

Emissions Inventory for Recreational Vehicles

California Air Resources Board

March 6, 2013

Outline

- Overview and Emissions
- Inputs
 - Base Population and Age Distribution
 - Forecasted Population and Age Distribution
 - Activity
 - Base Emission Factors
 - Regional Allocation and Corrections
 - Rule Scenario
- Results

Recreational Vehicles



Off-Highway Motorcycle (OHMC)



All Terrain Vehicles (ATV)



Snowmobile



Mini Bike



Specialty Vehicle and Golf Cart



Overview

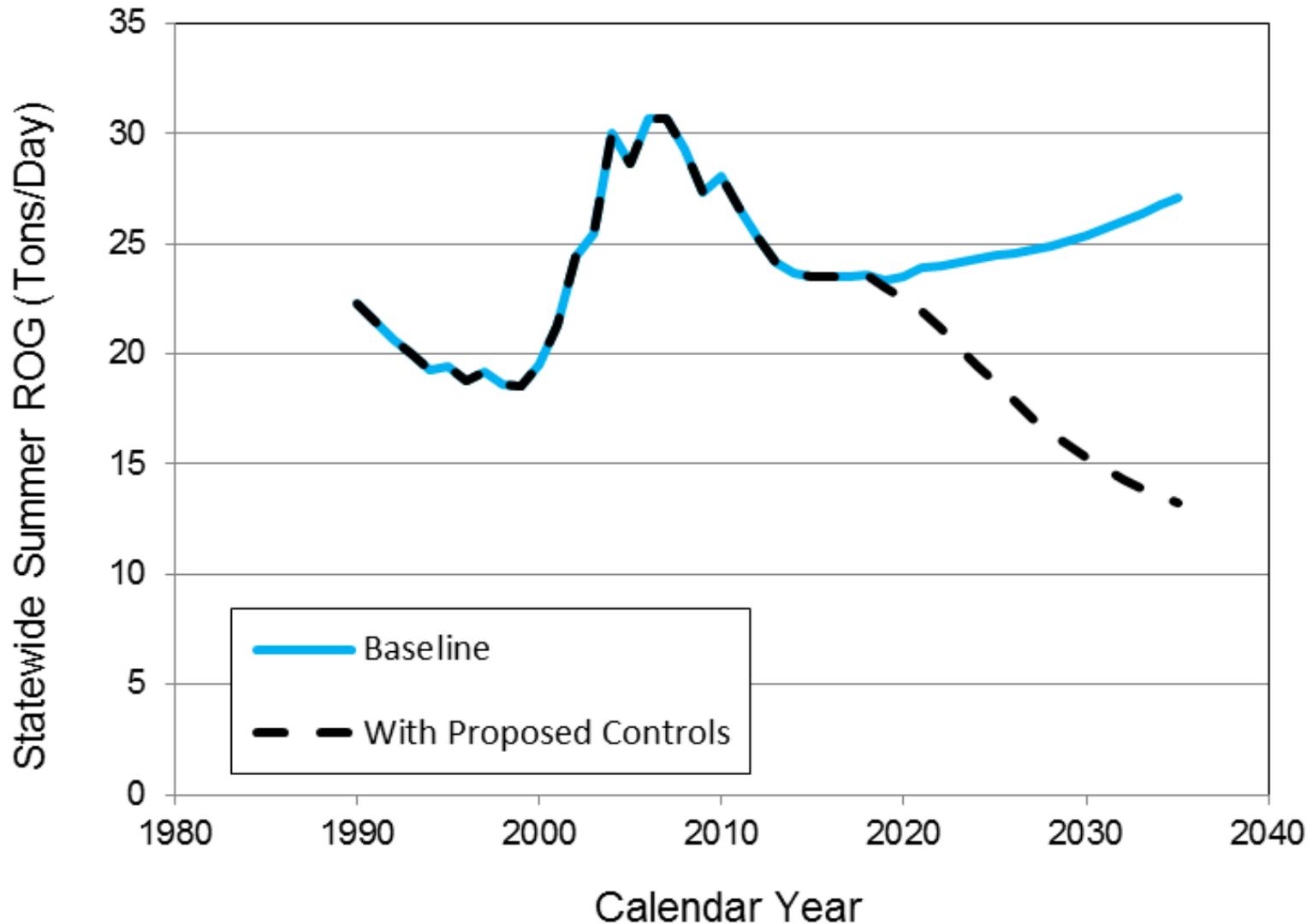
- What is an inventory?
 - An emissions inventory estimates the amount of pollutants released into the atmosphere for a specific area and time span from a source
 - An emissions inventory helps policymakers to develop control strategies and policies
- How is it calculated?
 - Emissions = Population x Activity x Emission Factor

Overview – Emissions Results

Statewide Summer Reactive Organic Gases (ROG) (tons per day)

CY	Baseline			Baseline with Proposed Controls			Proposed Net Benefit
	Exhaust ROG	Evap ROG	Total ROG	Exhaust ROG	Evap ROG	Total ROG	
2020	5.1	18.4	23.5	5.1	17.4	22.6	0.9
2025	4.6	19.9	24.5	4.6	14.1	18.7	5.8
2030	4.5	20.9	25.4	4.5	10.8	15.3	10.1
2035	4.6	22.5	27.1	4.6	8.6	13.2	13.9

Statewide Summer ROG (tons per day)

