

Gasoline and Diesel Options for Southeast Michigan

Regional Air Quality Workshop

March 8, 2004

Air Improvement Resource, Inc.

Project Sponsors

- SEMCOG
- Alliance of Automobile Manufacturers
- American Petroleum Institute

Status of Project

- Final Report Issued February 24

Why?

- 8 counties originally designated as Moderate 8-hour nonattainment area
- Received reclassification from EPA as Marginal
- SEMCOG committed to attaining 8-hour standard as soon as possible (attainment deadline is June 2007)
- SEMCOG evaluating non-fuel options as well

Current Fuel Requirements

- Gasoline
 - Volatility: 7.8 psi in summer months (local program)
 - Ethanol volatility waiver
 - No MTBE (statewide beginning in 2003)
- Diesel
 - No local or state specifications
 - Subject to federal requirements for sulfur content for on- and off-highway diesel

Baseline Gasoline in 2006, SE Michigan

- 7.8 RVP, with ethanol waiver
- 30 ppm sulfur
- Current ethanol market penetration of about 25%, with average concentration of 9.5%
- Note: all emission changes in this study are compared to this baseline, and as such, are not necessarily applicable to other states unless the baseline is very similar to Southeast Michigan baseline

Gasoline Options as Defined in This Study

- Federal RFG with ethanol (E10)
- Federal RFG without ethanol
- California RFG (E6)
- California RFG without ethanol
- Lower sulfur (10 ppm average)
- Lower RVP (7.0 psi)
- Lower RVP with higher T50
- Ethanol (E10) coverage (0, 100%), with current waiver
- *(Lower sulfur, and RVP modeled with current ethanol market penetration and RVP waiver)*

Notes on Gasoline Options

- Fed RFG w/o ethanol and Ca RFG, with or w/o ethanol, are not assumed to meet toxic requirements of RFGs
- RFG w/o Oxygen is technically not “RFG” according to 1990s CAAAs
- Several of these study gasolines have not been implemented by any other state:
 - Lower sulfur
 - No ethanol

Diesel Options

- Cetane Program
 - Average cetane number of 50
- CARB Diesel
- Biodiesel
 - 5% and 20% biodiesel
- Retrofits
 - 3 levels of on-highway retrofits

Scope

- Assume 2006 implementation
- Take into account other EPA programs (Tier 2, lower sulfur, 2007 HD, etc.)
- Evaluate 2007-2020
- VOC, CO, NO_x, PM
- Assume offroad fuel could also change
- Use latest techniques, and where there are differences, compare
- Include all known effects
 - increased permeation VOC emissions due to ethanol

Modeling Issues - Onroad

- No ethanol permeation effect
- MOBILE6.2 cannot be used to evaluate:
 - Sub 30 ppm gasoline sulfur content
 - California RFG
 - Diesel fuel programs
- No NO_x increase due to ethanol in MOBILE6.2
 - EPA COMPLEX model also has no NO_x increase due to ethanol
 - ARB Predictive Model does have NO_x increase due to ethanol for all 1988 and later vehicles
- Both ARB and EPA do agree that there is a ethanol related NO_x increase for 1988-1995 vehicles

Modeling Issues - Nonroad

- No ethanol permeation effect
- Model currently only contains diurnal emissions
 - 1 g/gal/day
 - No hot soak, running, resting losses
 - EPA plans to release update later this year (I think)
 - Model contains RVP corrections for existing diurnal
- Portable containers must be modeled outside of NONROAD
 - Permeation and volatility effects
- NONROAD does correct for ethanol's effect on exhaust emissions
- No need to use Complex or Predictive with NONROAD, because these sources have relatively simple emission controls

Approaches

- Ethanol VOC permeation
 - use techniques developed in AIR's study of ethanol permeation for API
- Other evap (hot soak, running loss, diurnal, non-ethanol permeation)
 - use MOBILE6.2/NONROAD to estimate other non-ethanol permeation evap effects (e.g., effects of lower volatility on running losses, etc.)
- Gasoline Exhaust
 - Utilize EPA COMPLEX model and ARB Predictive Model to determine gasoline effects on exhaust emissions
 - Use NONROAD directly
- Diesel Exhaust
 - Utilize EPA guidance methodologies

Gasoline Methods

- Determine “expected” gasoline properties in SE Michigan post-Tier 2 sulfur for baseline and options
- Estimate baseline on-road and off-road exhaust and evap inventories
- Estimate % differences in exhaust emissions with COMPLEX and Predictive Models and apply to baseline exhaust
- Estimate evap inventory differences with MOBILE6.2 and NONROAD
- Estimate ethanol permeation effects and add separately

Table 15. Gasoline Properties Assumed for the 2006 and Beyond, Summer

Scenario	ETOH	ETOH Mkt %	ETOH Concen. Vol%	RVP psi	E200 %	E300 %	Arom. Vol %	Olef. Vol %	Ben Vol %	Sulfur Wt %
Baseline	Yes	25	9.4	8.7	50.7	81.8	28.5	7.2	1.2	0.0030
	No	75	0.0	7.6	44.5	79.6	32.9	8.6	1.5	0.0030
Ca RFG	Yes	100	6.0	6.9	45.5	87.9	23.0	4.0	1.2	0.0011
Ca RFG, w/o E6	No	0	0.0	7.2	47.0	88.4	22.7	5.5	1.2	0.0008
RFG	Yes	100	10.0	6.8	45.0	84.0	22.0	4.9	0.87	0.0030
RFG w/o E10	No	0	0.0	6.7	46.0	85.0	24.0	5.5	0.87	0.0030
Low Sulfur	Yes	25	9.4	8.7	50.7	81.8	28.5	7.2	1.2	0.0010
	No	75	0.0	7.6	44.5	79.6	32.9	8.6	1.5	0.0010
7 RVP	Yes	25	9.4	7.8	50.7	81.8	28.5	7.2	1.2	0.0030
	No	75	0.0	6.8	44.5	79.6	32.9	8.6	1.5	0.0030
7 RVP, 3 °F higher T50 (lower E200)	Yes	25	9.4	7.8	49.4	81.8	28.5	7.2	1.2	0.0030
	No	75	0.0	6.8	43.1	79.6	32.9	8.6	1.5	0.0030
No E10	No	0	0.0	7.6	44.5	79.6	32.9	8.6	1.5	0.0030
100% E10	Yes	100	9.4	8.7	50.7	81.8	28.5	7.2	1.2	0.0030

Table 16. RVP Levels and Oxygen Weight Percents Used in NONROAD

Case	RVP	Oxygen Vol % (wt%)
Baseline	7.87	2.4 (0.8)
Ca RFG	6.9	6.0 (2.0)
Ca RFG w/o E6	7.2	0.0 (0.0)
RFG	6.8	10.0 (3.4)
RFG w/o E6	6.7	0.0 (0.0)
Low RVP	7.05	2.4 (0.8)
No E10	7.6	0.0 (0.0)
100% E10	8.7	10.0 (3.4)

