

***Upcoming EPA and California Policy  
Decisions:  
Creating A Platform for Cleaner, Low-  
Carbon Natural Gas Vehicles***

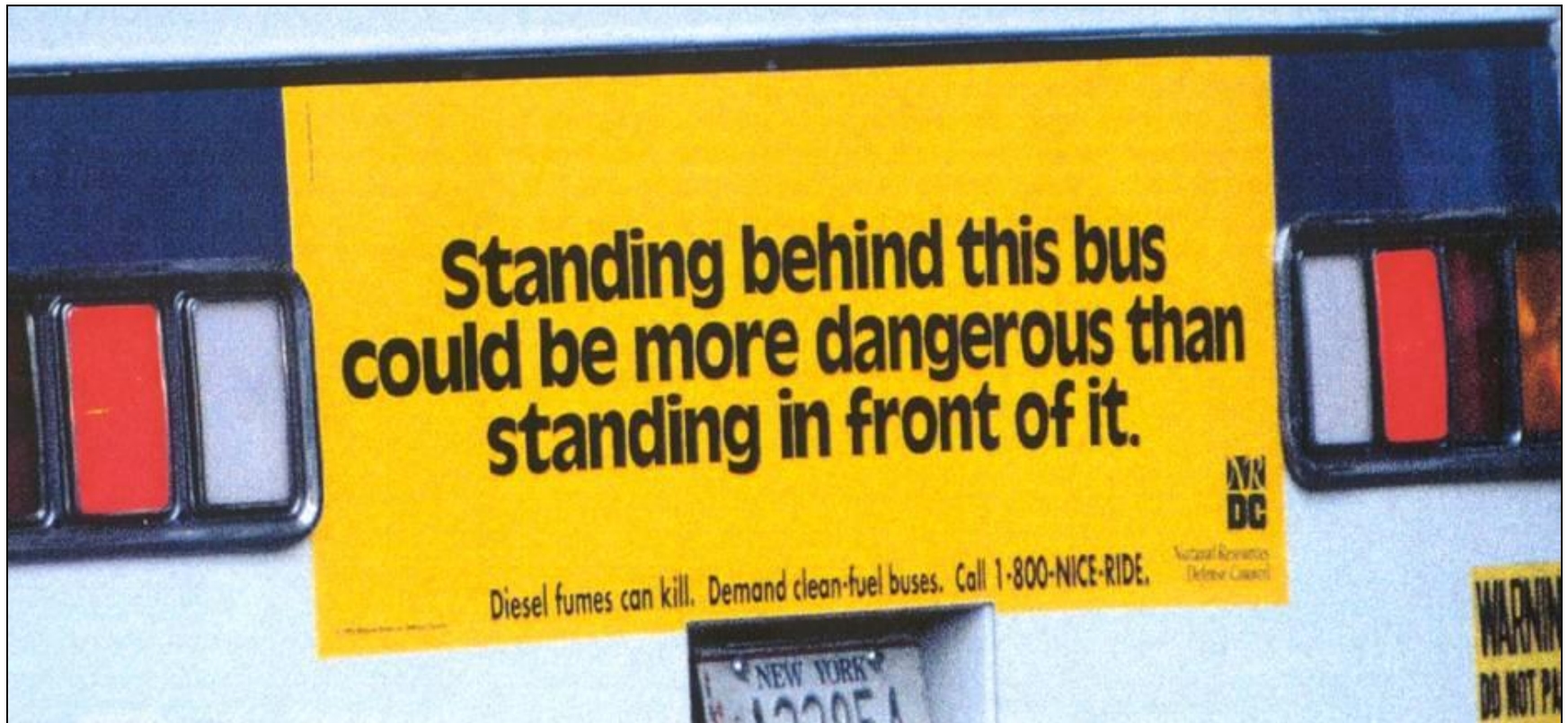
Rich Kassel

[rich.kassel@gladstein.org](mailto:rich.kassel@gladstein.org)