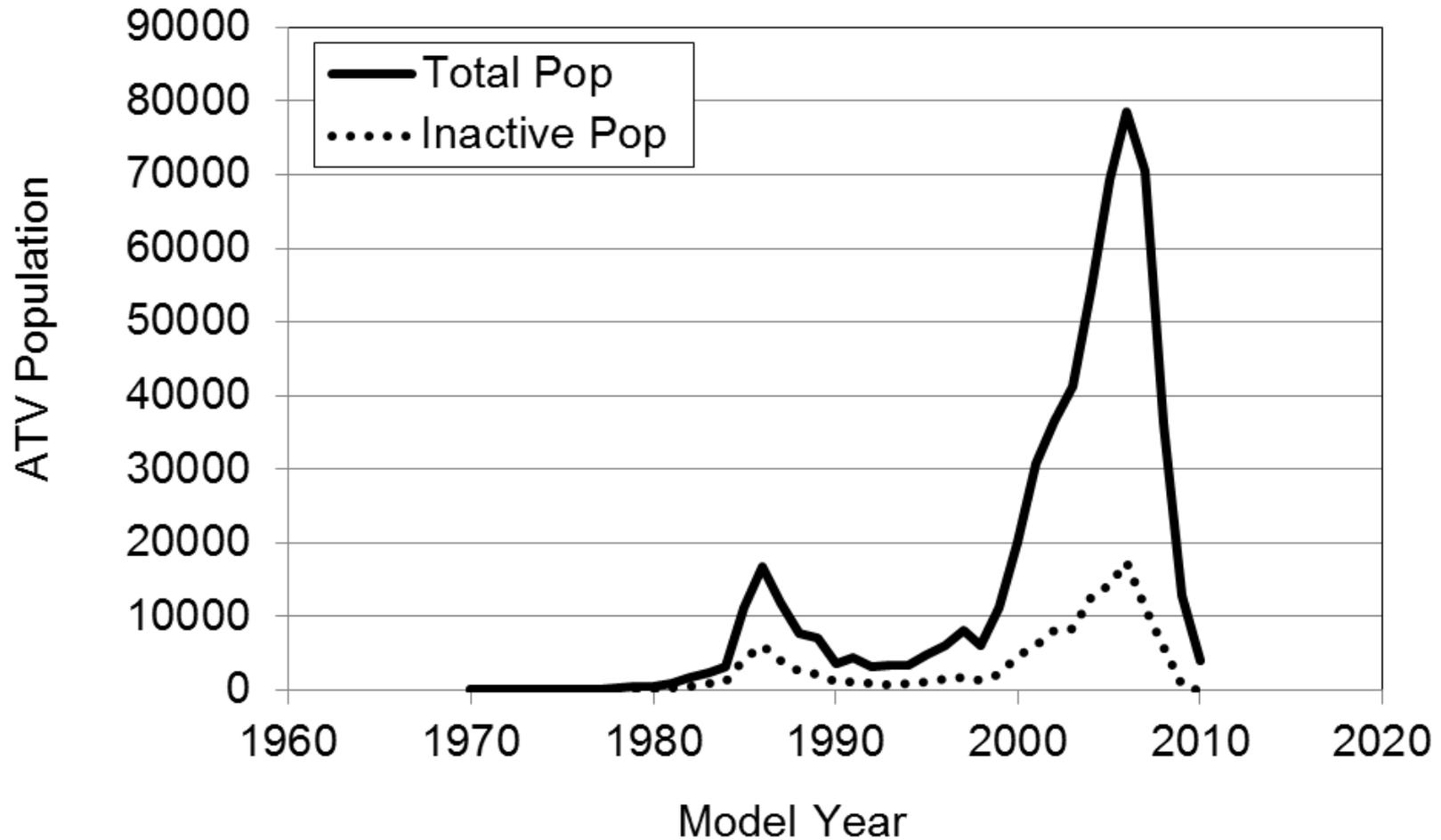


Inputs: Population and Age Distribution

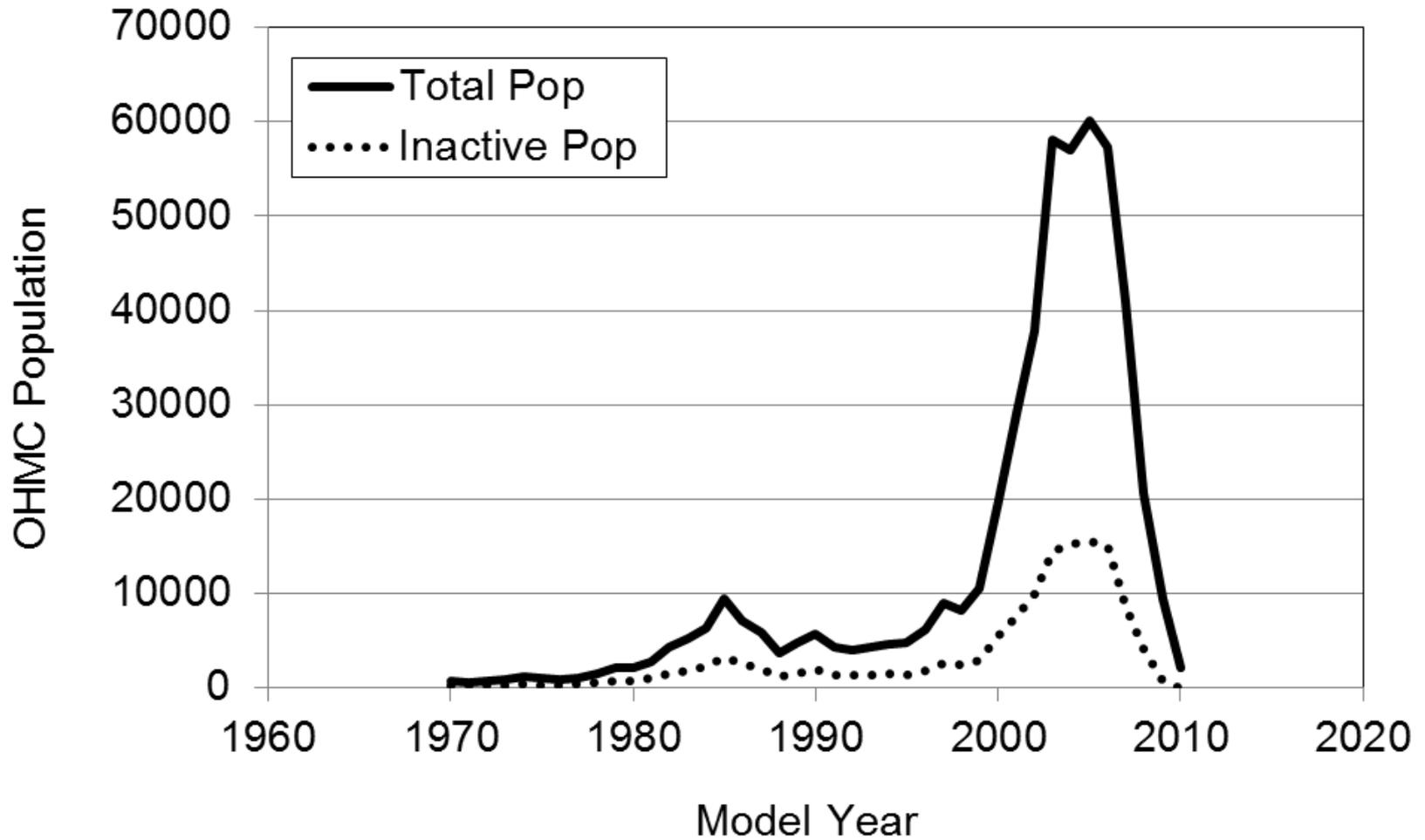
- DMV Registration Data (CY 2000 to 2010)
 - Vehicle population by age for each calendar year
 - Vehicle Identification Number (VIN) number
 - Registration code
 - Codes N, P, R are unregistered vehicles
 - We assume all N, P, R code vehicles are stored at the location of prior registration
 - These “inactive” vehicles have diurnal and resting emissions only

DMV code	Definition	Status
C	Currently registered	Active
E	Evidence of use	Active
S	Pending	Active
N	Not currently registered	Inactive
P	Planned non-operational	Inactive
R	Prior history	Inactive

Age Distribution of ATV (2010 DMV)



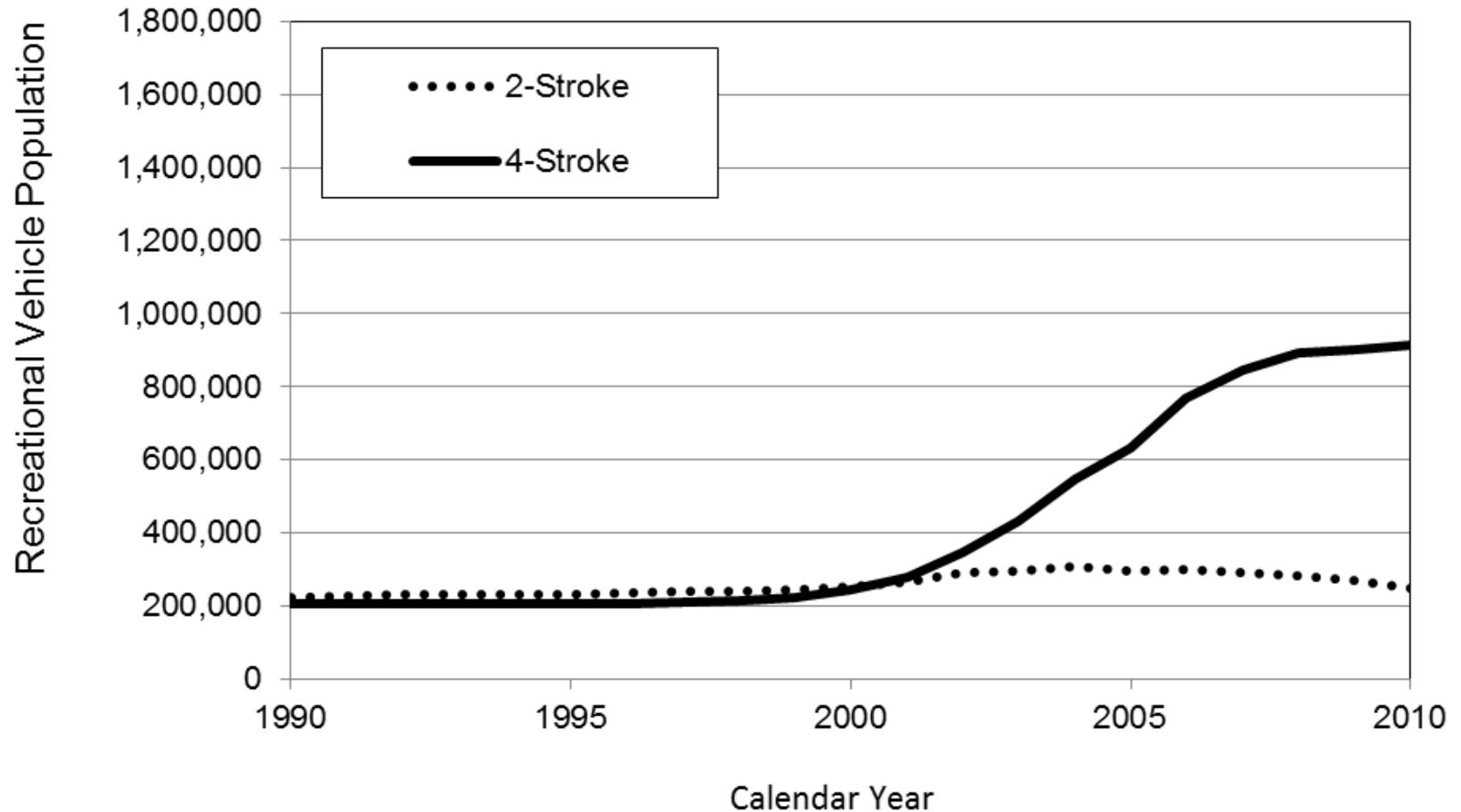
Age Distribution of OHMC (2010 DMV)



Inputs: Population and Age Distribution

- Vehicle technology
 - Two vs. Four Stroke Engines
 - Two-stroke engines have much higher emissions
 - Identifiable in DMV data using VIN decoder