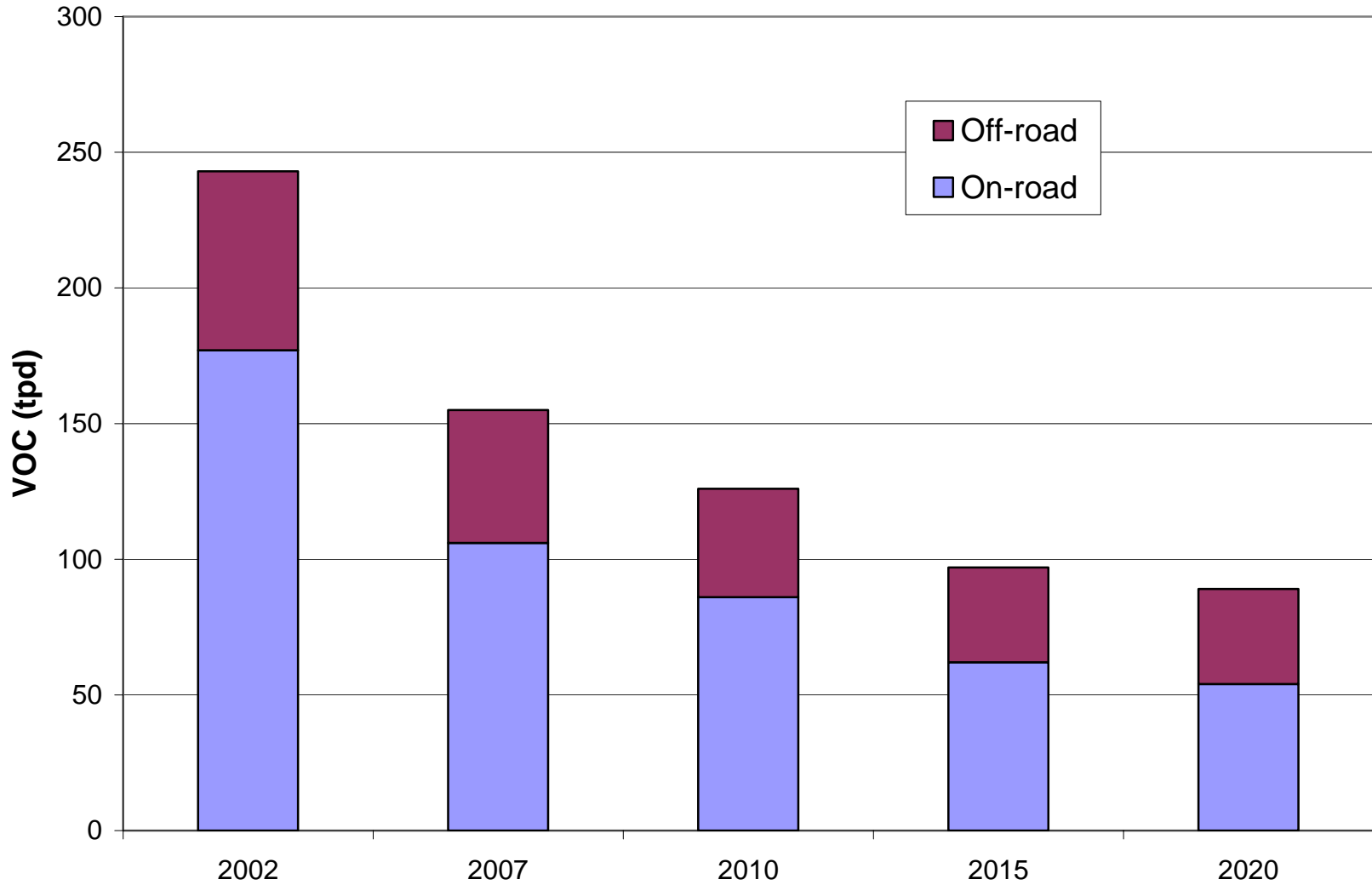
Diesel Methods

- On-highway baseline diesel based on Alliance Survey
 - Adjustments made to cetane and sulfur in 2006 to account for ULSD
- Off-highway baseline diesel assumed to be the same as on-highway except for cetane and sulfur
 - Cetane and sulfur adjustments made to reflect changes in off-highway diesel in 2006 and 2010
- Cetane, CARB diesel, and biodiesel programs follow EPA guidance, two programs modeled
 - On-highway only program
 - Both on- and off-highway program

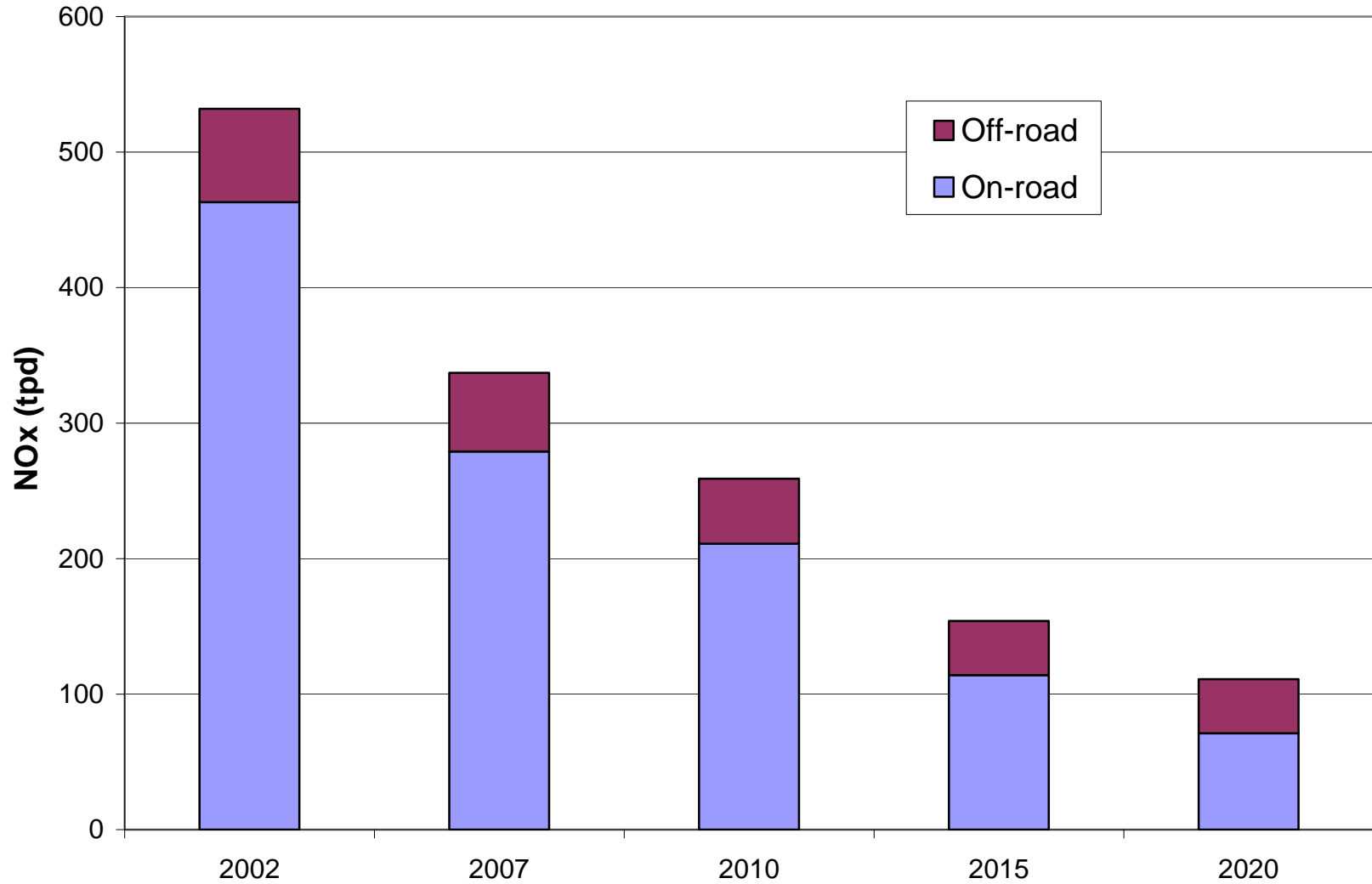
Diesel Retrofits

- Retrofit programs modeled based on currently certified technologies (on-highway only)
 - 3 levels of PM control (20%, 60%, 85%)
 - Technologies also result in HC and CO benefits

