Texas Implementation of the Motor Vehicle Emission Simulator (MOVES) Model

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Presentation Overview

- MOBILE Model Vehicle Classification
- MOVES Fuel Types and Source Use Types (SUTs)
- Recent Texas Transportation Institute (TTI) Work
- 2006 and 2018 MOVES-versus-MOBILE6 On-Road Inventory Comparisons for Houston/Galveston/Brazoria
- Custom Source Classification Codes (SCCs) for MOVES:
  - Source Use Type
  - Fuel Type
  - Emission Process
  - Roadway Type
  - Alpha and Numeric Options
  - Aggregation Options
- Spatial Allocation Approach for “Non-Link” Emissions
- Spatial Allocation Options for Off-Network Emission Types
- TCEQ On-Road Inventory Development Plans With MOVES

MOBILE Model Vehicle Classification

- Light-duty, heavy-duty, fuel type, and gross vehicle weight rating (GVWR)

MOBILE5	MOBILE6	MOBILE5	MOBILE6	MOBILE5	MOBILE6
LDGV	LDGV	HDGV	HDGV2b	HDDV	HDDV2b
LDGT1	LDGT1		HDGV3		HDDV3
	LDGT2		HDGV4		HDDV4
LDGT2	LDGT3		HDGV5		HDDV5
	LDGT4		HDGV6		HDDV6
LDDV	LDDV		HDGV7		HDDV7
LDDT	LDDT12		HDGV8a		HDDV8a
	LDDT34		HDGV8b		HDDV8b
MC	MC		HDGB		HDDBT
					HDDBS

MOVES Source Use Types (SUTs)

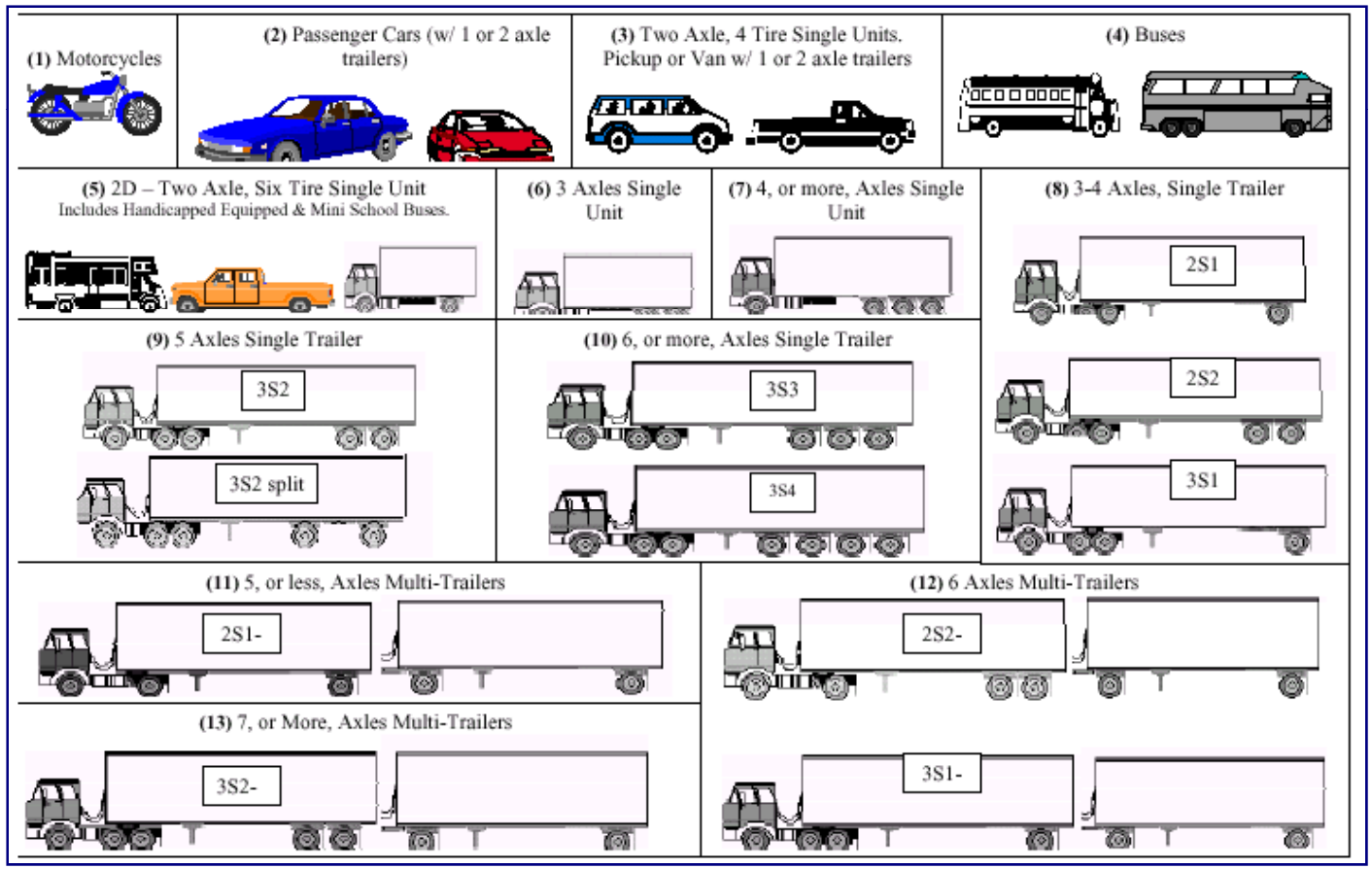
MOVES Code	Source Use Type Description
11	Motorcycle
21	Passenger Car
31	Passenger Truck
32	Light Commercial Truck
41	Intercity Bus
42	Transit Bus
43	School Bus
51	Refuse Truck
52	Single-Unit Short-Haul Truck
53	Single-Unit Long-Haul Truck
54	Motor Home
61	Combination Short Haul Truck
62	Combination Long-Haul Truck

