



Preliminary Comparison Between MOVES and MOBILE6 Houston/Galveston/Brazoria (HGB) On-Road Emission Inventories for 2006 and 2018

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Presentation Overview

- EPA's On-Road Emission Estimation Models From 1978-2010
- How On-Road Emission Estimation Models Are Used
- Texas Transportation Institute MOVES Work Over Last Two Years
- HGB MOBILE6-to-MOVES NO_x, VOC, and CO Emission Differences for 2006 and 2018
- 2006 and 2018 HGB On-Road Emission Differences by Aggregate Vehicle Category
- 2006 and 2018 HGB On-Road Emission Differences by Process Type
- EPA Requirements With Release of MOVES
- Excerpts From EPA's MOVES Policy Guidance
- TCEQ Mid-Course Review State Implementation Plan Commitments
- Running MOVES versus MOBILE6
- Improved In-Use Emission Data Sets in MOVES
- MOBILE6 Default Light-Duty In-Use Emission Rates and Reductions by Certification Standard
- TCEQ Current On-Road Inventory Development Plans With MOVES



EPA On-Road Emission Estimation Models From 1978-2010

- MOBILE1 – MOBILE6:
 - FORTRAN software tools to predict gram-per-mile emission rates for nitrogen oxides (NO_x), volatile organic compounds (VOC), and carbon monoxide (CO).
 - Periodically updated to include new emission standards, input options, and collected data:
 - MOBILE1 1978
 - MOBILE2 1981
 - MOBILE3 1984
 - MOBILE4 1989
 - MOBILE5 1993
 - MOBILE6 2002 (<http://www.epa.gov/otaq/m6.htm>)
- Motor Vehicle Emission Simulator (MOVES) Model:
 - Database-driven tool for estimating either emission rates or total emissions.
 - Latest MOVES2010a version released on September 23, 2010.
 - Available at <http://www.epa.gov/otaq/models/moves/>



How On-Road Emission Estimation Models Are Used

- MOBILE6 (or latest version called MOBILE6.2.03):
 - Output NO_x, VOC, and CO emission rates (e.g., units of grams/mile) for any year from 1952-2050.
 - Separately multiply emission rates by vehicle miles traveled (VMT) to estimate total emissions.
- MOVES (or latest version called MOVES2010a):
 - Can estimate just emission rates (e.g., grams/mile, grams/vehicle); or
 - Can input VMT and vehicle populations to output total emissions.
 - Analysis years confined to 1990 and 1999-2050.
- Emission models are better at showing relative changes in emissions over several years rather than obtaining “snapshot” accuracy for a given year.
 - EPA's April 2007 *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze*
<http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf>
 - Section 1.3.1 on Page 3, “There is uncertainty accompanying model predictions...First, we recommend using models in a relative sense in concert with observed air quality data...”



Texas Transportation Institute (TTI)

MOVES Work Over Last Two Years

- Methodologies for Conversion of Data Sets for MOVES Model Compatibility, August 2009
http://www.tceq.texas.gov/airquality/airmod/project/pj_report_mob.html
- Update of On-Road Inventory Development Methodologies for MOVES Model Compatibility, July 2010
ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/MOVES/utilities/
- 2006 and 2018 HGB On-Road Emission Inventory Examples With MOVES, July 2010
ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/MOVES/HGB/
 - VMT consistent with MOBILE6 inventories for 3-10-2010 HGB SIP
 - Summer Weekday vehicle miles traveled (VMT) of 133,868,661 for 2006 and 180,993,087 for 2018
- Compared with MOBILE6, MOVES on-road emission estimates:
 - Go down a little for CO;
 - Go up a little for VOC
 - Go up a lot for NO_x; but
 - Decline substantially over time for NO_x, VOC, and CO due to fleet turnover even with expected annual growth in VMT.