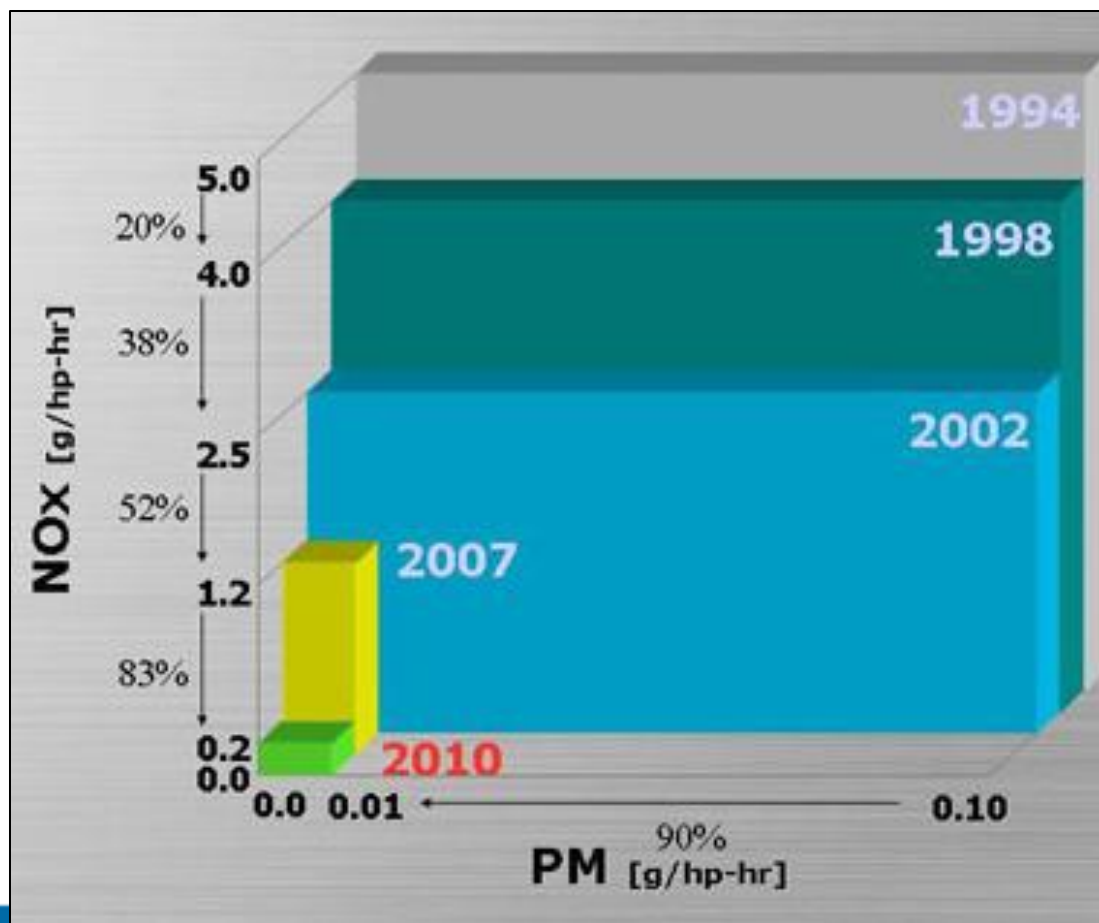
U.C. Davis Workshop on Natural Gas Vehicles