Trends in Baseline Mobile Source VOC Emissions



Trends in Baseline Mobile Source NOx Emissions



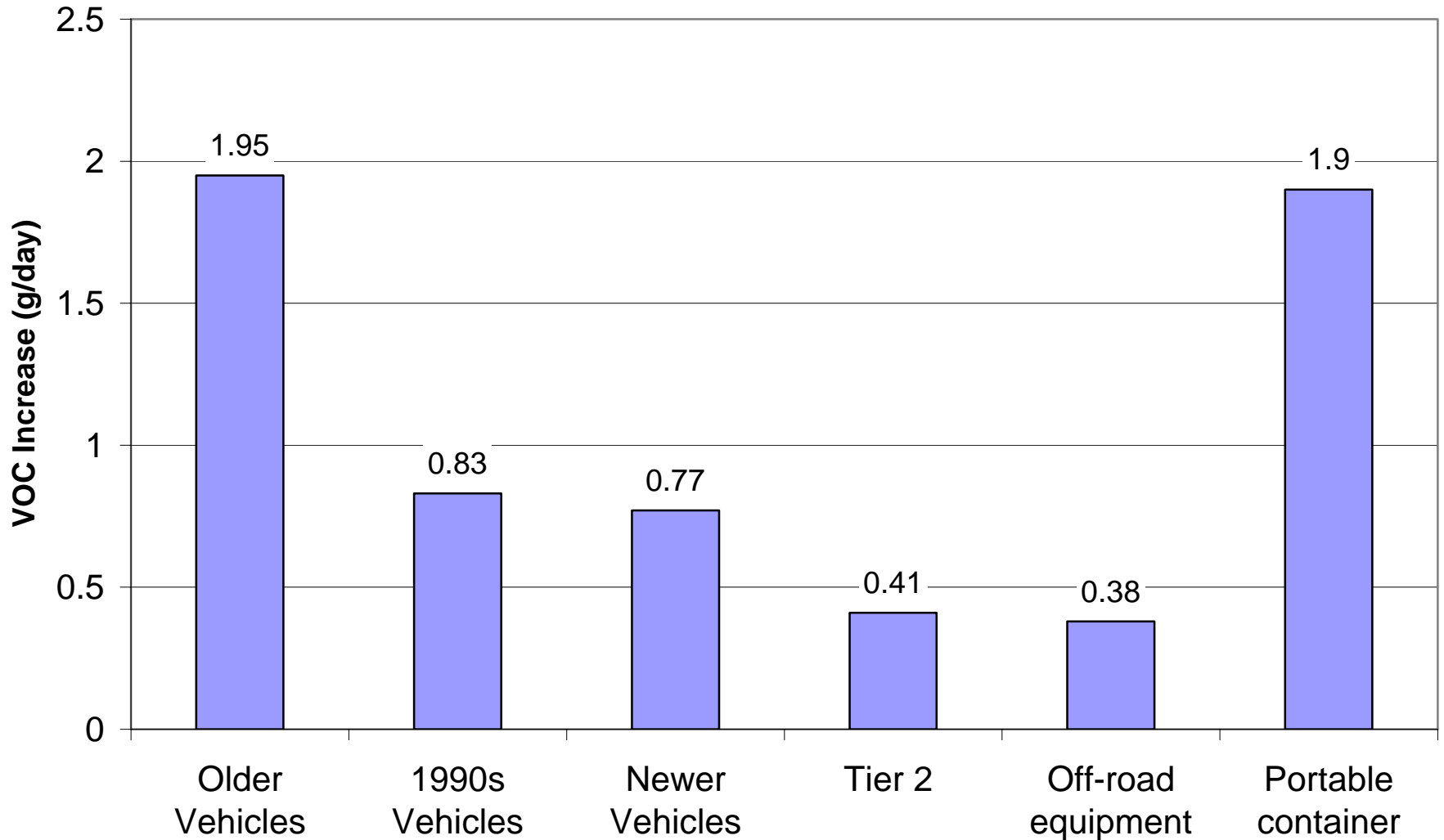
Gasoline Program Results

- Some uncertainty in projections due to different models producing different results
- All results in tons per summer day
 - Permeation
 - No permeation evap VOC
 - Total VOC evap with permeation
 - Exhaust VOC and NO_x
 - Total VOC and NO_x
 - CO

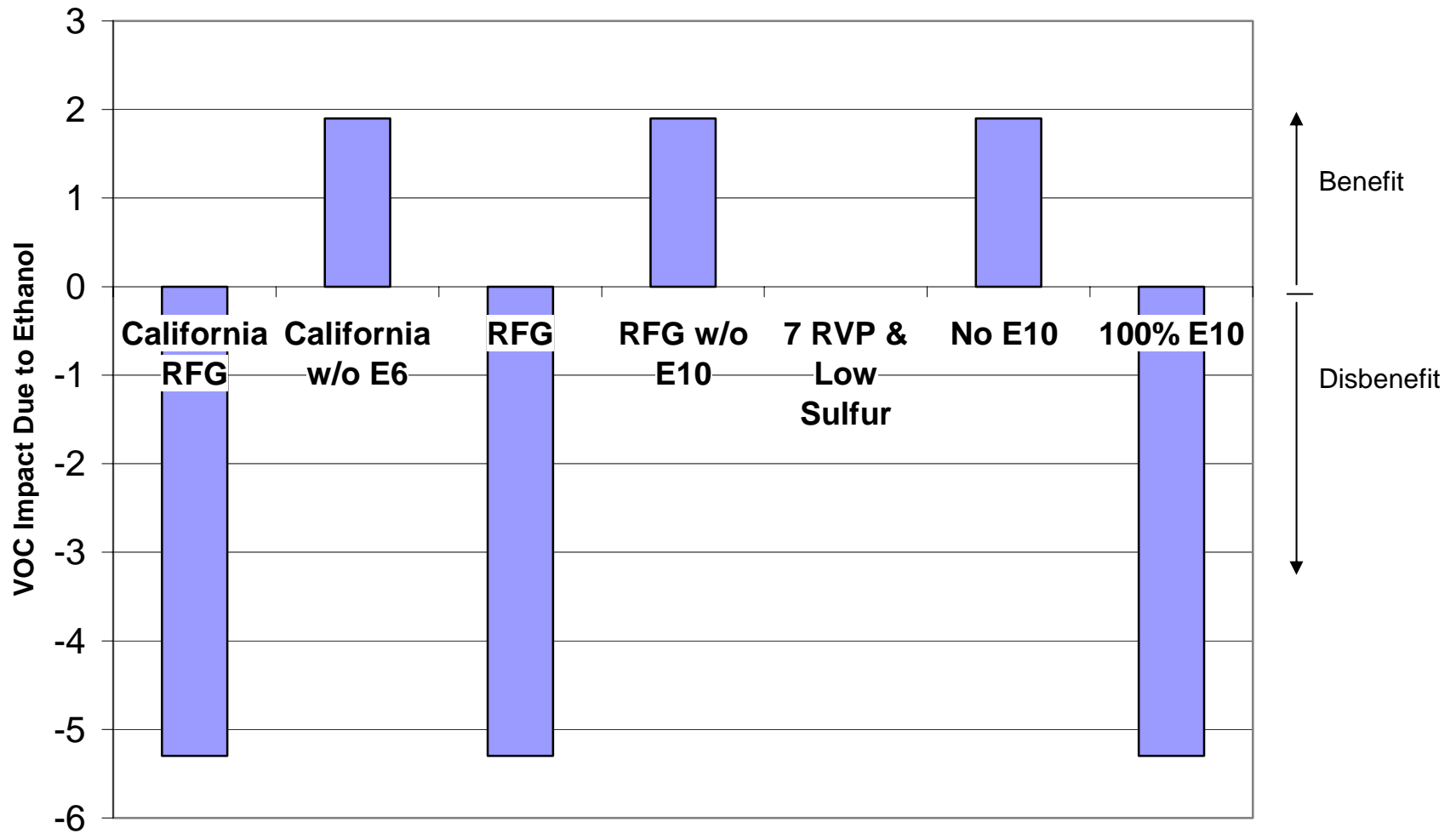
Permeation Due to Ethanol

- Affects on-road vehicles, off-road vehicles and equipment, and portable containers
- Based on tests using California's test temperatures (65-105), and 6% ethanol by volume
- Results are temperature-corrected to Michigan temperatures
- Total effect assumed to be proportional to ethanol market share