HGB MOBILE6-to-MOVES NO_x Emissions Difference for 2006 and 2018

Calendar Year	Summer Weekday NO _x Emissions (tons per day)			
	MOBILE6	MOVES	Difference	Change
2006 VMT-133,868,661	206.74	292.65	85.91	42%
2018 VMT-180,993,087	52.55	109.07	56.53	108%
Difference	-154.20	-183.58		
Change	-75%	-63%		



HGB MOBILE6-to-MOVES VOC Emissions Difference for 2006 and 2018

Calendar Year	Summer Weekday VOC Emissions (tons per day)			
	MOBILE6	MOVES	Difference	Change
2006 VMT-133,868,661	90.71	107.57	16.86	19%
2018 VMT-180,993,087	45.97	48.10	2.13	5%
Difference	-44.74	-59.47		
Change	-49%	-55%		



HGB MOBILE6-to-MOVES CO Emissions Difference for 2006 and 2018

Calendar Year	Summer Weekday CO Emissions (tons per day)			
	MOBILE6	MOVES	Difference	Change
2006 VMT-133,868,661	1,115.28	1,013.21	-102.06	-9%
2018 VMT-180,993,087	733.18	617.79	-115.39	-16%
Difference	-382.09	-395.42		
Change	-34%	-39%		



2006 HGB On-Road Emissions by Aggregate Vehicle Category

Aggregate Category	Vehicle Miles Traveled	Emissions (tons per day)		
		NO _x	VOC	CO
MOBILE6				
Light-Duty	121,830,352	88.96	84.89	1,074.55
Heavy-Duty	12,038,309	117.78	5.82	40.72
Total Fleet	133,868,661	206.74	90.71	1,115.28
MOVES				
Light-Duty	120,177,940	137.95	93.66	901.46
Heavy-Duty	13,690,721	154.71	13.91	111.76
Total Fleet	133,868,661	292.65	107.57	1,013.21
Change From MOBILE6 to MOVES				
Light-Duty		48.98	8.77	-173.10
Heavy-Duty		36.92	8.09	71.04
Total Fleet	0	85.91	16.86	-102.06
Relative Change From MOBILE6 to MOVES				
Light-Duty		55%	10%	-16%
Heavy-Duty		31%	139%	174%
Total Fleet	0%	42%	19%	-9%



2018 HGB On-Road Emissions by Aggregate Vehicle Category

Aggregate Category	Vehicle Miles Traveled	Emissions (tons per day)		
		NO _x	VOC	CO
MOBILE6				
Light-Duty	164,917,093	31.53	42.28	715.80
Heavy-Duty	16,075,994	21.02	3.69	17.38
Total Fleet	180,993,087	52.55	45.97	733.18
MOVES				
Light-Duty	162,564,729	49.71	40.12	550.02
Heavy-Duty	18,428,358	59.36	7.98	67.78
Total Fleet	180,993,087	109.07	48.10	617.79
Change From MOBILE6 to MOVES				
Light-Duty		18.18	-2.16	-165.78
Heavy-Duty		38.35	4.29	50.40
Total Fleet	0	56.53	2.13	-115.39
Relative Change From MOBILE6 to MOVES				
Light-Duty		58%	-5%	-23%
Heavy-Duty		182%	116%	290%
Total Fleet	0%	108%	5%	-16%



HGB On-Road NO_x Emissions by Process Type for 2006 and 2018

Process Type	2006 MOBILE6		2006 MOVES		2018 MOBILE6		2018 MOVES	
	NO _x (tpd)	Relative Portion	NO _x (tpd)	Relative Portion	NO _x (tpd)	Relative Portion	NO _x (tpd)	Relative Portion
Running Exhaust	189.27	91.55%	254.16	86.85%	46.56	88.61%	88.36	81.01%
Start Exhaust	14.64	7.08%	33.43	11.42%	5.55	10.55%	14.18	13.00%
Extended Idle	2.83	1.37%	5.06	1.73%	0.44	0.83%	6.53	5.99%
Evaporative								
Total	206.74	100.00%	292.65	100.00%	52.55	100.00%	109.07	100.00%



HGB On-Road VOC Emissions by Process Type for 2006 and 2018

Process Type	2006 MOBILE6		2006 MOVES		2018 MOBILE6		2018 MOVES	
	VOC (tpd)	Relative Portion	VOC (tpd)	Relative Portion	VOC (tpd)	Relative Portion	VOC (tpd)	Relative Portion
Running Exhaust	25.37	27.97%	34.93	32.47%	14.13	30.73%	12.18	25.32%
Start Exhaust	20.29	22.36%	34.93	32.47%	9.35	20.35%	17.86	37.13%
Extended Idle	0.09	0.10%	1.90	1.77%	0.07	0.16%	2.34	4.87%
Evaporative	44.96	49.57%	35.81	33.29%	22.42	48.76%	15.72	32.68%
Total	90.71	100.00%	107.57	100.00%	45.97	100.00%	48.10	100.00%