October 1, 2015

# ***Twenty Years Ago, There Was No Such Thing As A Clean Diesel...***



# *...Today, All New Heavy-Duty Diesel Engines Should Be Clean*

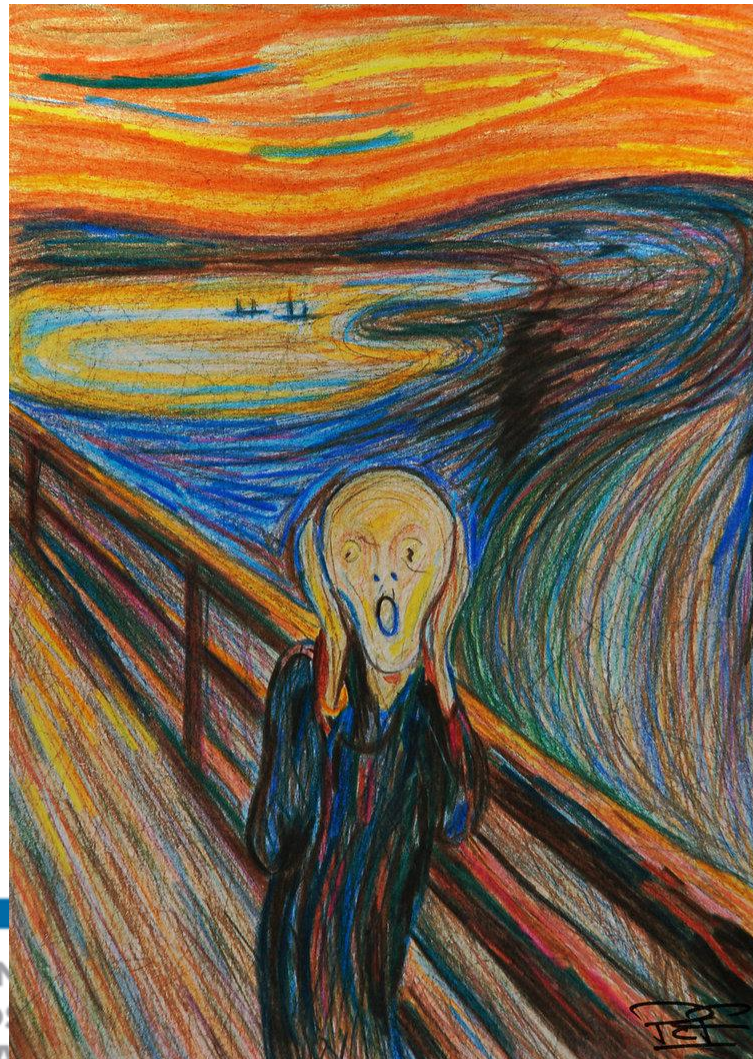


# ***...But People Are More Concerned Than Ever...***





***...Don't Lose Hope...***



GLADSTEIN  
NEANDROSS  
& ASSOCIATES

ION & ENERGY CONSULTANTS

San Francisco, CA • New York, NY • Irvine, CA

310.314.1934 • [www.gladstein.org](http://www.gladstein.org)