Increase in Permeation Due to Ethanol



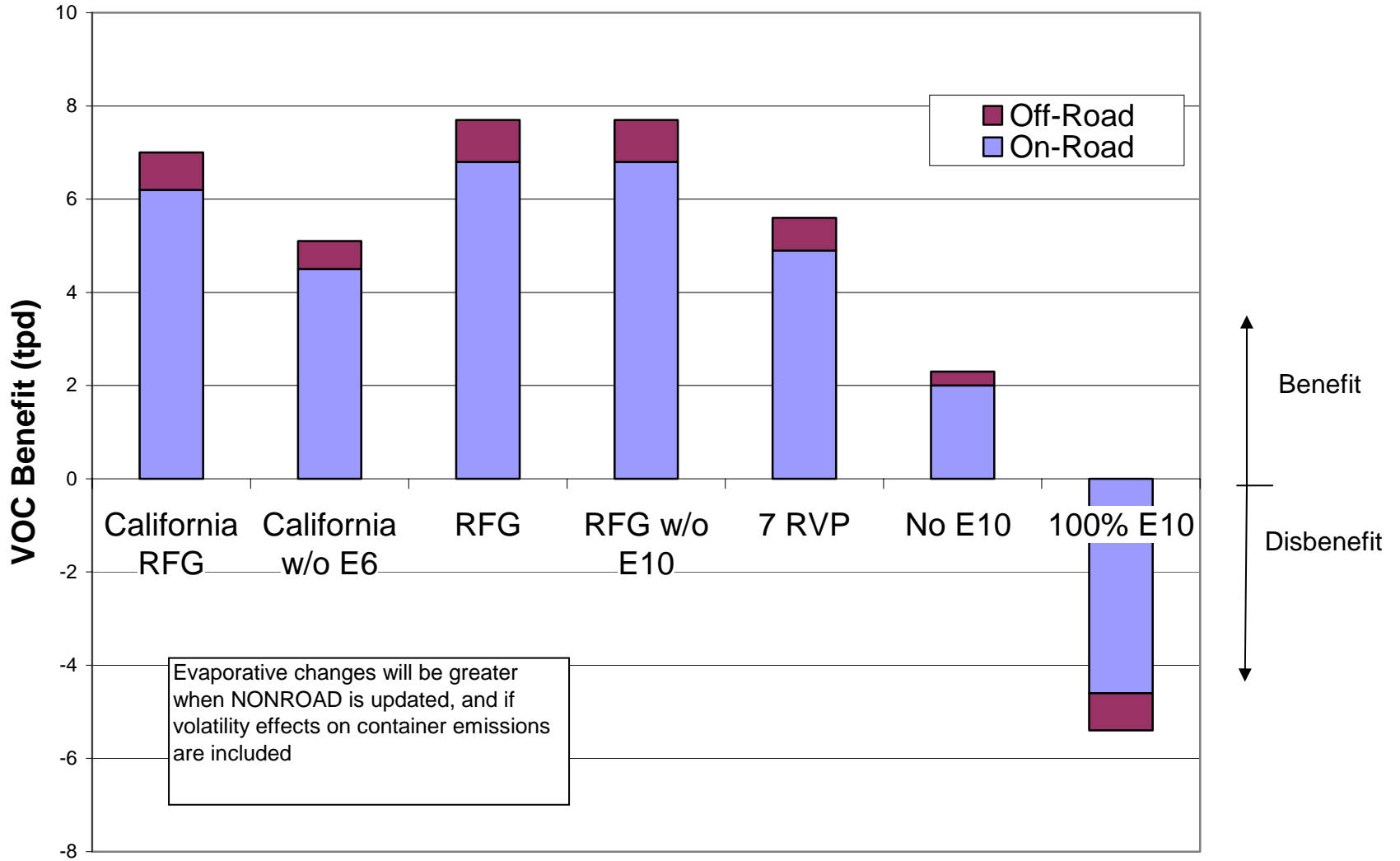
Ethanol Permeation Difference from Baseline - 2007 (tons per summer day)



Evaporative Benefits

- Shown for 2007
- Includes on-road and off-road vehicle effect shown
- Without ethanol permeation effects
- These reduce in future years as fleet turns over to vehicles with lower standards