HGB On-Road CO Emissions by Process Type for 2006 and 2018

Process Type	2006 MOBILE6		2006 MOVES		2018 MOBILE6		2018 MOVES	
	CO (tpd)	Relative Portion	CO (tpd)	Relative Portion	CO (tpd)	Relative Portion	CO (tpd)	Relative Portion
Running Exhaust	847.44	75.98%	721.32	71.19%	515.05	70.25%	427.47	69.19%
Start Exhaust	267.29	23.97%	289.17	28.54%	218.01	29.74%	186.55	30.20%
Extended Idle	0.55	0.05%	2.72	0.27%	0.11	0.02%	3.77	0.61%
Evaporative								
Total	1,115.28	100.00%	1,013.21	100.00%	733.18	100.00%	617.79	100.00%



EPA Requirements With Release of MOVES

- **START** using MOVES instead of MOBILE6 for state implementation plan (SIP) inventory development.
- SIP revisions are **NOT** required just because MOVES is replacing MOBILE6.
- MOVES does not need to be used if **SIGNIFICANT** SIP work has already occurred with MOBILE6.
- Mid-course review SIPs under the current eight-hour ozone standard of 84 parts per billion (ppb) will require the use of MOVES for on-road inventory development.
- Future Attainment and Reasonable Further Progress (RFP) SIPs under the revised eight-hour ozone standard (60-75 ppb) will require the use of MOVES for on-road inventory development.



Excerpts From EPA's MOVES Policy Guidance

Page 6 of "Policy Guidance on the Use of MOVES2010 for State Implementation Plan Development, Transportation Conformity, and Other Purposes"

<http://www.epa.gov/otaq/models/moves/420b09046.pdf>

- "The release of MOVES2010 would not require a SIP revision solely based on the existence of the new model."
- "EPA believes that the Clean Air Act does not require states that have already submitted SIPs or will submit SIPs shortly after the release of MOVES2010 to revise these SIPs simply because a new motor vehicle emissions model is now available."
- "EPA does not believe that the state's use of MOBILE6.2 should be an obstacle to EPA approval for reasonable further progress (RFP), attainment, or maintenance SIPs that have been or will soon be submitted based on MOBILE6.2, assuming that such SIPs are otherwise approvable and significant SIP work has already occurred (e.g., attainment modeling for an attainment SIP has already been completed with MOBILE6.2)."
- "It would be unreasonable to require the states to revise these SIPs with MOVES2010 since significant work has already occurred based on the latest information available at the time, and EPA intends to act on these SIPs in a timely manner."
- "States should use MOVES2010 where SIP development is in its initial stages or has not progressed far enough along that switching to MOVES2010 would create a significantly adverse impact on state resources."



TCEQ Mid-Course Review SIP Commitments

Section 6.3.1, Mid-Course Review (MCR), on Page 6-4 of the March 10, 2010, Attainment Demonstration SIP for HGB:

http://www.tceq.texas.gov/implementation/air/sip/HGB_eight_hour.html

- “In response to comments, the executive director will perform a 1997 eight-hour ozone MCR and, with commission approval, submit the results to the EPA concurrently with a SIP revision for the EPA’s revised ozone standard, which is scheduled to be submitted to the EPA no later than December 2013. In the event that the schedule for the revised ozone standard is changed by the EPA, the schedule for the MCR submission will change accordingly.”
- “The MCR will involve a thorough evaluation of all modeling, inventory data, and other tools and assumptions used to develop the attainment demonstration.”



Running MOVES versus MOBILE6

- Run time: MOBILE6 runs much faster than MOVES (seconds versus hours).
- Recent data: MOBILE6 has not been updated since 2003, while MOVES contains the most up-to-date information.
- Vehicle categorization:
 - MOBILE6 combines vehicle and fuel types into 28 gasoline/diesel fuel categories.
 - MOVES has 13 source use type (SUT) categories with multiple fuel types including electricity, which will become very important for future work.
- Emissions estimation: MOBILE6 estimates emission rates only, while MOVES estimates emission rates or total emissions (by multiplying rates by activity).
- Pollutants available for modeling:
 - Both models estimate NO_x , VOC, CO, carbon dioxide (CO_2), ammonia (NH_3), sulfur dioxide (SO_2), particulate matter (PM), and toxic compounds.
 - MOVES also models energy consumption and nitrous oxide (N_2O).
- NO_x emissions estimation:
 - MOBILE6 estimates just total NO_x emissions, where $\text{NO}_x = \text{NO} + \text{NO}_2$.
 - MOVES estimates NO and NO_2 separately, which is important for ozone modeling.
- Operating speeds: MOBILE6 estimates emission rates from 2.5 – 65 miles per hour (mph), while MOVES estimates emission rates from 2.5 – 75 mph.