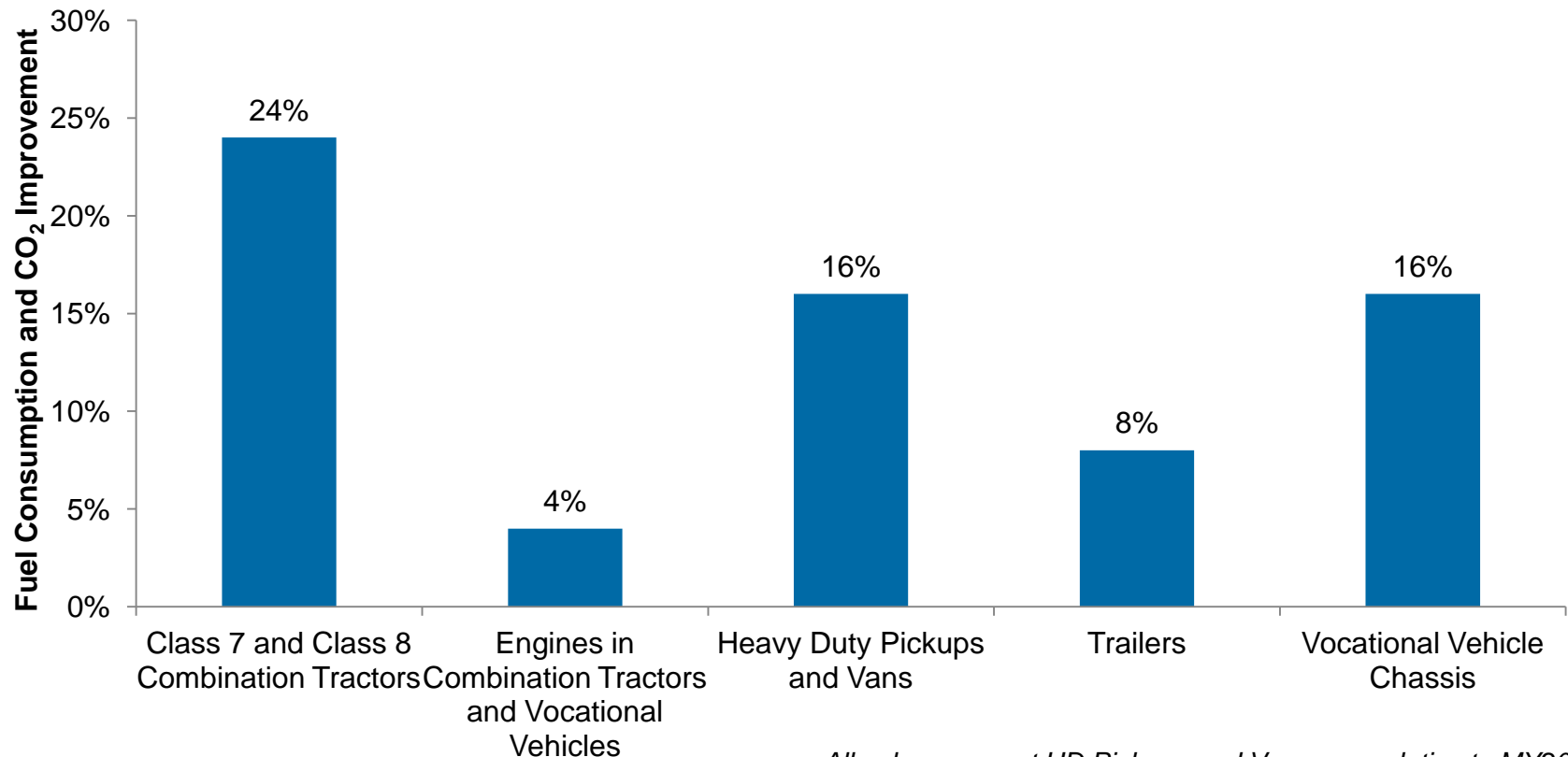
# ***New Policies Are Creating Opportunities for Extremely Clean Heavy-Duty Natural Gas Vehicles***

- Policy Opportunities Lie Ahead
  - EPA/NHTSA Phase 2 Proposal
  - California's Suite of Policies
  - EPA's new Ozone NAAQS
- Near-Zero, "Power Plant Equivalent" Natural Gas Engines Are Coming
- Renewable Natural Gas Creates An Even Bigger Win-Win Opportunity

# ***Overview of the GHG and Fuel Economy Phase 2 Proposed Rule***

- Proposal covers medium- and heavy-duty vehicles, engines, and trailers
  - Model years 2021-2027 (trailers start in 2018)
- Expected Benefits include:
  - 1B metric tons of GHG emissions eliminated
  - 1.8B barrels of oil conserved
  - \$170B in fuel costs saved
  - \$230B in net health and environmental benefits