Statewide Population: Vehicle Technology



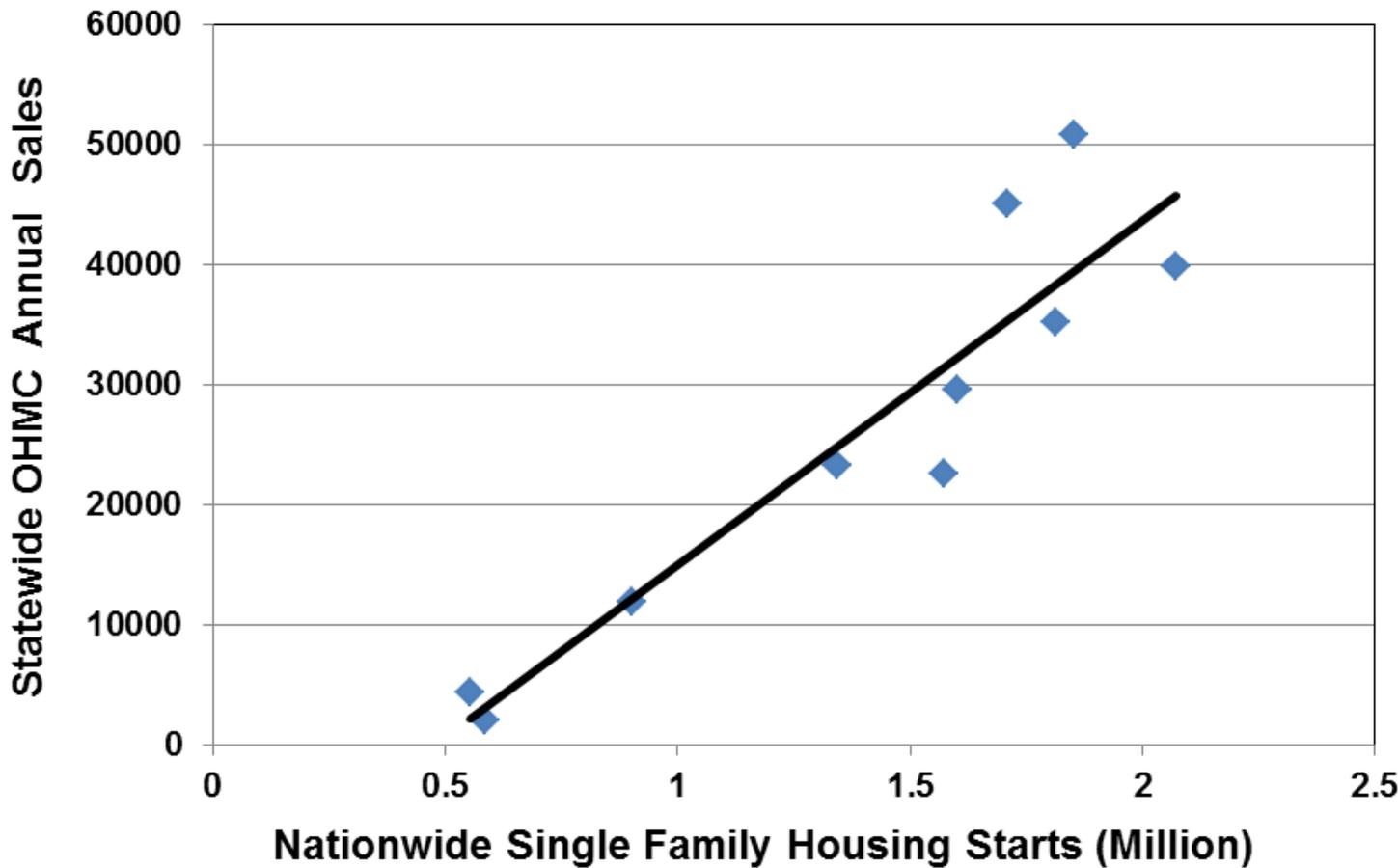
Inputs: Forecasted Population and Age Distribution

- $\text{Pop} = \text{Base Pop} + \text{Annual Sales} - \text{Vehicle Attrition}$
- Population forecast elements
 - Annual sales
 - New vehicles added to the population
 - Reflects forecast of engine characteristics (two vs. four-stroke)
 - Vehicle attrition
 - Scrapped vehicles deleted from the population

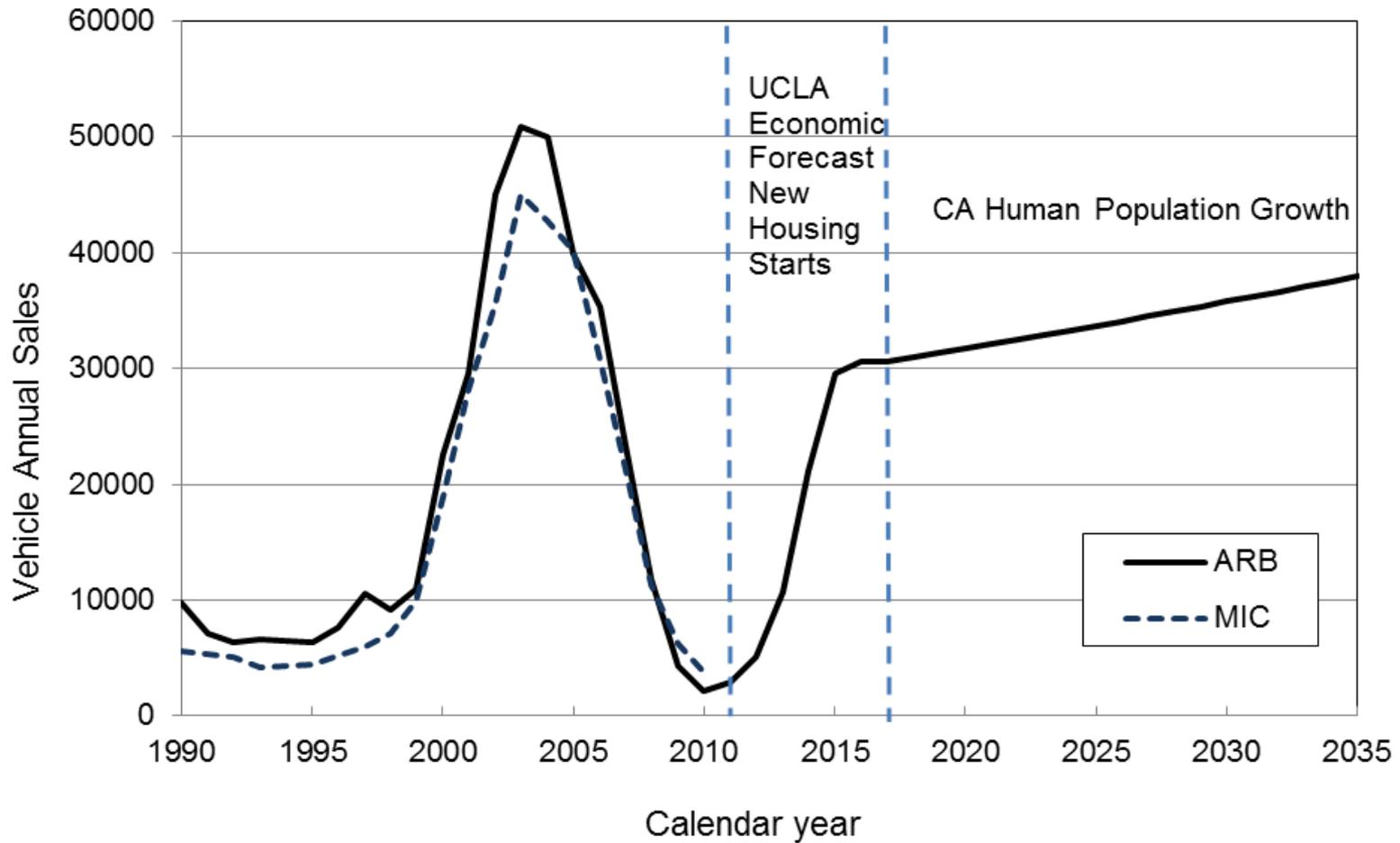
Inputs: Forecasted New Vehicle Sales

- Annual sales growth
 - Modeled recreational vehicle sales in California as a function of forecasted nationwide housing starts
 - Housing starts
 - General indicator of economy, discretionary spending
 - Correlate well with historical annual vehicle sales
 - Short Term Forecast
 - 2011 to 2017, based on forecasted nationwide new housing starts (2012 UCLA Economic Forecast)
 - Long Term Forecast
 - 2018+, based on CA human population growth (1.2%)