MOVES Fuel Types

MOVES Code	Fuel Type Description
1	Gasoline
2	Diesel Fuel
3	Compressed Natural Gas (CNG)
3	Liquefied Petroleum Gas (LPG)
5	Ethanol
9	Electricity

SUT Age Distribution & Miles Traveled

- County age distribution queries by source use type from the Texas vehicle registration database.
- Vehicle miles traveled (VMT) distribution from Texas Department of Transportation (TxDOT) roadside vehicle classification counts for the following categories:



Short-Haul Versus Long-Haul

- Roadside classification counts cannot distinguish between short-haul and long-haul contributions.
- MOVES has separate short-haul and long-haul categories for single-unit and combination trucks.
- TTI approach:
  - Assume that activity from locally registered trucks comprises short-haul component.
  - Long-haul component determined by subtracting short-haul estimate from total by area.
  - For more detail, refer to *Methodologies for Conversion of Data Sets for MOVES Model Compatibility*, August 2009.

    http://www.tceq.state.tx.us/implementation/air/airmod/project/pj_report_mob.html

Recent TTI MOVES Work for TCEQ

- *Update of On-Road Inventory Development Methodologies for MOVES Model Compatibility*, August 2010
  - ftp://ftp.tceq.state.tx.us/pub/OEPAA/TAD/Modeling/Mobile_EI/MOVES/utilities/
- 2006 and 2018 Houston/Galveston/Brazoria (HGB) on-road emission inventory "practice runs" with MOVES2010 version:
  - VMT consistent with MOBILE6 inventories for 3-10-2010 HGB SIP.
  - eight-county HGB Summer Weekday VMT of 133,868,661 for 2006 and 180,993,087 for 2018.
  - ftp://ftp.tceq.state.tx.us/pub/OEPAA/TAD/Modeling/Mobile_EI/MOVES/HGB/
- Compared with MOBILE6, MOVES on-road emission estimates:
  - go down a little for carbon monoxide (CO);
  - go up a little for volatile organic compounds (VOC);
  - go up a lot for oxides of nitrogen (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)			Emission Rates (grams per mile)		
		NO_x	VOC	CO	NO_x	VOC	CO
MOBILE6							
Light-Duty	121,830,352	88.96	84.89	1,074.55	0.6624	0.6321	8.0014
Heavy-Duty	12,038,309	117.78	5.82	40.72	8.8757	0.4386	3.0688
Total Fleet	133,868,661	206.74	90.71	1,115.28	1.4010	0.6147	7.5578
MOVES							
Light-Duty	120,177,940	137.95	93.66	901.46	1.0413	0.7070	6.8048
Heavy-Duty	13,690,721	154.71	13.91	111.76	10.2511	0.9216	7.4054
Total Fleet	133,868,661	292.65	107.57	1,013.21	1.9832	0.7290	6.8662
Change From MOBILE6 to MOVES							
Light-Duty		48.98	8.77	-173.10	0.3789	0.0749	-1.1966
Heavy-Duty		36.92	8.09	71.04	1.3755	0.4830	4.3367
Total Fleet	0	85.91	16.86	-102.06	0.5822	0.1143	-0.6916
Relative Change From MOBILE6 to MOVES							
Light-Duty		55%	10%	-16%	57%	12%	-15%
Heavy-Duty		31%	139%	174%	15%	110%	141%
Total Fleet	0%	42%	19%	-9%	42%	19%	-9%