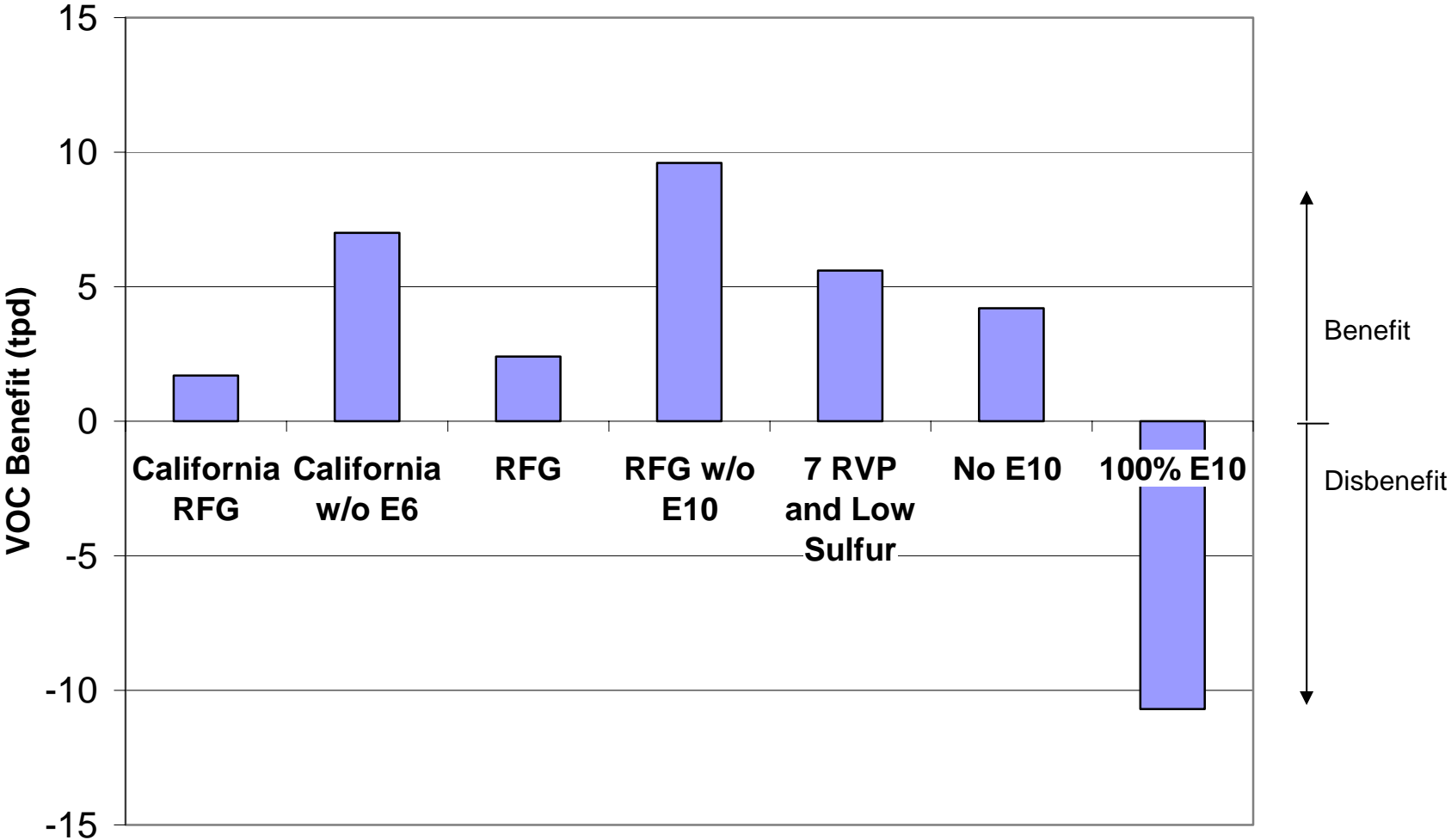
Evaporative Benefit in 2007



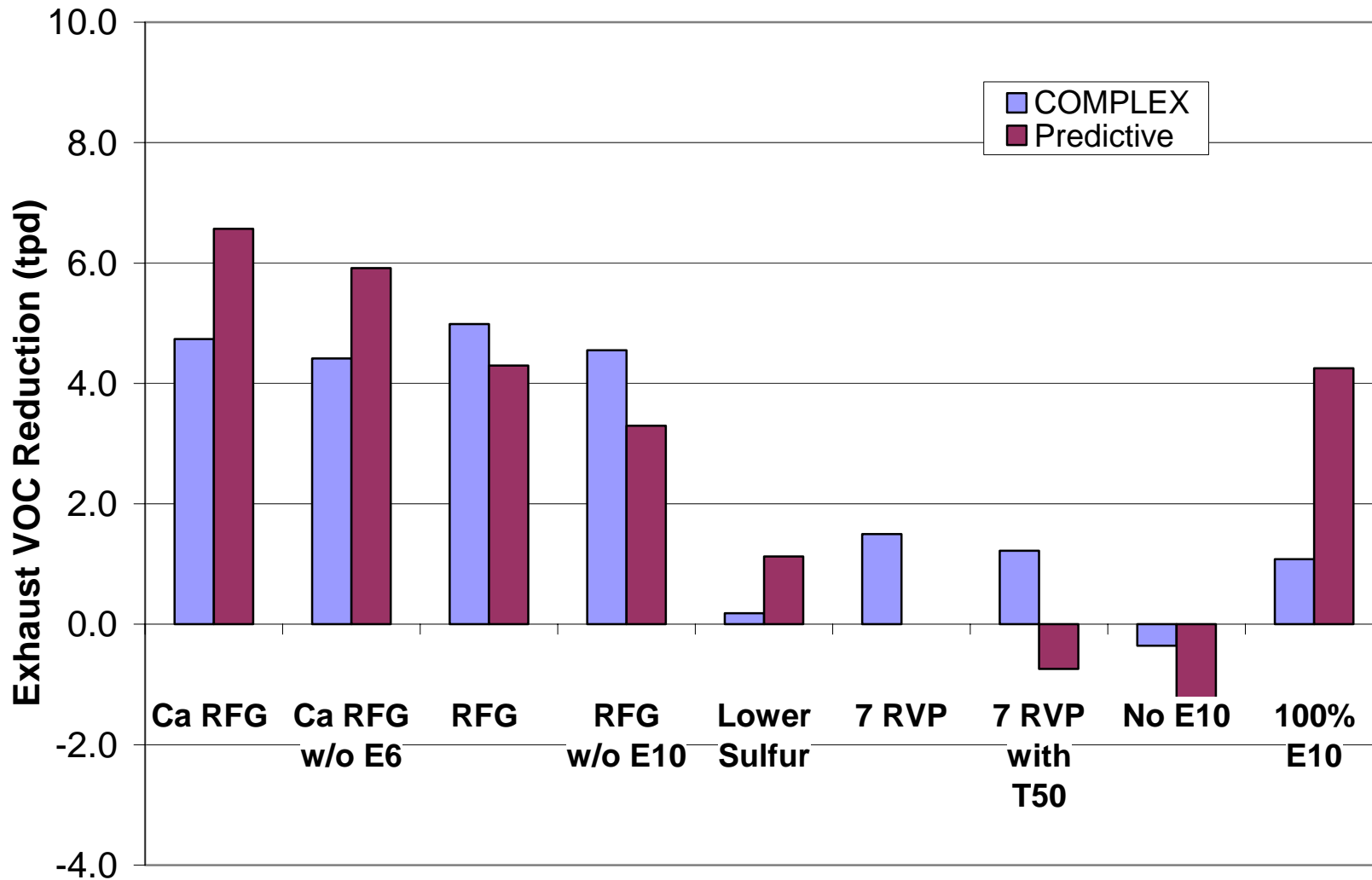
Evaporative Benefits With Ethanol Permeation

- Net evaporative benefits with ethanol permeation effects
- Evap benefit is estimated for on-road and off-road, permeation effects from all three sources
 - on-road
 - off-road equipment and vehicles
 - portable containers

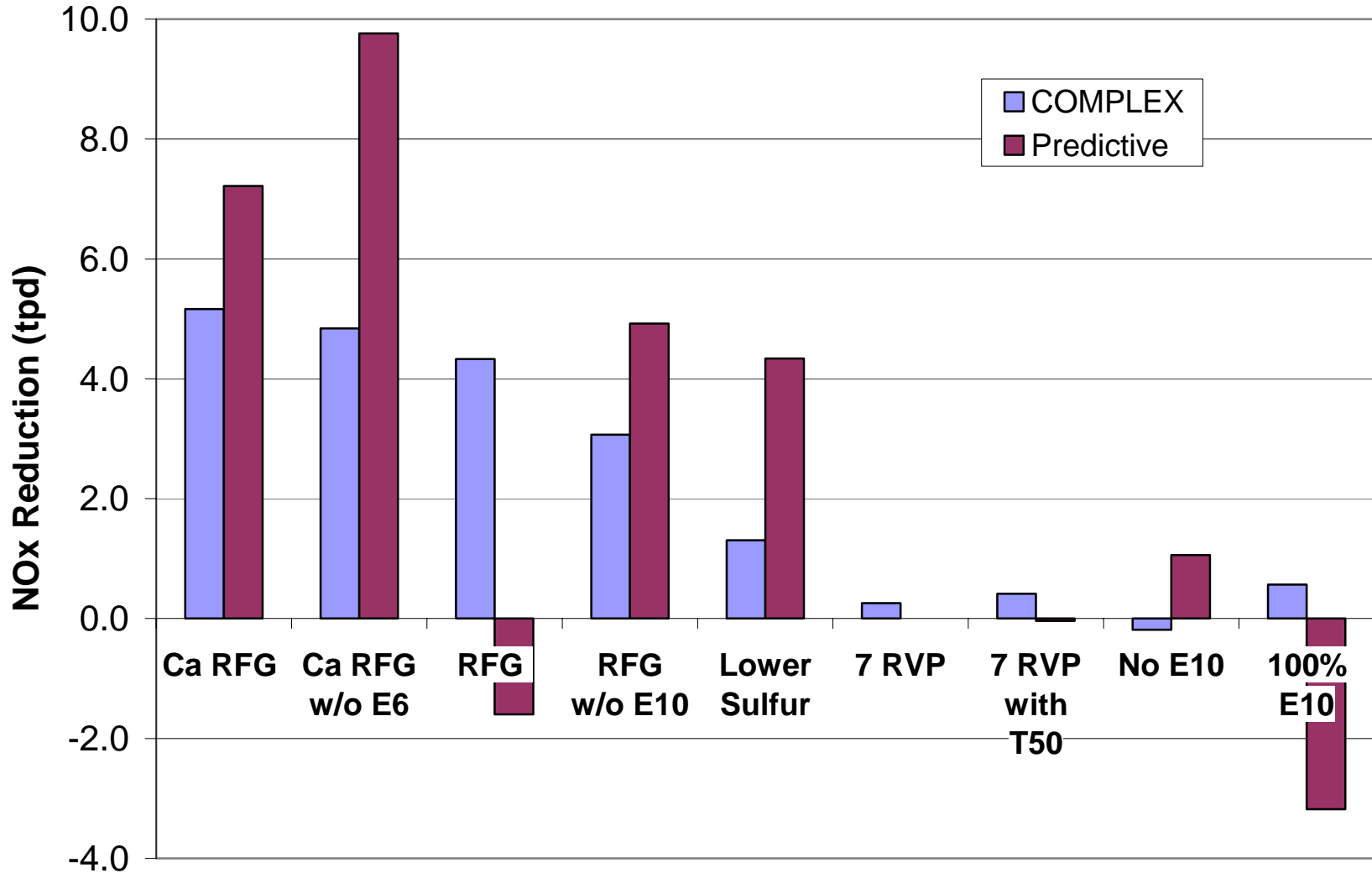
Net Evaporative Benefit in 2007 (tons per summer day)