Correlation Between OHMC Annual Sales and Nationwide New Housing Starts



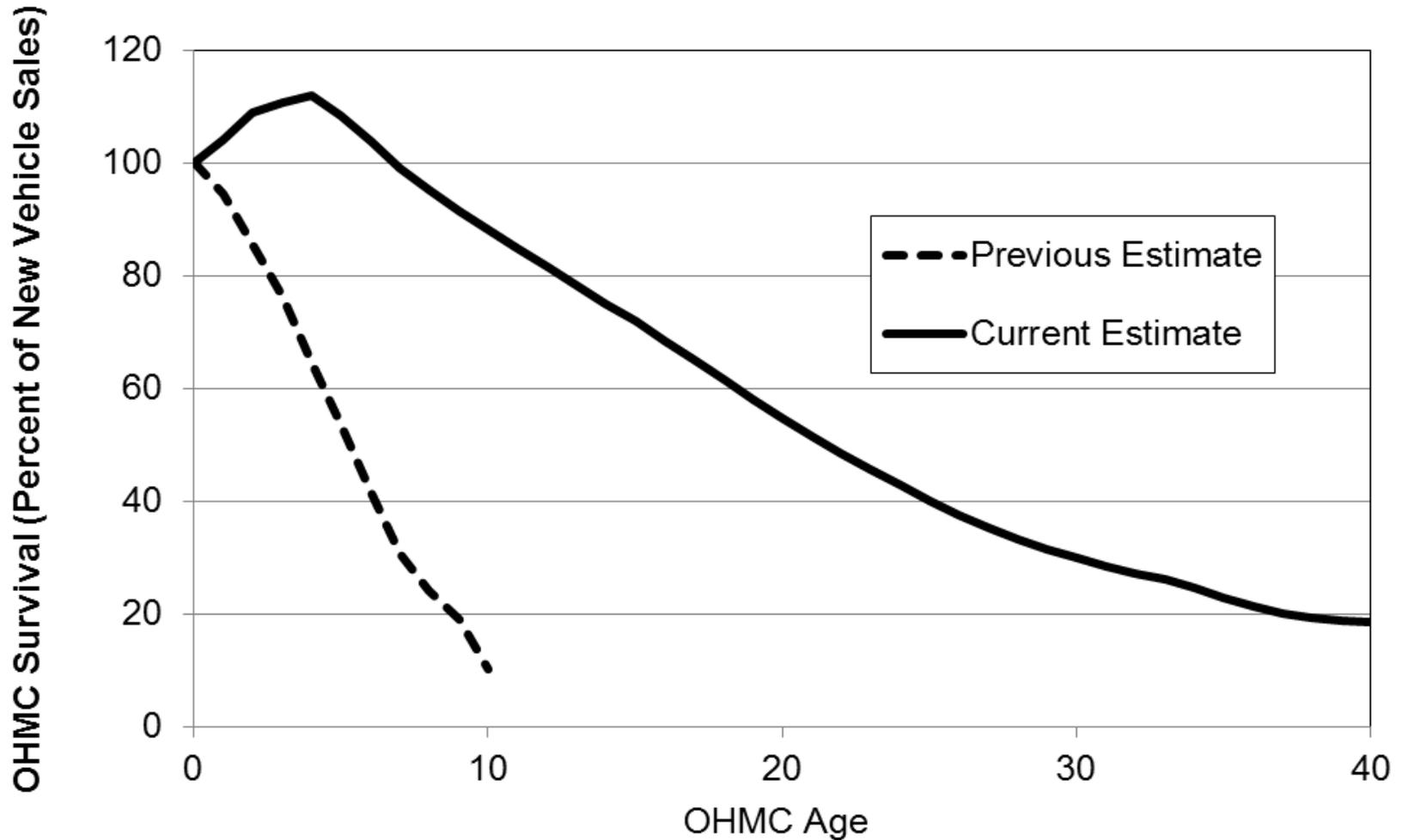
Annual OHMC Sales Estimates ARB and MIC



Inputs: Vehicle Attrition

- Estimate of population survival by age
- Expressed as a survival curve
- Derived from year to year analysis of DMV registration data
- Results: much longer vehicle lifetime than previously estimated using industry reports