2018 HGB On-Road Emissions by Aggregate Vehicle Category

Aggregate Category	Vehicle Miles Traveled	Emissions (tons per day)			Emission Rates (grams per mile)		
		NO_x	VOC	CO	NO_x	VOC	CO
MOBILE6							
Light-Duty	164,917,093	31.53	42.28	715.80	0.1734	0.2326	3.9375
Heavy-Duty	16,075,994	21.02	3.69	17.38	1.1860	0.2081	0.9808
Total Fleet	180,993,087	52.55	45.97	733.18	0.2634	0.2304	3.6749
MOVES							
Light-Duty	162,564,729	49.71	40.12	550.02	0.2774	0.2239	3.0693
Heavy-Duty	18,428,358	59.36	7.98	67.78	2.9223	0.3929	3.3364
Total Fleet	180,993,087	109.07	48.10	617.79	0.5467	0.2411	3.0965
Change From MOBILE6 to MOVES							
Light-Duty		18.18	-2.16	-165.78	0.1040	-0.0087	-0.8682
Heavy-Duty		38.35	4.29	50.40	1.7363	0.1848	2.3556
Total Fleet	0	56.53	2.13	-115.39	0.2833	0.0107	-0.5784
Relative Change From MOBILE6 to MOVES							
Light-Duty		58%	-5%	-23%	60%	-4%	-22%
Heavy-Duty		182%	116%	290%	146%	89%	240%
Total Fleet	0%	108%	5%	-16%	108%	5%	-16%

HGB On-Road NO_X Emissions by Process for 2006 and 2018

Emission Process	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 for 2006 and 2018

Emission Process	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 for 2006 and 2018

Emission Process	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%

Custom Source Classification Codes (SCCs)

- SCC essential for photochemical model emissions processing:
  - tracking and reporting by SUT, fuel type, etc.;
  - chemical speciation (e.g., gasoline versus diesel);
  - spatial/temporal allocation; and
  - post-processing, control strategy adjustments, etc.
- Both alpha and numeric SCC approaches proposed for MOVES:
  - two characters for source use type;
  - two characters for fuel type;
  - three characters for emission process; and
  - three characters for roadway type.
- Alpha SCC approach is easier for instant identification.
- Numeric SCC approach requires lookup but offers more options.
- Could MOVES model offer both options to users?

Source Use Type Portion of SCC

MOVES Code	MOVES Description	Alpha Code	Numeric Code
11	Motorcycle	MC	11
21	Passenger Car	PC	21
31	Passenger Truck	PT	31
32	Light Commercial Truck	LT	32
41	Intercity Bus	IB	41
42	Transit Bus	TB	42
43	School Bus	SB	43
51	Refuse Truck	RT	51
52	Single Unit Short-Haul Truck	SS	52
53	Single Unit Long-Haul Truck	SL	53
54	Motor Home	MH	54
61	Combination Short-Haul Truck	CS	61
62	Combination Long-Haul Truck	CL	62

Fuel Type Portion of SCC

MOVES Code	MOVES Description	Alpha Code	Numeric Code
1	Gasoline	GS	01
2	Diesel Fuel	DS	02
3	Compressed Natural Gas (CNG)	CN	03
4	Liquefied Petroleum Gas (LPG)	LP	04
5	Ethanol	ET	05
9	Electricity	EL	09

Emission Process Portion of SCC

MOVES Code	MOVES Description	Alpha Code	Numeric Code
1	Running Exhaust	RNX	001
2	Start Exhaust	STX	002
9	Brake Wear	BWR	009
10	Tire Wear	TWR	010
11	Evaporative Permeation	EPR	011
12	Evaporative Fuel Vapor Venting	EFV	012
13	Evaporative Fuel Leaks	EFL	013
15	Crankcase Running Exhaust	CRX	015
16	Crankcase Start Exhaust	CSX	016
17	Crankcase Extended Idle Exhaust	CIX	017
18	Refueling Displacement Vapor Loss	RFD	018
19	Refueling Spillage Loss	RFS	019
90	Extended Idle Exhaust	EIX	090
99	Well-to-Pump	WTP	099