Improved In-Use Emission Data Sets in MOVES

- MOBILE5 came out in 1993 and MOBILE6 came out in 2002:
 - Available in-use emissions data for MOBILE6 were from the 1994-2002 calendar years.
 - Long-term in-use emission rate data were not yet available for vehicles meeting Tier 1 standards (1994-2000 model years) and National Low Emission Vehicle (NLEV) standards (2001-2003 model years).
- MOVES came out in 2010:
 - Long-term in-use data available from 2003-2010 were used.
 - Long-term in-use emission rate data are not yet available for vehicles meeting Tier 2 standards (2004-and-newer model years).
 - Future MOVES releases will have improved data for Tier 2 vehicles, along with improved data on heavy-duty vehicles that have engines meeting the most stringent 2007-and-newer standards.
- It is impossible to accurately predict long-term in-use emission rates for vehicle technologies that either have not yet been introduced to the fleet or are very new.



MOBILE6 Default Light-Duty Vehicle In-Use Emission Rates by Certification Standard

Federal Emission Standard Scenario	Average In-Use Emission Rates (grams per mile)		
	NO _x	VOC	CO
Unregulated 1960 Model Year	4.4663	16.4065	117.4838
Tier 0 (Pre-1994 Model Years)	1.1924	0.6303	8.8534
Tier 1 (1994 – 2000 Model Years)	0.8820	0.4566	6.5060
NLEV / California LEV-1 (2001 – 2003 Model Years)	0.5166	0.2722	3.8454
Tier 2 – Bin 5 (Most 2004-and-Newer)	0.1552	0.2459	3.9124
Tier 2 – Bin 4 (Example – Saturn Vue Hybrid)	0.1250	0.2198	3.4573
Tier 2 – Bin 3 (Example – Toyota Prius)	0.1135	0.2079	3.4573
Tier 2 – Bin 2 (Example – Honda Civic Hybrid)	0.1034	0.1720	3.4573



MOBILE6 Default Light-Duty Vehicle In-Use Emission Reductions by Certification Standard

Federal Emission Standard Scenario	Relative Reduction From Unregulated 1960 Model Year		
	NO _x	VOC	CO
Unregulated 1960 Model Year			
Tier 0 (Pre-1994 Model Years)	73.3%	96.2%	92.5%
Tier 1 (1994 – 2000 Model Years)	80.3%	97.2%	94.5%
NLEV / California LEV-1 (2001 – 2003 Model Years)	88.4%	98.3%	96.6%
Tier 2 – Bin 5 (Most 2004-and-Newer)	96.5%	98.5%	96.7%
Tier 2 – Bin 4 (Example – Saturn Vue Hybrid)	97.2%	98.7%	97.1%
Tier 2 – Bin 3 (Example – Toyota Prius)	97.5%	98.7%	97.1%
Tier 2 – Bin 2 (Example – Honda Civic Hybrid)	97.7%	99.0%	97.1%



TCEQ Current On-Road Inventory Development Plans With MOVES

- HGB link-based on-road inventories based on local travel demand model (TDM):
 - 2006 base case and 2008 baseline inventories scheduled for completion by August of 2011 from TTI.
 - Needed future-case inventories will be developed roughly 18-24 months prior to scheduled SIP adoption.
 - If developed too soon, future-case on-road inventories are obsolete at the time of SIP adoption.
- Non-link on-road inventories for all 254 Texas counties:
 - 2006 base case and 2008 baseline scheduled for completion by August 2011 from TTI.
 - Future-case inventories will be developed as needed years are identified.
- Non-Texas on-road emissions based on default MOVES runs:
 - 2006 and 2008 MOVES runs currently being done by TCEQ staff.
- All final work will be posted to the TCEQ on-road mobile emission inventory FTP site: ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/



Questions?

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