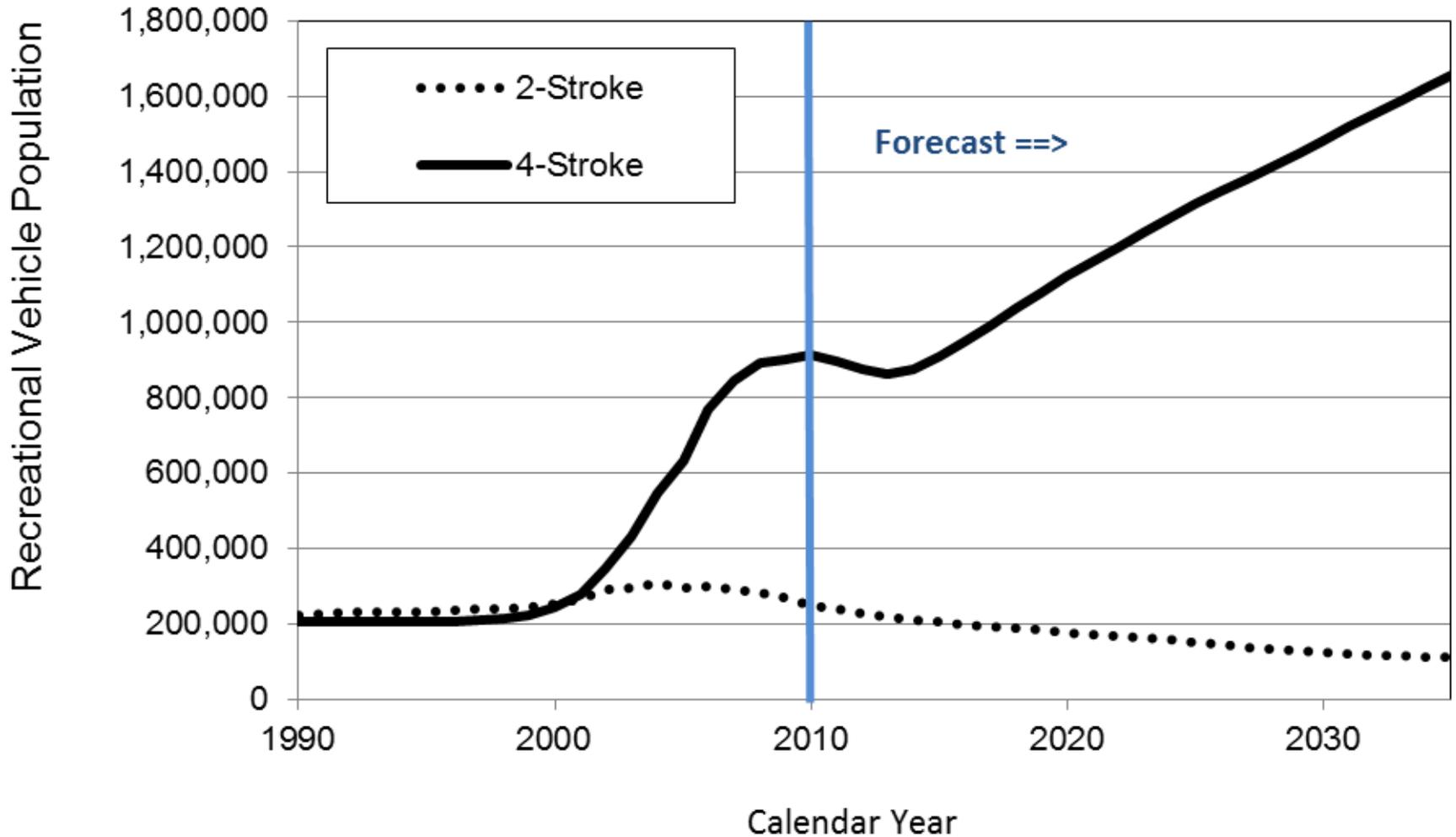
Comparison of Survival Rate for OHMC



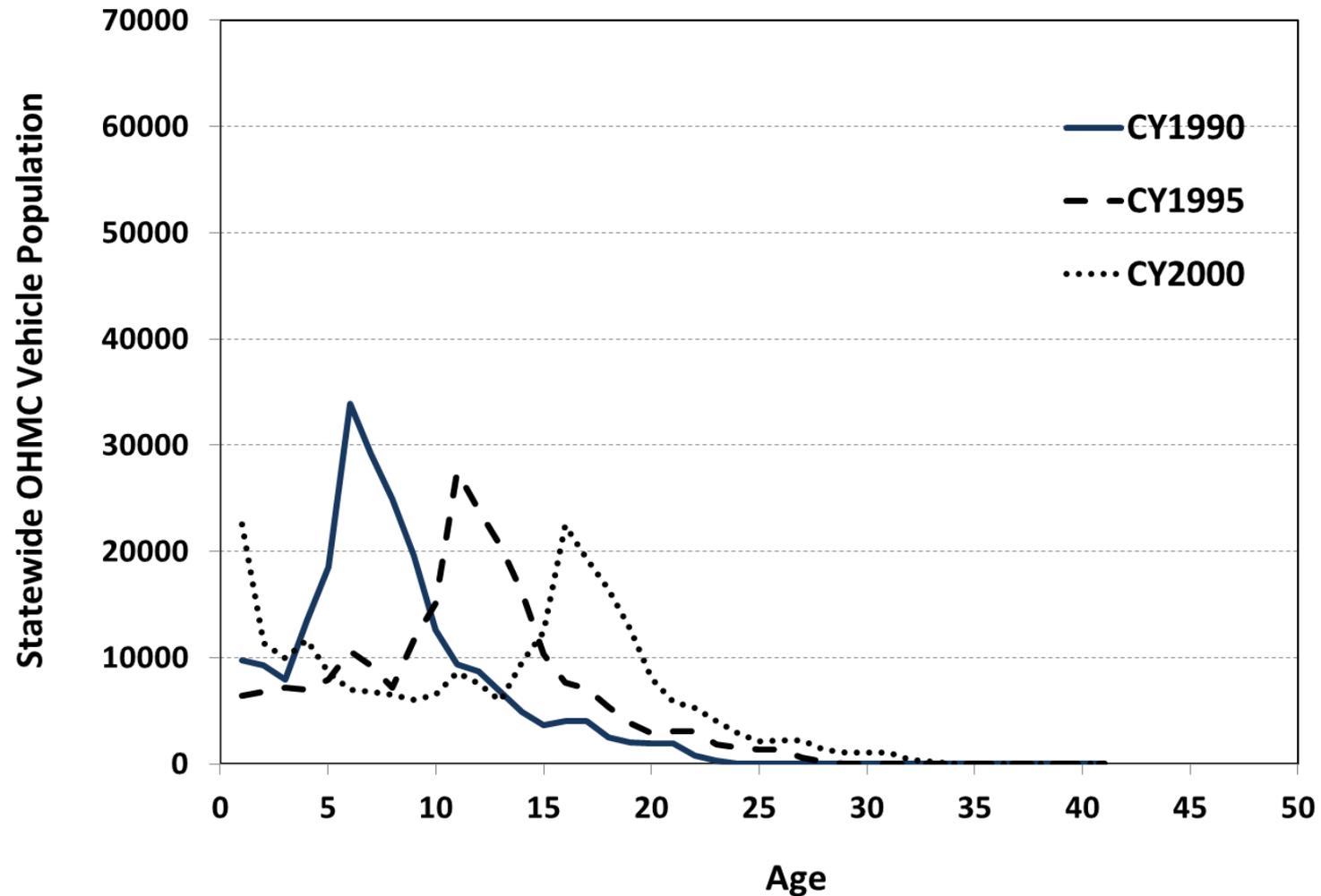
Inputs: Vehicle Technology

- Two vs. Four Stroke
 - CY 2000 and earlier, use the same split from CY 2000
 - CY 2010 and later, use the same split from CY 2010

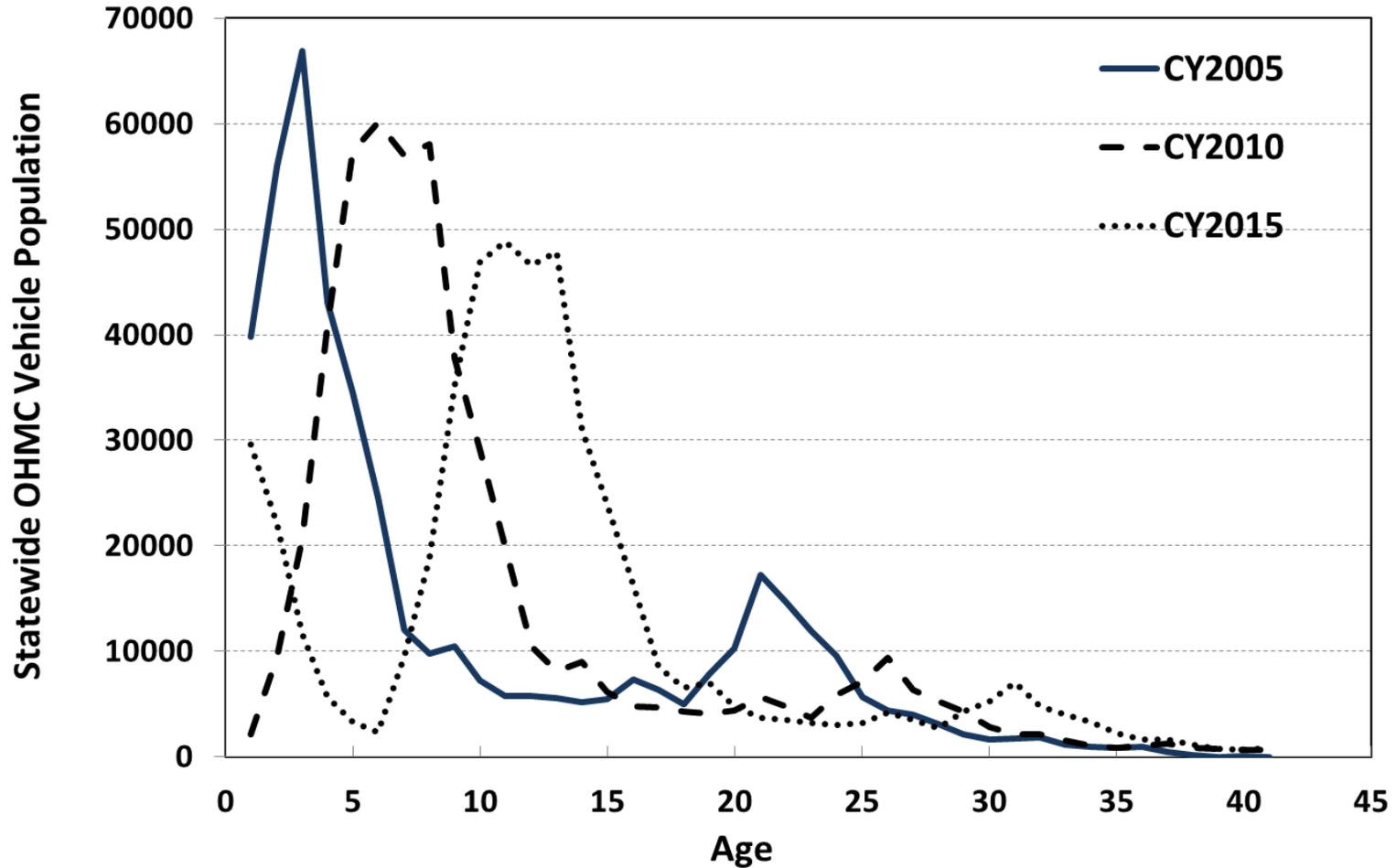
Forecast: Statewide Population by Vehicle Technology



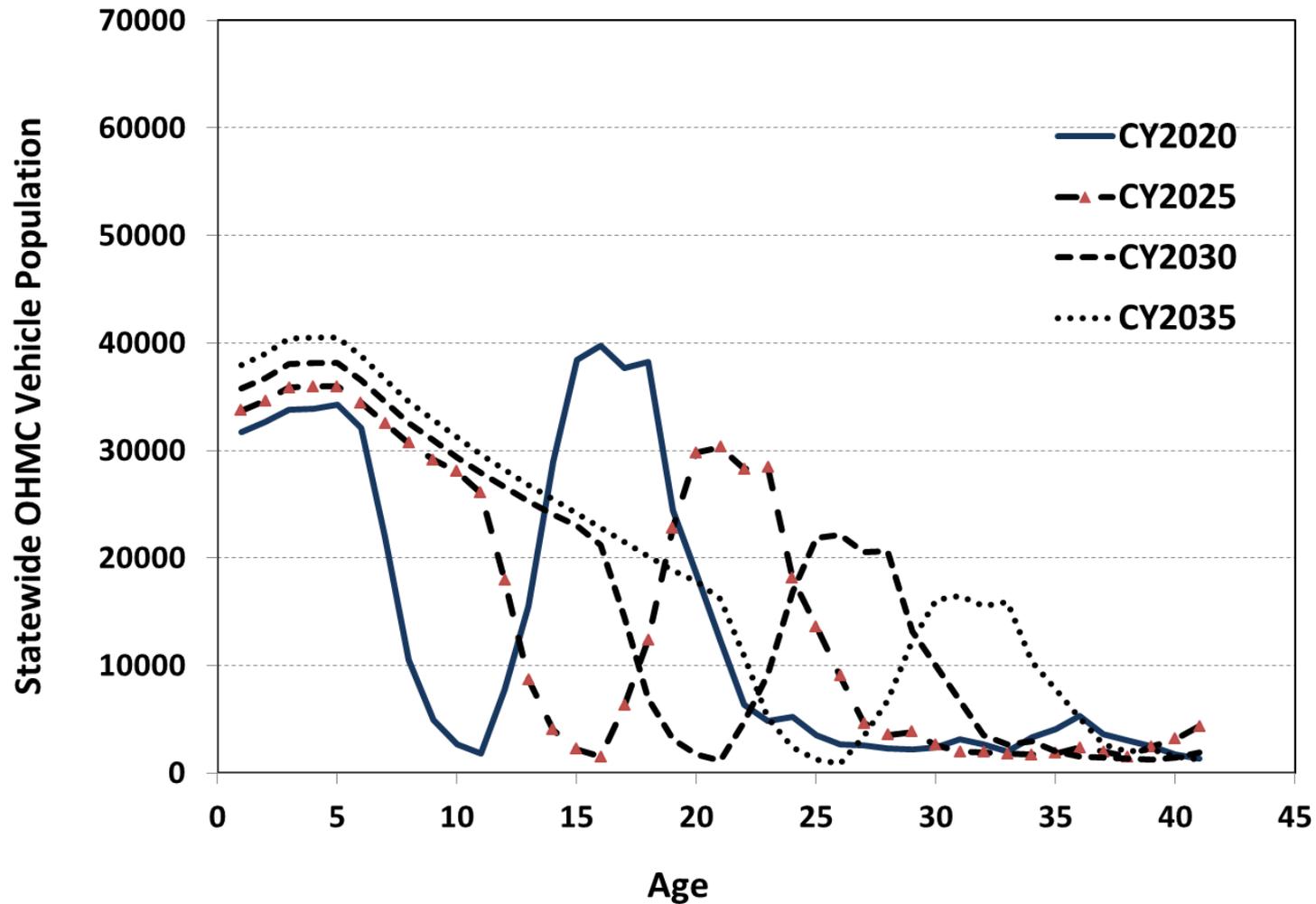
Age Distribution of OHMC (1990 to 2000)