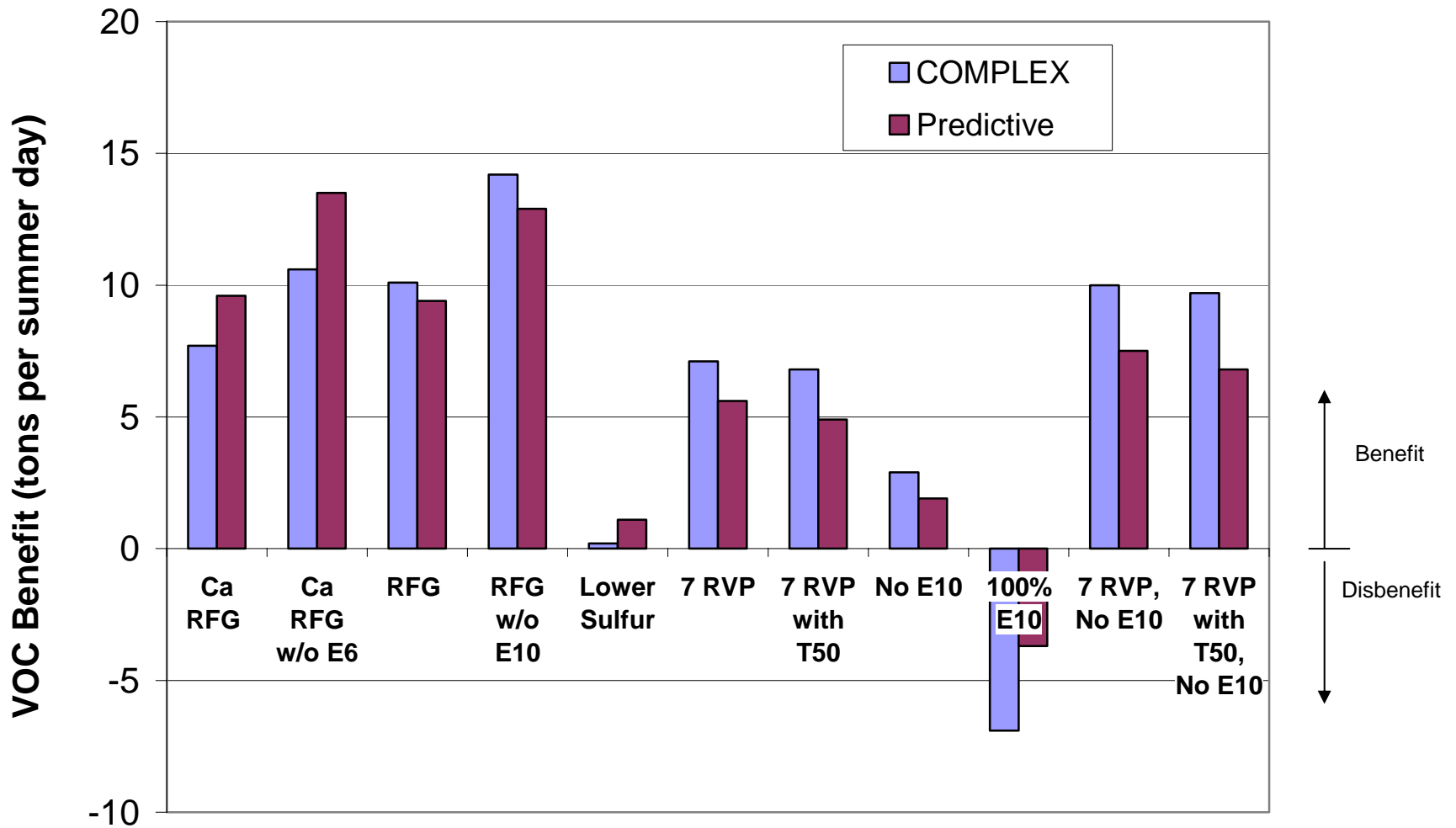
VOC Onroad Exhaust Inventory Reductions in 2007