# ***Per Vehicle Fuel Consumption and CO<sub>2</sub> Improvements in the Phase 2 Proposal***



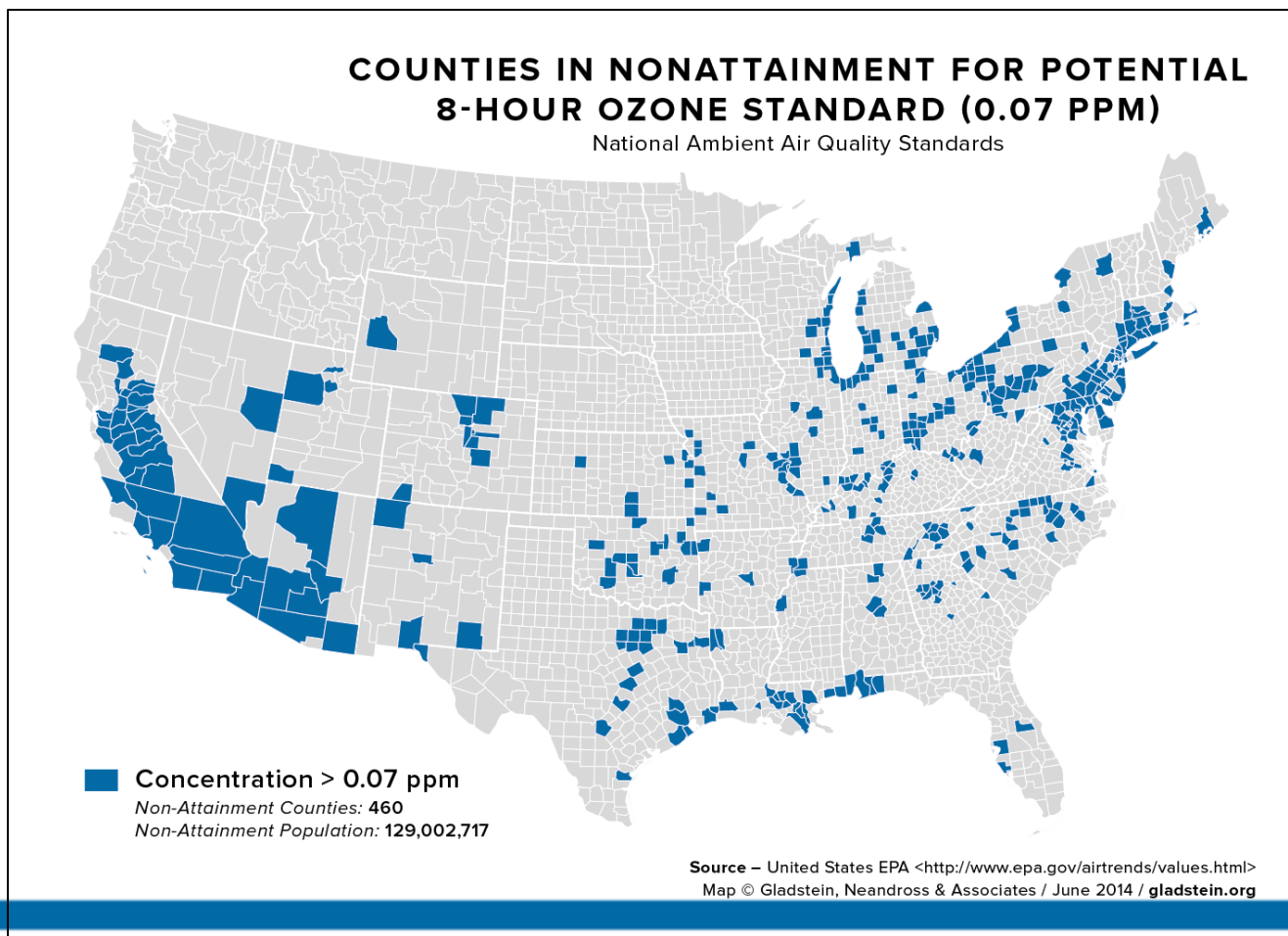
*All values, except HD Pickups and Vans, are relative to MY2017 baselines. HD Pickups and Vans are relative to MY2018-2020 standards.*



## ***Phase 2 Proposal is Fuel-Neutral, But Some Provisions Will Help Advance Natural Gas Trucks***

- Maintains Phase 1 approach to compliance pathway flexibility for CH<sub>4</sub>, N<sub>2</sub>O, and CO<sub>2</sub>
- Resolves longstanding issue of methane leakage from crankcases
- Codifies best practices for LNG refueling to reduce methane emissions during LNG refueling