Age Distribution of OHMC (2005 to 2015)



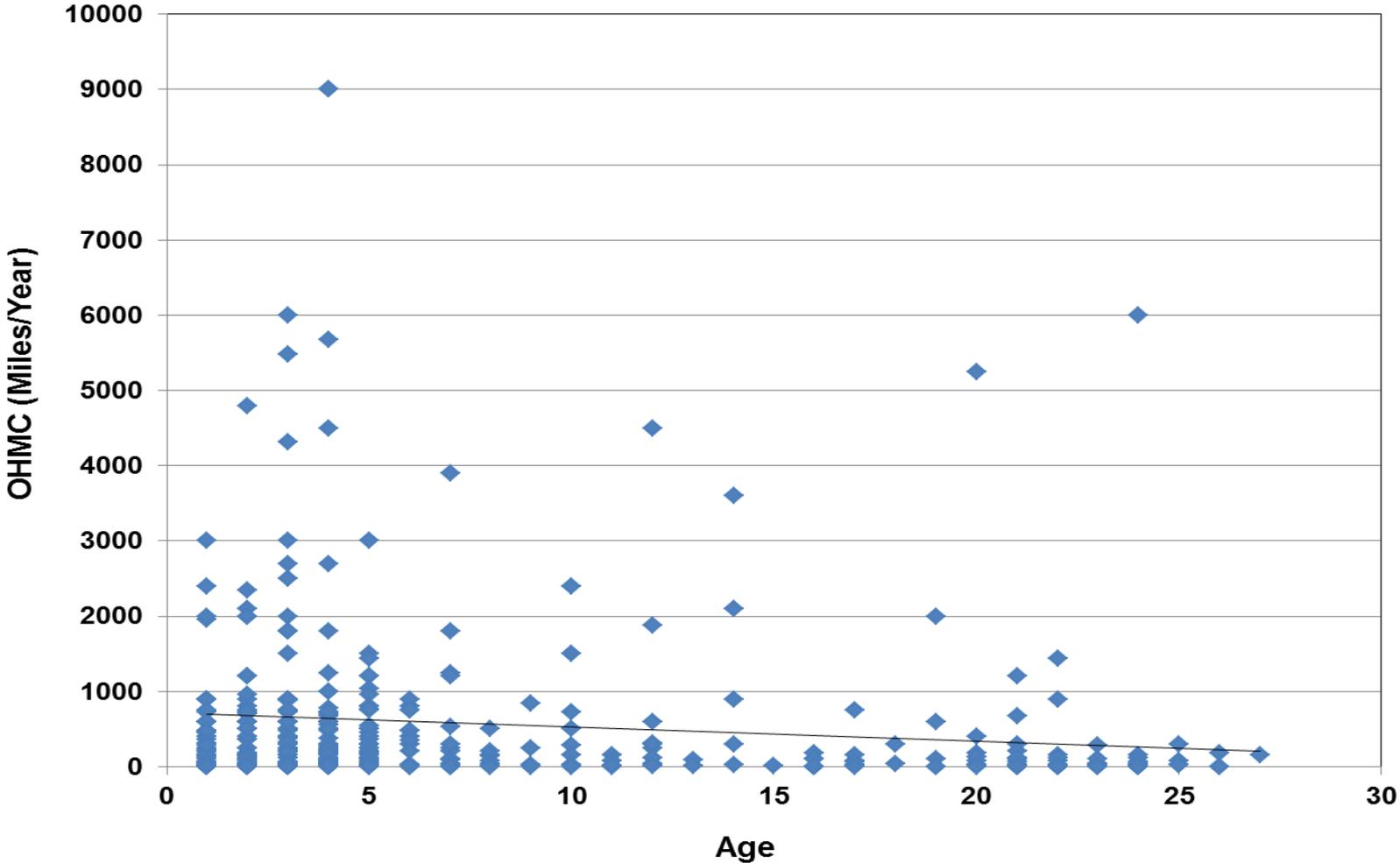
Age Distribution of OHMC (2020 to 2035)



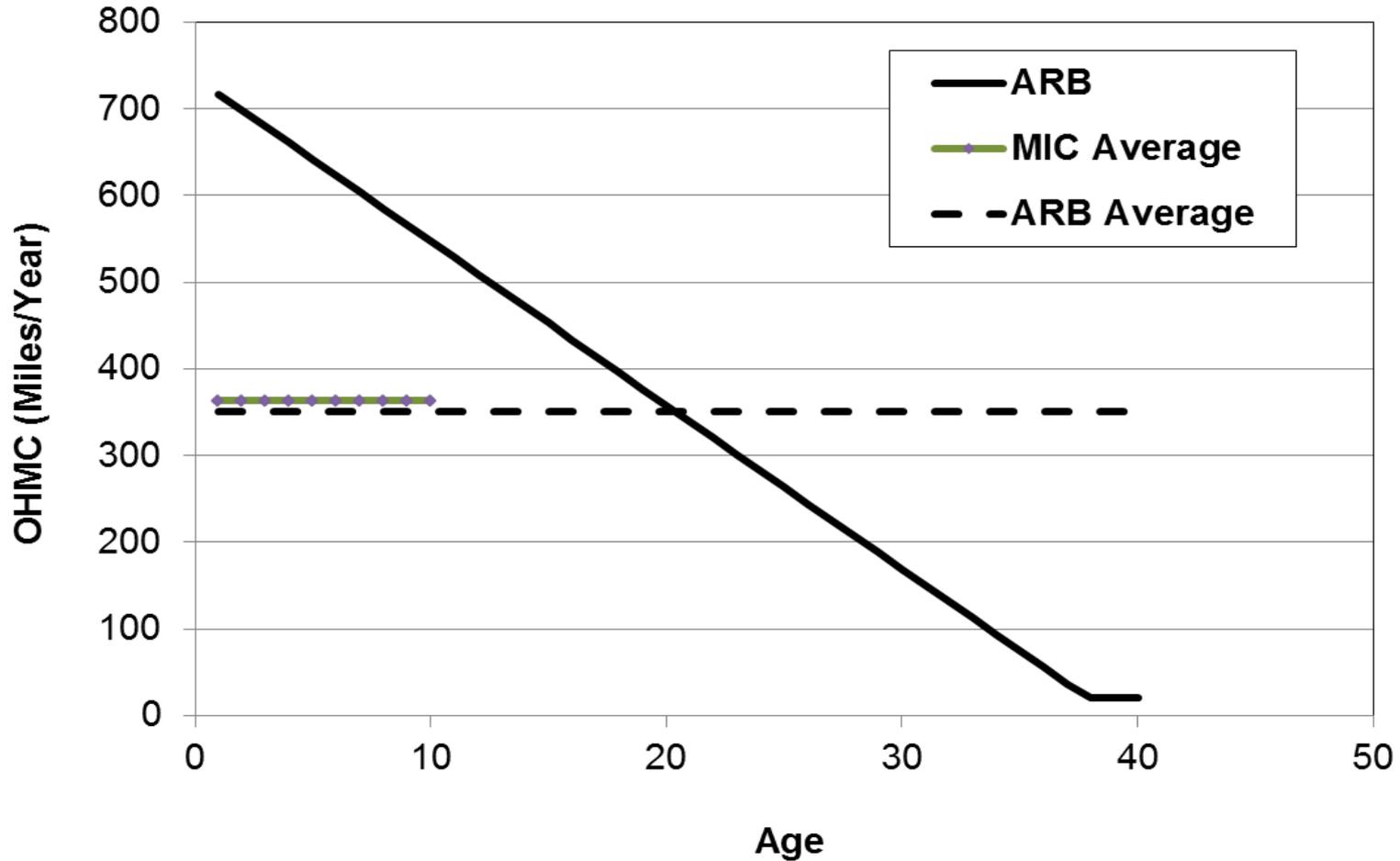
Inputs: Activity

- Activity (hours of operation or miles travelled/yr)
- Based on Broad 2009 Survey (n=1127)
 - Provides use frequency and area of operation
- Supplemented with
 - Information from internet user's forums
 - Used vehicle sales websites
- Activity Estimates
 - Decline with vehicle age
 - Are not assumed to change with economic trends