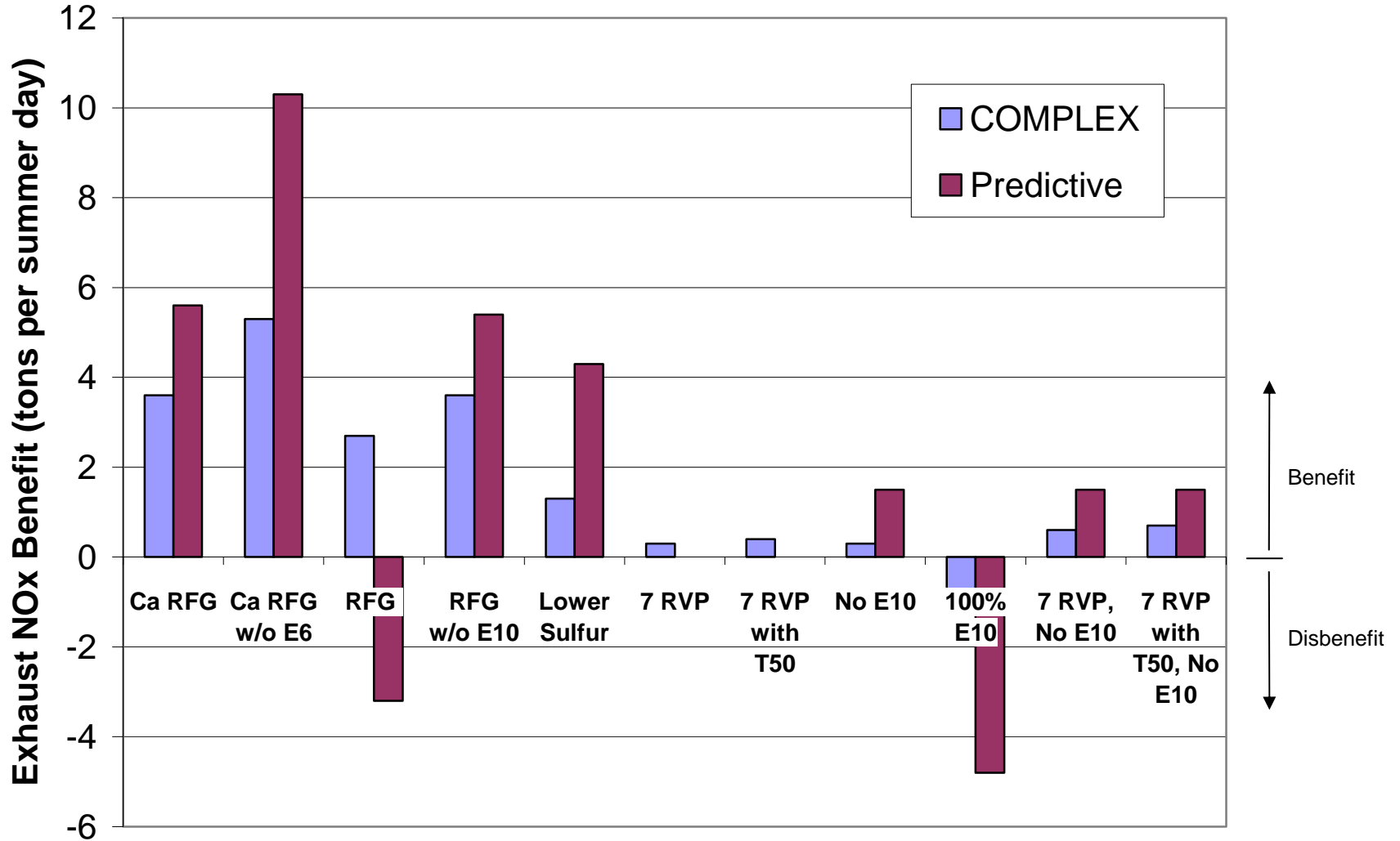
NOx Onroad Exhaust Inventory Reductions in 2007



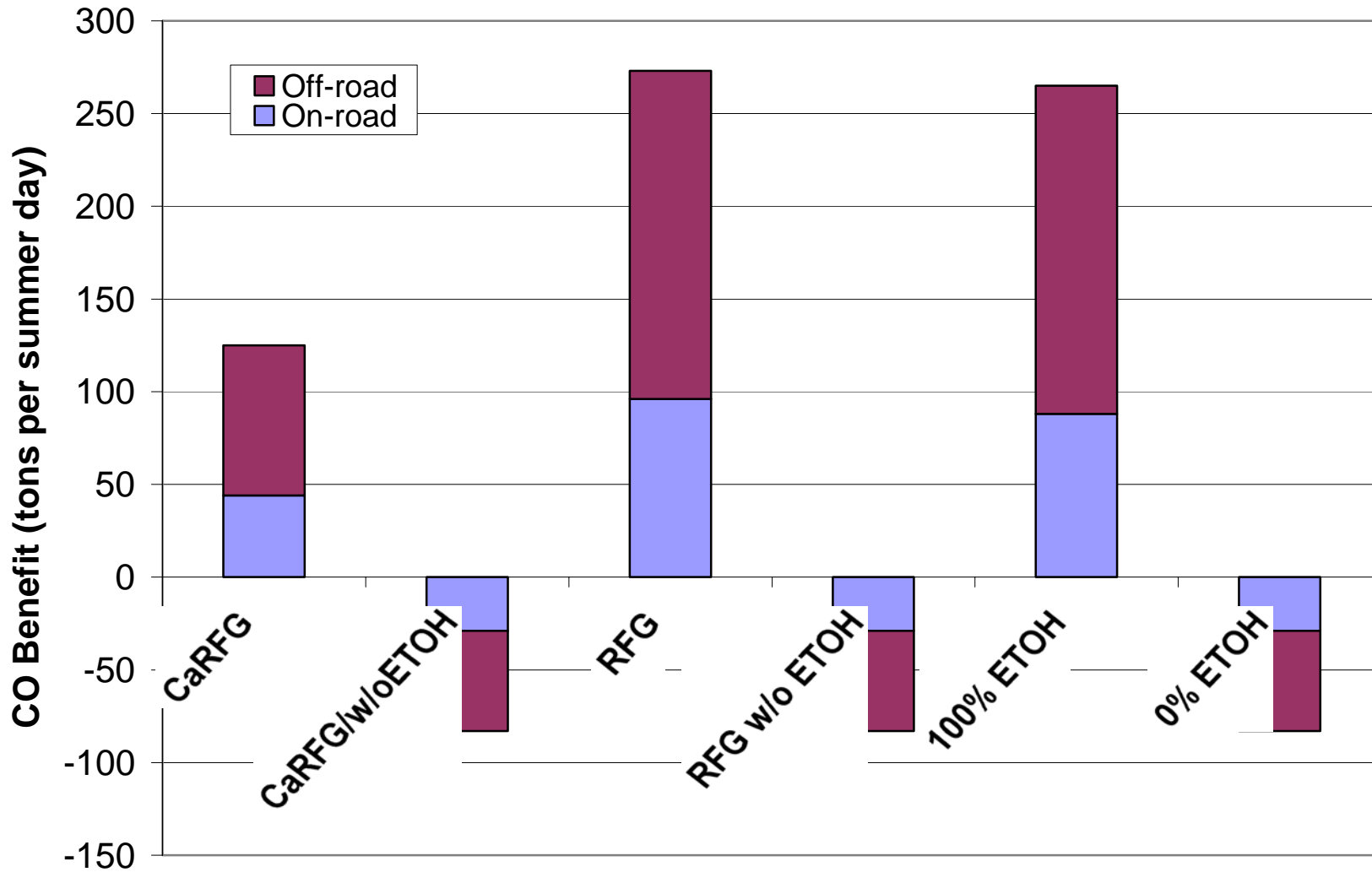
Net VOC Benefits in 2007 - All Sources (tons per summer day)



Net NOx Exhaust Benefits in 2007 - All Sources (tons per summer day)