# ***Ozone Alert: At 70 ppb, 40% of the U.S. Population Will Live in an Ozone Nonattainment Area***



# ***California Has A Broad Suite Of Transportation Policy Goals***

- ☐ 50% petroleum displacement by 2030
- ☐ Reduce NOx emissions and smog (EPA NAAQS; Oct. '15)
- ☐ Eliminate toxic diesel PM
- ☐ Reduce GHG emissions by 80% by 2050 (AB 32)
- ☐ Reduce GHG emissions from various waste streams (landfills, dairies, MWW, etc.)
- ☐ Reduce short lived climate pollutants (e.g., black carbon, methane)
- ☐ Drive economic development and job creation via in-state biofuel production
- ☐ Create fuel cost savings for California fleet operators and businesses
- ☐ Advance California's transportation technology leadership

# ***Natural Gas Advances All Of These Policy Goals***

- ✓ 50% petroleum displacement by 2030
- ✓ Reduce NOx emissions and thus smog (EPA NAAQS; Oct. '15)
- ✓ Eliminate toxic diesel PM
- ✓ Reduce GHG emissions by 80% by 2050 (AB 32)
- ✓ Reduce GHG emissions from various waste streams (landfills, dairies, MWW, etc.)
- ✓ Reduce short lived climate pollutants (black carbon, methane)
- ✓ Drive economic development and job creation via in-state biofuel production
- ✓ Result in fuel cost savings for California fleet operators and businesses
- ✓ Advance California's transportation technology leadership



# ***California Sustainable Freight Strategy Should Advance These Goals Through A Comprehensive Approach to Goods Movement***

- Issued by Governor Brown on July 17, 2015 under Executive Order B-32-15
- Requires multiple agencies to develop an integrated action plan by July 2016
- Plan will establish clear targets to:
  - Improve freight efficiency,
  - Transition to zero-emission technologies, and
  - Increase competitiveness of freight system

# ***Key Provisions for the Natural Gas Transportation Sector***

- Lower the carbon intensity of the freight sector to achieve an 80% GHG emissions reduction from 1990 levels by 2050
- Achieve up to a 50% reduction in fossil fuel use by cars and trucks by 2030
- Optional low-NO<sub>x</sub> standard for heavy-duty truck engines
- Develop LNG fueling infrastructure for ocean going vessels, harbor craft, and locomotives
- Potential renewable natural gas standard

# ***Despite Lack of HD Battery Electric Trucks, “Power Plant Equivalent” Engines are Coming***

- GNA survey: No signs of significant deployment in battery electric Class 7 or 8 HD trucks for long-haul service by 2030
- But California’s Optional Low-NOx Emission Standard (0.02 g/bhp-hr) is equivalent to a battery electric truck charged from a modern combined cycle gas turbine (CCGT) power plant
- “Near-Zero” or “power plant equivalent” emissions are coming

# "Power Plant Equivalent" Natural Gas Engines Are Being Certified

California Environmental Protection Agency <b>Air Resources Board</b>	CUMMINS INC.	EXECUTIVE ORDER A-021-0630 New On-Road Heavy-Duty Engines Page 1 of 2 Pages
--	--------------	---

Pursuant to the authority vested in the Air Resources Board by Health and Safety Code Division 26, Part 5, Chapter 2; and pursuant to the authority vested in the undersigned by Health and Safety Code Sections 39515 and 39516 and Executive Order G-14-012;

**IT IS ORDERED AND RESOLVED:** The engine and emission control systems produced by the manufacturer are certified as described below for use in on-road motor vehicles with a manufacturer's GVWR over 14,000 pounds. Production engines shall be in all material respects the same as those for which certification is granted.