OHMC Survey Activity Data



OHMC Activity: ARB and MIC



Note: Average is defined as lifetime average (not weighted by VMT or population)

Inputs: Base Emission Factor (EF)

- Exhaust
- Evaporative
 - Vehicle in operation
 - Hot Soak (emissions after an engine is shut off)
 - Running (emissions while the engine is operating)
 - Vehicle in storage
 - Diurnal (emissions driven by the rising ambient temperature)
 - Resting Loss (emissions driven by the declining ambient temperature)

Inputs: Base Exhaust Emission Factors

- Based on OFFROAD2007
- Updated specialty vehicles and golf carts for consistency with ATV emissions
- CO2 adjustment to reflect real-world emissions
 - Adjustment not applied to criteria pollutants

Exhaust EF (zero hour)

Vehicle Type	Tech Group	HP	Model Year	HC	CO	NOX	PM	CO2
OHMC (g/mile)	G2	All	All	34.2	54.1	0.01	0.42	79.58
	G4	All	1997 and before	3.59	39.1	0.49	0.06	79.58
			1998 and later	0.68	19.8	0.64	0.06	79.58
ATV (g/mile)	G2	All	All	34.2	54.1	0.01	0.42	109.63
	G4	All	1997 and before	3.59	39.1	0.49	0.06	109.63
			1998 and later	0.68	19.8	0.64	0.06	109.63
Mini Bike (g/mile)	G2	All	All	34.2	54.1	0.01	0.42	79.58
	G4	All	1994 and before	24.25	488.10	2.03	0.71	79.58
			1995-1998	8.68	300	2.8	0.75	79.58
			1999 and later	0.47	100	2.7	0.25	79.58
Snowmobile (g/bhp-hr)	G2	All	2005 and before	140.7	385.1	0.54	2.3	615
			2006	89.75	246.1	0.54	2.3	615
			2007-2009	74.5	205	0.54	2.23	615
			2010 and later	55.9	205	0.54	1.57	615
	G4	All	All	3.5	59.3	6.57	0.2	615
Golf Cart & Specialty Vehicle (g/bhp-hr)	G2	0 - 5	All	92	145.5	0.03	1.13	446.2
		>5	All	63.27	100.09	0.02	0.78	446.2
	G4	0 - 5	1997 and before	14.6	159.1	2.6	0.24	446.2
			1998 and later	2.77	80.59	1.99	0.24	446.2
		>5	1997 and before	6.64	72.33	1.18	0.11	446.2
			1998 and later	1.26	36.63	0.91	0.11	446.2

Note that CARB and FI are included in both G2 and G4

Inputs: Base Evaporative Emission Factors

- Updated with new test data including hot soak, running loss, diurnal and resting loss
 - 2003 ATL study
 - ATV (n=4) and OHMC (n=4)
 - 65 to 105 F
 - Phase-II Reformulated Gasoline
 - 2009 limited ARB in-house test data
 - ATV (n=5) and OHMC (n=9)
 - 72 to 96 F and 65 to 105 F
 - Phase-III Reformulated Gasoline
- No deterioration assumed

Evaporative Emission Factors

Vehicle Type	Model Year Group (all Tech Group)	Hot Start (g/event)	Diurnal (g/day)	Resting (g/day)	Running Loss (g/mile)
OHMC	2007 and before	3.12	12.23	6.59	1.07
	2008 and after	2.37	9.29	5.01	0.81
ATV	2007 and before	1.28	6.93	3.73	1.08
	2008 and after	0.97	5.26	2.83	0.82
Mini Bike	2007 and before	3.12	12.23	6.59	1.07
	2008 and after	2.37	9.29	5.01	0.81
Snowmobile*	2007 and before	1.46	8.74	4.71	1.25
	2008 and after	1.11	6.64	3.58	0.95
Golf Cart & Specialty Vehicle*	All	1.23	1.26	0.71	0.34