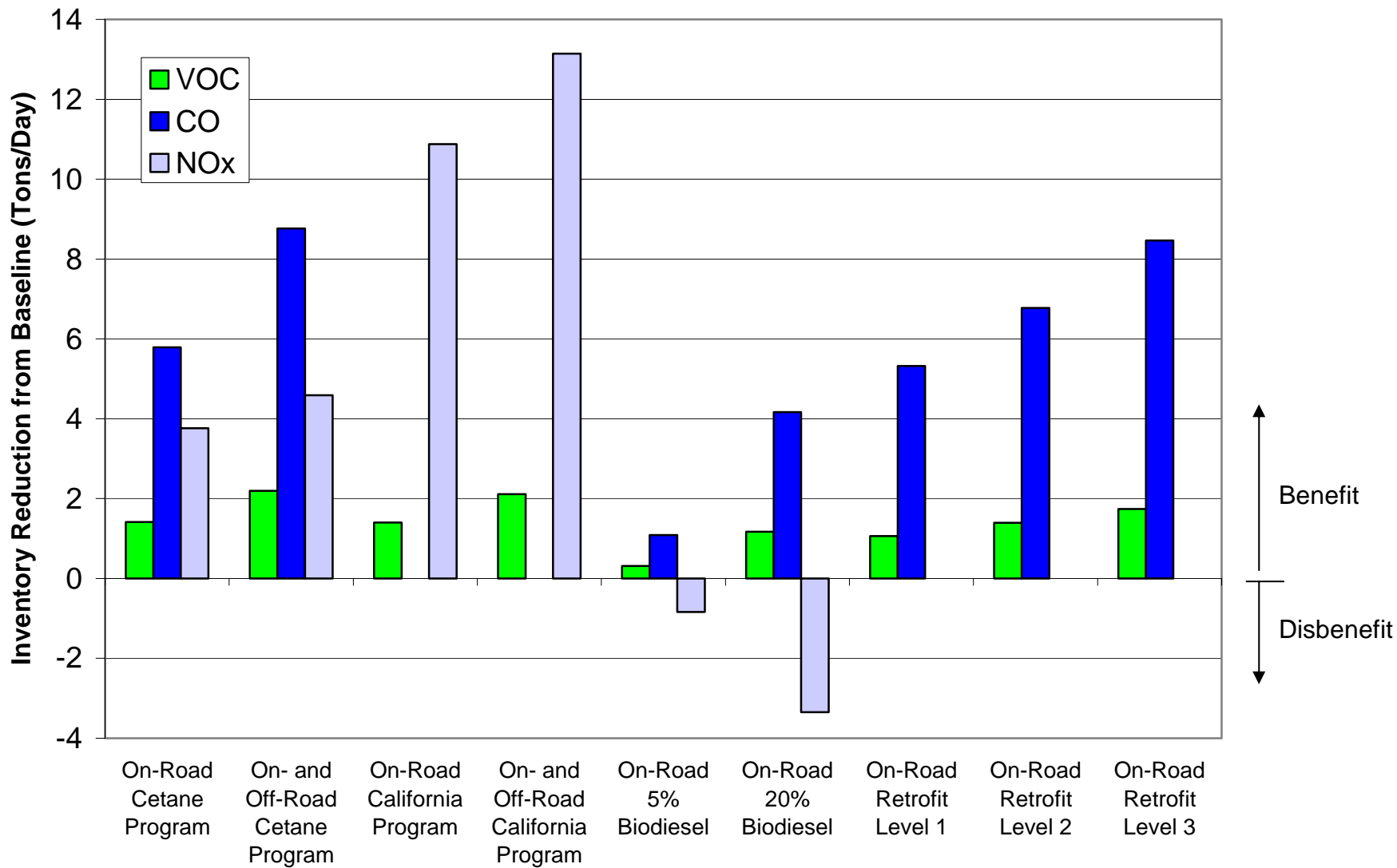


Net 2007 CO Benefits - All Sources

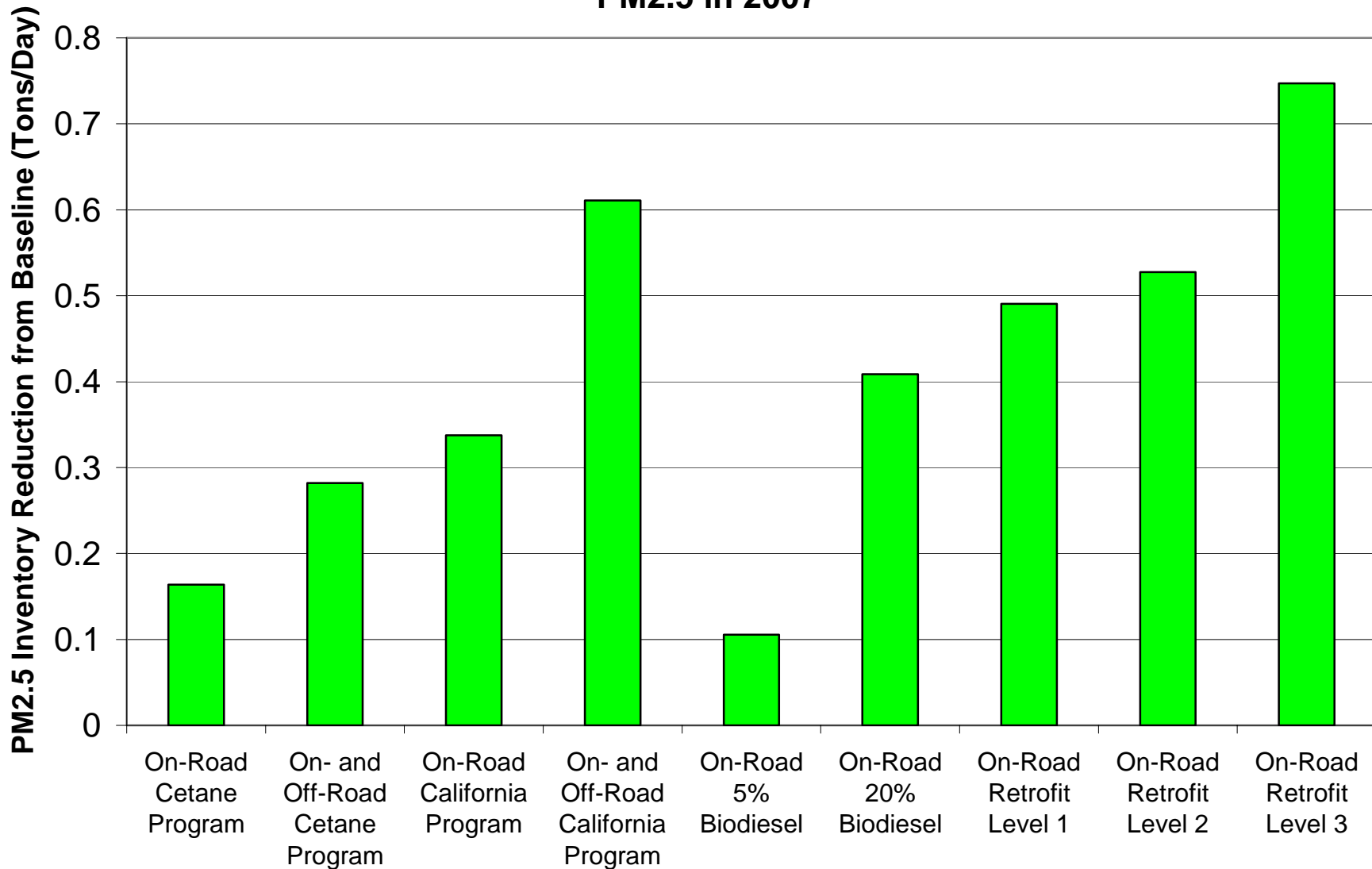


Diesel Program Results

Summary of Inventory Benefits of Diesel Programs VOC, CO and NOx in 2007



Summary of Inventory Benefits of Diesel Programs PM2.5 in 2007



Some Uncertainties

- Fuel properties could be different than we projected
- Differences in exhaust models, both need to be updated
- Disbenefits of 100% ethanol without waiver greater if NONROAD updated for evap, and RVP effect on portable containers included
- Benefits of RVP control greater if same items included
- Ethanol NO_x effects on new technology uncertain (data forthcoming from CRC soon)
- Permeation effects could also be different (CRC obtaining more data on Tier 2 evap vehicles)

The End

ARB Draft Ethanol Report

- February 2005
- California currently has about 95% ethanol market share (E6)
- Estimated changes in VOC, CO, NO_x with a non-oxygenated gasoline
- Draft estimates and methods released for the purpose of obtaining public comment

VOC Permeation

- Estimates used in SEMCOG study are lower than ARB's under identical conditions
- Different method used by ARB
 - Linked to EMFAC model, which has fundamentally different evap definitions than MOBILE

CO

- ARB estimates a ton of non-oxygenated gasoline permeation emissions = 57 tons of CO
- If true, from an air quality standpoint, the CO reduction from increasing ethanol market share in SE MI would partially offset some of the permeation VOC increase

NO_x

- ARB estimates a 3% NO_x decrease (on gasoline vehicles) with California RFG without ethanol