Roadway Type Portion of SCC

MOVES Code	MOVES Description	Alpha Code	Numeric Code
1	Off-Network	OFF	001
2	Rural Restricted Access	RRA	002
3	Rural Unrestricted Access	RUA	003
4	Urban Restricted Access	URA	004
5	Urban Unrestricted Access	UUA	005
6 (assumed)	Ramp	RMP	006

Custom SCC Examples

- Running exhaust emissions from gasoline-powered passenger cars operating on an urban restricted access roadway (e.g., interstate):
  - Alpha code: `PCGSRNXURA`
  - Numeric code: `2101001004`
- Off-network extended idle exhaust emissions from diesel-powered combination long-haul trucks:
  - Alpha code: `CLDSEIXOFF`
  - Numeric code: `6202017001`
- 434 unique MOVES-based SCCs for gasoline and diesel vehicle categories:
  - numeric codes did not conflict with 11,655 existing SCCs; and
  - obvious non-existent categories excluded such as diesel-powered motorcycles and gasoline-powered combination long-haul trucks.

Possible Emission Process SCC Aggregation

MOVES Emission Process		Combination Process & Codes		
Code	**Description**	**Description**	**Alpha**	**Numeric**
1	Running Exhaust	Running Exhaust	RXH	901
2	Start Exhaust	Start Exhaust	SXH	902
11	Evaporative Permeation	Gasoline Vapor	VPR	912
12	Evaporative Fuel Vapor Venting	Gasoline Vapor	VPR	912
13	Evaporative Fuel Leaks	Gasoline Liquid	LQD	913
15	Crankcase Running Exhaust	Running Exhaust	RXH	901
16	Crankcase Start Exhaust	Start Exhaust	SXH	902
17	Crankcase Extended Idle Exhaust	Idle Exhaust	IXH	990
90	Extended Idle Exhaust	Idle Exhaust	IXH	990

Highway Performance Monitoring System (HPMS) Roadway Types

Area Type	Roadway Type Description	HPMS Code	MOVES Code
Rural	Interstate	110	11
	Other Principal Arterial	130	13
	Minor Arterial	150	15
	Major Collector	170	17
	Minor Collector	190	19
	Local	210	21
Urban	Interstate	230	23
	Other Freeways and Expressways	250	25
	Other Principal Arterial	270	27
	Minor Arterial	290	29
	Collector	310	31
	Local	330	33

Sample Spatial Surrogate Assignment for Non-Link On-Road Emissions

Area Type	Road Type Description	Spatial Surrogate Assignment
Rural	Interstate	Rural Primary Roads
	Other Principal Arterial	Rural Primary Roads
	Minor Arterial	Rural Primary Roads
	Major Collector	Rural Secondary Roads
	Minor Collector	Rural Secondary Roads
	Local	Rural Population
Urban	Interstate	Urban Primary Roads
	Other Freeways and Expressways	Urban Primary Roads
	Other Principal Arterial	Urban Primary Roads
	Minor Arterial	Urban Primary Roads
	Collector	Urban Secondary Roads
	Local	Urban Population

Spatial Allocation Options for Off-Network Emission Types

Surrogate Assignment Order	Off-Network Emission Type		
	Start Exhaust	**Evaporative**	**Extended Idle**
Primary	Travel Demand Model Trip Origins by Time-of-Day	Travel Demand Model Trip "Ends" by Time-of-Day	Known Truck Stop Locations
Secondary	Vehicle Registrations by Zip Code		Interstates / Primary Roads
Tertiary	Residential Housing		
Backup	Human Population		

TCEQ On-Road Inventory Development Plans With MOVES

- Ozone attainment modeling for State Implementation Plans (SIPs):
  - 2006 base case episode and 2008 baseline; and
  - future years as needed for moderate, serious, and/or severe nonattainment areas.
- Link-based on-road inventories based on travel demand models (TDMs):
  - for moderate-and-above metropolitan areas requiring SIPs;
  - developed 1.5-2.5 years prior to SIP adoption;
  - Weekday, Friday, Saturday, and Sunday "day types"; and
  - School and Summer (non-School) seasons
- Non-link on-road inventories for all 254 Texas counties:
  - emissions by SUT/fuel combinations, roadway type, and hour; and
  - Weekday, Friday, Saturday, and Sunday day types.
- Non-Texas on-road emissions based on default MOVES runs.
- All final work will be posted to TCEQ on-road mobile emission inventory FTP site: ftp://ftp.tceq.state.tx.us/pub/OEPAA/TAD/Modeling/Mobile_EI/.

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