVMT) for 2011. MassDOT provided DVMT by county and roadway class as shown in Table 4.4. The DVMT is classified by urban, small urban and rural areas using the Highway Performance Monitoring System (HPMS) criteria.

⁶ Emission Inventory Improvement Program Technical Report Series Volume 4 Mobile Sources.

<http://www.epa.gov/ttn/chief/eiip/techreport/volume04/index.html>

⁷ EPA Air Data "Monitor Values Report"-Criteria Air Pollutants 2009 to 2011. http://www.epa.gov/airdata/ad_about_reports.htm#mon

⁸ State Data Center, National Climatic Data Center "Local Climatological Data (LCD), Monthly Summary for Logan, Worcester (Mass), Bradley (Conn.) and Providence (RI)," 2009 to 2011. U.S. Department of Commerce, Washington D.C. replace with [NWS Boston](#)

The following is a description of the roadway urban and rural functional classes (UFC and RFC) for which DVMT were stratified:

Roadway Functional Class	Description
Urban Functional Class 1 (UFC1)	Interstate
Urban Functional Class 2 (UFC2)	Other Freeways and Expressways
Urban Functional Class 3 (UFC3)	Other Principal Arterial
Urban Functional Class 4 (UFC4)	Minor Arterial
Urban Functional Class 5 (UFC5)	Collector
Urban Functional Class 6 (UFC6)	Local
Rural Functional Class 1 (RFC1)	Interstate
Rural Functional Class 2 (RFC2)	Other Principal Arterial
Rural Functional Class 3 (RFC3)	Minor Arterial
Rural Functional Class 4 (RFC4)	Major Collector
Rural Functional Class 5 (RFC5)	Minor Collector
Rural Functional Class 6 (RFC6)	Local

The methodology MassDOT used for allocating DVMT to county is the roadway inventory data of mileage by functional class, representing both the statewide and county highway network. The underlying assumption in this method is that VMT is generally a function of total roadway mileage, and that this functional relationship becomes more direct as individual types of highways within specific areas are considered.

The DVMT data was originally presented by MassDOT to the Federal Highway Administration by Federal-Aid Urban Areas and rural areas by roadway functional class for 2011 as required by the Highway Performance Monitoring System (HPMS). The DVMT allocation factor from state to county was then derived as the ratio of the county to the state roadway mileage for each category of the highway in both rural and urban areas. The following is the formula from EIIP Volume IV p.4-44 which was used for allocating statewide VMT to county by roadway type:

$$F_{ci} = M_{ci} / M_{si}$$

Where: F_{ci} = the apportioning factor of statewide VMT to estimate county VMT for roadway type i
 M_{ci} = miles of each type of roadway in a county, and
 M_{si} = miles of the same type of roadway in the state

MassDOT estimated statewide DVMT from a limited sample of HPMS counts (less than a thousand statewide). Table 4.4 is a summary of the 2011 DVMT data by county and roadway class.

4.3-2 SEASONAL DVMT VARIATION

Table 4.6 presents the MassDOT-generated monthly variation in traffic. MassDEP estimated the seasonal adjustment factor for a typical summer day, by averaging the monthly factors for June, July and August (1.088, 1.105, and 1.110) for a composite factor of 1.101. Similarly, the average monthly factors for January, February and December were used for calculating a composite adjustment factor of 0.903 for a typical winter day.

4.4 MOVES RUN SPEC

To run the MOVES model, a run spec must be created which includes entering all of the above inputs. The following describes the MOVES run specs created for this project:

- Scale = County
- Calculation Type = Inventory
- Time Spans = July 2011, weekday, all hours
- Geographic Bounds = Middlesex Co., Hampden Co.
- Vehicles/Equipment
 - Fuels = Gasoline and Diesel
 - Source Use Types = All Selections = All except diesel motorcycle, gasoline combination long haul truck, and gasoline intercity bus
- Road Type = All
- Pollutants and Processes
 - Pollutants - VOC, NOx, PM2.5, PM10, CO, SO2, NH3
 - Processes – All start and running exhaust and extended idle exhaust
- Strategies
 - No entries
- General Output
 - Units – Tons, Joules, Miles

4.5 MOVES EMISSIONS POST-PROCESSING

Middlesex and Hampden counties were chosen as “representative” counties for the state. Middlesex represents the eastern part of the state and the following additional counties:

- Barnstable
- Bristol
- Essex
- Dukes
- Nantucket
- Norfolk
- Plymouth
- Suffolk
- Worcester

Hampden represents the western part of the state and the following additional counties:

- Berkshire
- Franklin
- Hampshire

Using VMT totals by county, “multipliers” were calculated so that emissions from the representative counties could be scaled up to represent the whole state. Middlesex emissions were multiplied by 3.83722727 to represent the eastern part of the state and Hampden emissions were multiplied by 1.82644604 to represent the western part of the state. Statewide emissions were then calculated by adding up the eastern and western parts.

MassDEP accepted EPA’s latest MOVES annual county emissions. These are summarized in Table 4.7. MassDEP ran MOVES for a typical summer day for Massachusetts and apportioned the emissions to counties based on county annual VMT in Table 4.8.