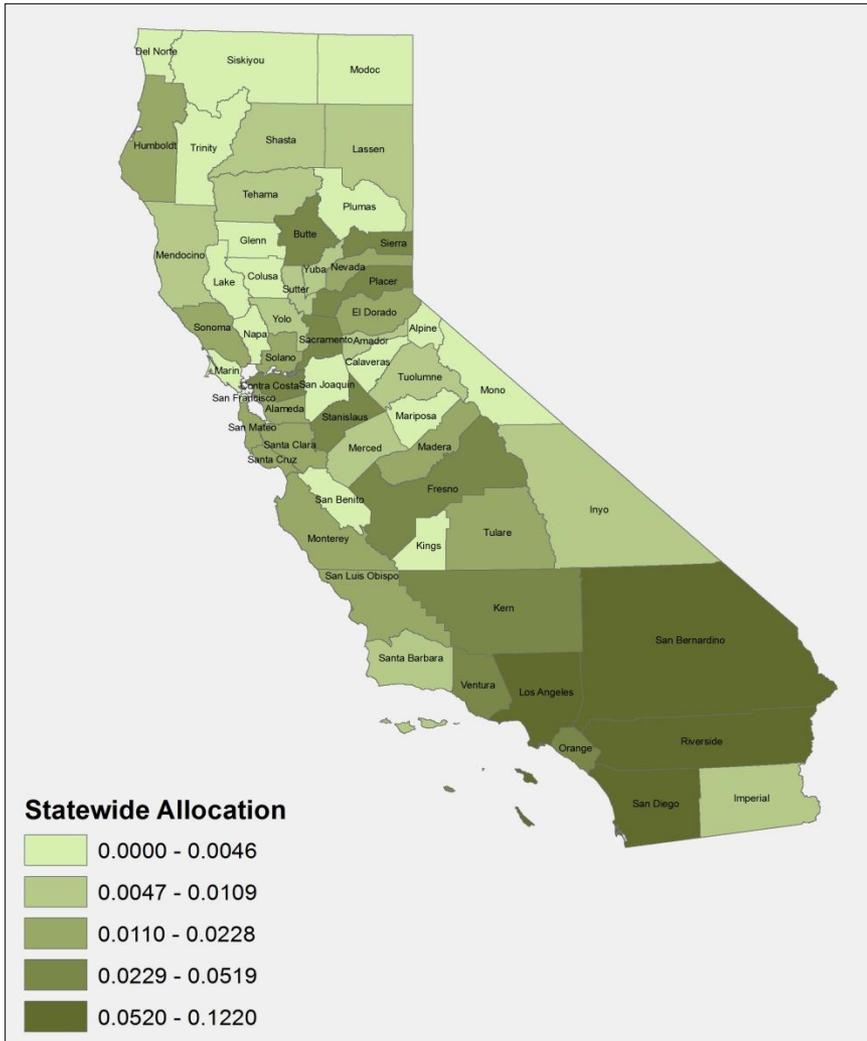
*running loss in g/bhp-hr

Inputs: Regional Allocation and Corrections

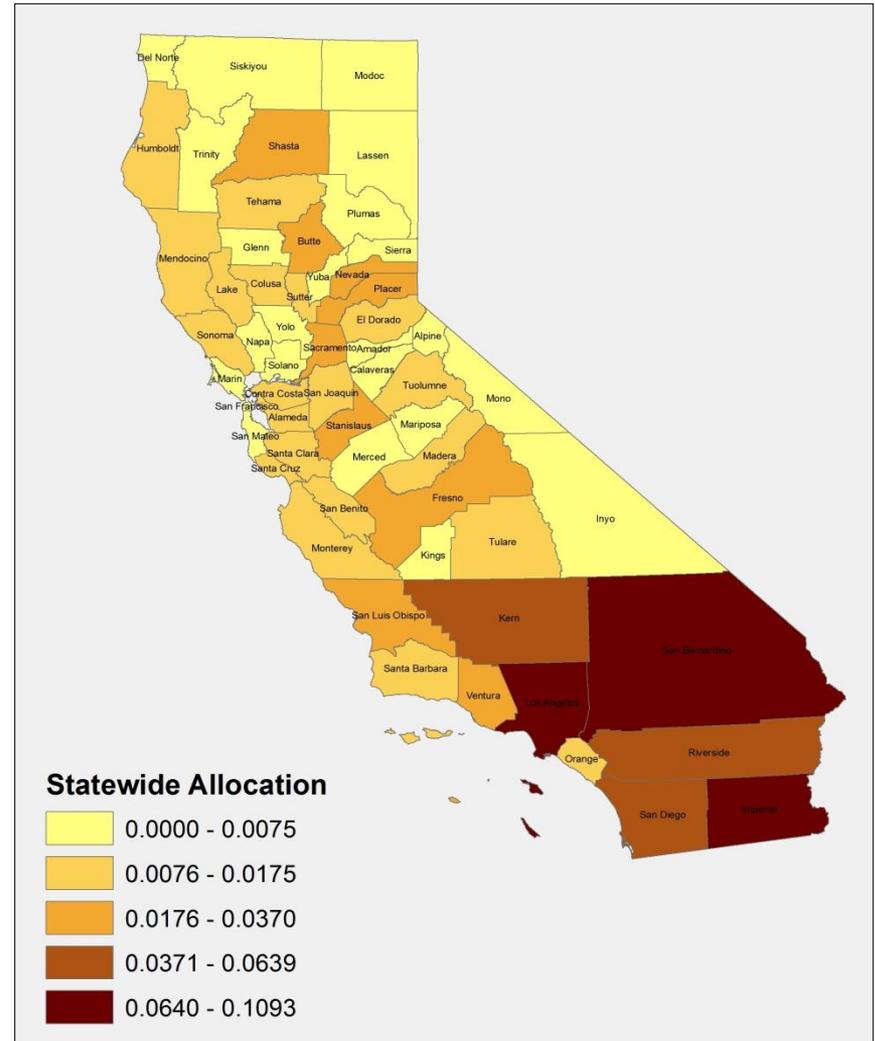
- Spatial Allocation
 - Area of operation (exhaust, hot soak, running loss)
 - Area of storage (diurnal and resting loss)
- Emission factor corrections based on regional climate conditions
 - Exhaust temperature and RH
 - Evaporative Temp and RVP
 - Garage Correction
 - Weathering correction for inactive vehicles
 - Red/Green Sticker program benefits

Spatial Allocation (OHMC)

Area of Storage



Area of Operation



Inputs: Emission Factor Corrections

- Region-Specific Exhaust Emissions
 - Correction for ambient temperature and relative humidity
- Region-Specific Evaporative Emissions
 - RVP correction for hot soak and running loss
 - Temperature/RVP correction for diurnal and resting

Inputs: Garage Correction

- Most recreational vehicles are stored in garages which experience less temperature gradients than ambient temperature
- Diurnal and resting loss emissions are adjusted to estimated garage temperatures
- For example
 - A 65-82 F ambient temperature equates to a 71-80 F garage temperature

Inputs: Weathering Correction on Inactive Vehicles

- Inactive recreational vehicles are assumed to generate diurnal and resting emissions only
 - Over the year, tank fuel vapor pressure will decrease as higher ends volatilize first
- Staff estimated weathering effect by modeling of the mass balance and vapor-liquid equilibrium
- Annual diurnal and resting loss from inactive vehicles are assumed to be about half (53%) as much as active vehicles

Inputs: Rule Scenario

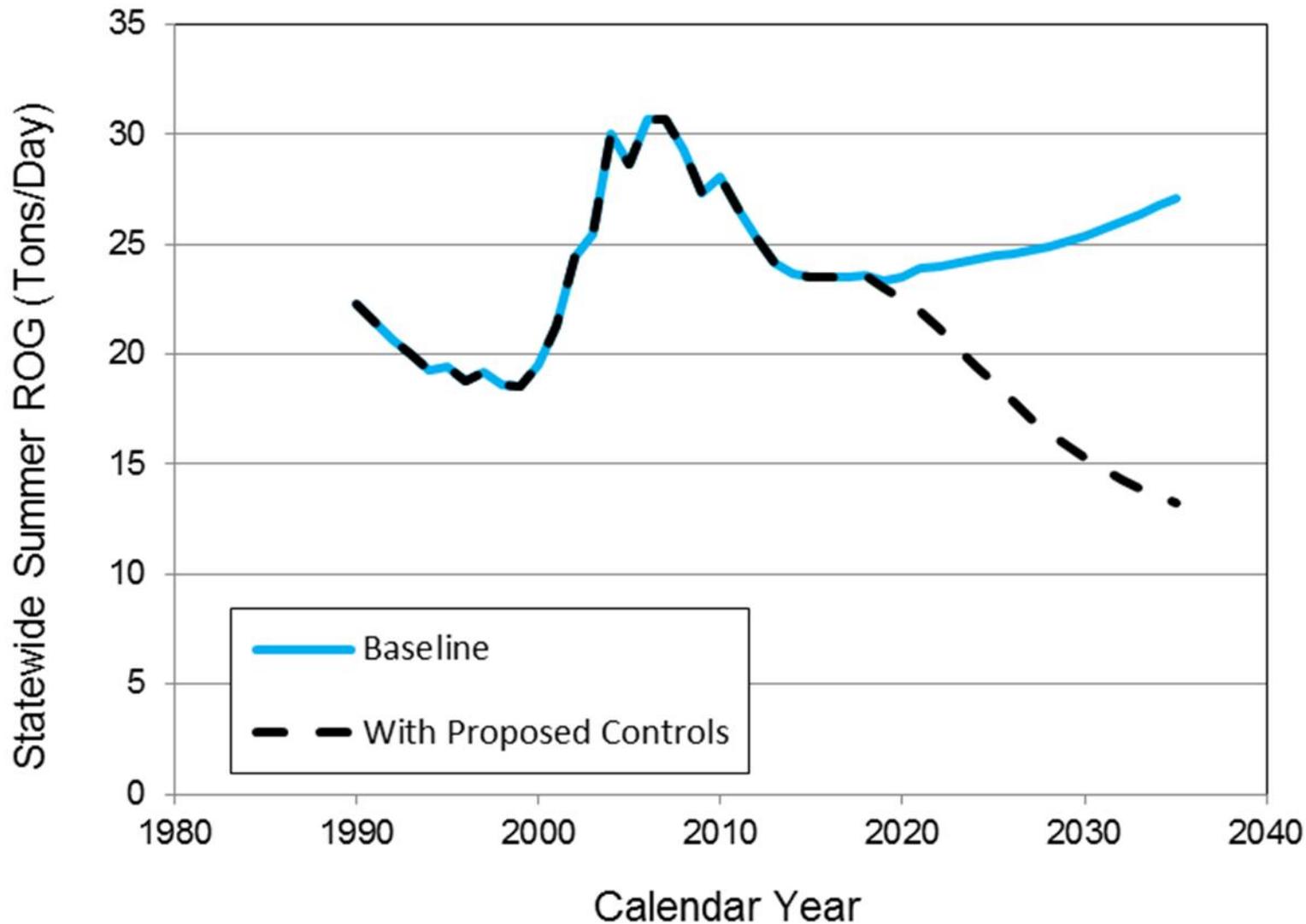
- Proposed lower evaporative emissions standard

Evaporative Process	New Standards	Proposed Emission Factor (THC)	Unit
Diurnal and Resting Loss	1.0 g TOG	0.89	g/day
Hot Soak	0.6 g TOG	0.35	g/event
Running Loss	0.6 g TOG	0.07	g/mi

Note that $THC = TOG / 1.1248$

- Phase in schedule: 2018 (33%), 2019 (67%) and 2020 (100%)

ROG Benefit with Proposed Rule (Statewide, Summer)



Summary of Benefits from Proposed Rule (tons/day)

2020	Baseline		Proposed Rule		Proposed Benefit	
	ROG	NOx	ROG	NOx	ROG	NOx
Statewide	23.5	1.0	22.6	1.0	1.0	0
SJV Unified APCD	2.9	0.1	2.8	0.1	0.1	0
South Coast AQMD	6.2	0.8	6.0	0.8	0.3	0

2025	Baseline		Proposed Rule		Proposed Benefit	
	ROG	NOx	ROG	NOx	ROG	NOx
Statewide	24.5	1.1	18.7	1.1	5.8	0
SJV Unified APCD	3.1	0.1	2.3	0.1	0.8	0
South Coast AQMD	6.6	0.9	4.8	0.9	1.8	0

2030	Baseline		Proposed Rule		Proposed Benefit	
	ROG	NOx	ROG	NOx	ROG	NOx
Statewide	25.4	1.2	15.3	1.2	10.2	0
SJV Unified APCD	3.2	0.1	1.8	0.1	1.3	0
South Coast AQMD	6.9	0.1	3.8	0.1	3.1	0

Next Steps

- Please provide comments:
 - David Chou (cchou@arb.ca.gov)
- Staff Report Release (6/5/13)
 - Inventory release (documentation and model)
- Board Hearing (7/25/13 to 7/26/13)