MODEL YEAR	ENGINE FAMILY	ENGINE SIZES (L)	FUEL TYPE <sup>1</sup>	STANDARDS & TEST PROCEDURE	INTENDED SERVICE CLASS <sup>2</sup>	ECS & SPECIAL FEATURES <sup>3</sup>	DIAGNOSTIC <sup>6</sup>
2016	GCEXH0540LBJ	8.9	CNG/LNG	Diesel	MHDD	TBI, TC, CAC, ECM, EGR, TWC, HO2S	EMD+
PRIMARY ENGINE'S IDLE EMISSIONS CONTROL <sup>5</sup>		ADDITIONAL IDLE EMISSIONS CONTROL <sup>5</sup>					
30g		N/A					
ENGINE (L)	ENGINE MODELS / CODES (rated power, in hp)						
8.9	ISL G 320 / 4835;FR95347 (320), ISL G 300 / 4835;FR95350 (300), ISL G 280 / 4835;FR95353 (280)						
8.9	ISL G 260 / 4835;FR95356 (260), ISL G 250 / 4835;FR95358 (258)						

<sup>\*</sup> =not applicable; GVWR=gross vehicle weight rating; 13 CCR xyz=Title 13, California Code of Regulations, Section xyz, 40 CFR 86.abc=Title 40, Code of Federal Regulations, Section 86.abc; <sup>L</sup>=liter; hp=horsepower; kw=kilowatt; hr=hour;

<sup>1</sup> CNG/LNG=compressed/liquefied natural gas; LPG=liquefied petroleum gas; E85=85% ethanol fuel; MF=multi fuel a.k.a. BF=bi fuel; DF=dual fuel; FF=flexible fuel;

<sup>2</sup> L/M/H HDD=light/medium/heavy heavy-duty diesel; UB=urban bus; HDO=heavy duty Otto;

<sup>3</sup> ECS=emission control system; TWC/OC=three-way/oxidizing catalyst; NAC=NOx adsorption catalyst; SCR-U / SCR-N=selective catalytic reduction -- urea / -- ammonia; WU (prefix) =warm-up catalyst; DPF=diesel particulate filter; PTOX=periodic trap oxidizer; HO2S/O2S=heated/oxygen sensor; HAFS/AFS=heated/air-fuel-ratio sensor (a.k.a., universal or linear oxygen sensor); TBI=throttle body fuel injection; SFI/MFI=sequential/multi port fuel injection; DGI=direct gasoline injection; GCARB=gaseous carburetor; IDI/DDI=indirect/direct diesel injection; TC/SC=turbo/super charger; CAC=charge air cooler; EGR / EGR-C=exhaust gas recirculation / cooled EGR; PAIR/AIR=pulsed/secondary air injection; SPL=smoke puff limiter; ECM/PCM=engine/powertrain control module; EM=engine modification; 2 (prefix)=parallel; (2) (suffix)=in series;

<sup>5</sup> ESS=engine shutdown system (per 13 CCR 1956.8(a)(6)(A)(1); 30g=30 g/hr NOx (per 13 CCR 1956.8(a)(6)(C); APS =internal combustion auxiliary power system; ALT=alternative method (per 13 CCR 1956.8(a)(6)(D); Exempt=exempted per 13 CCR 1956.8(a)(6)(B) or for CNG/LNG fuel systems; N/A=not applicable (e.g., Otto engines and vehicles);

<sup>6</sup> EMD=engine manufacturer diagnostic system (13 CCR 1971); OBD=on-board diagnostic system (13 CCR 1971.1);

Following are: 1) the exhaust emission standards, or family emission limit(s) as applicable, under 13 CCR 1956.8; 2) the SET and NTE values under the applicable exhaust emission standards and test procedures for heavy-duty diesel engines and vehicles (Test Procedures); and 3) the corresponding certification levels, for this engine family. "Diesel" CO, SET and NTE certification compliance may have been demonstrated by the manufacturer as provided under the applicable Test Procedures in lieu of testing. (For flexible- and dual-fueled engines, the CERT values in brackets [ ] are those when tested on conventional test fuel. For multi-fueled engines, the STD and CERT values for default operation permitted in 13 CCR 1956.8 are in parentheses.).

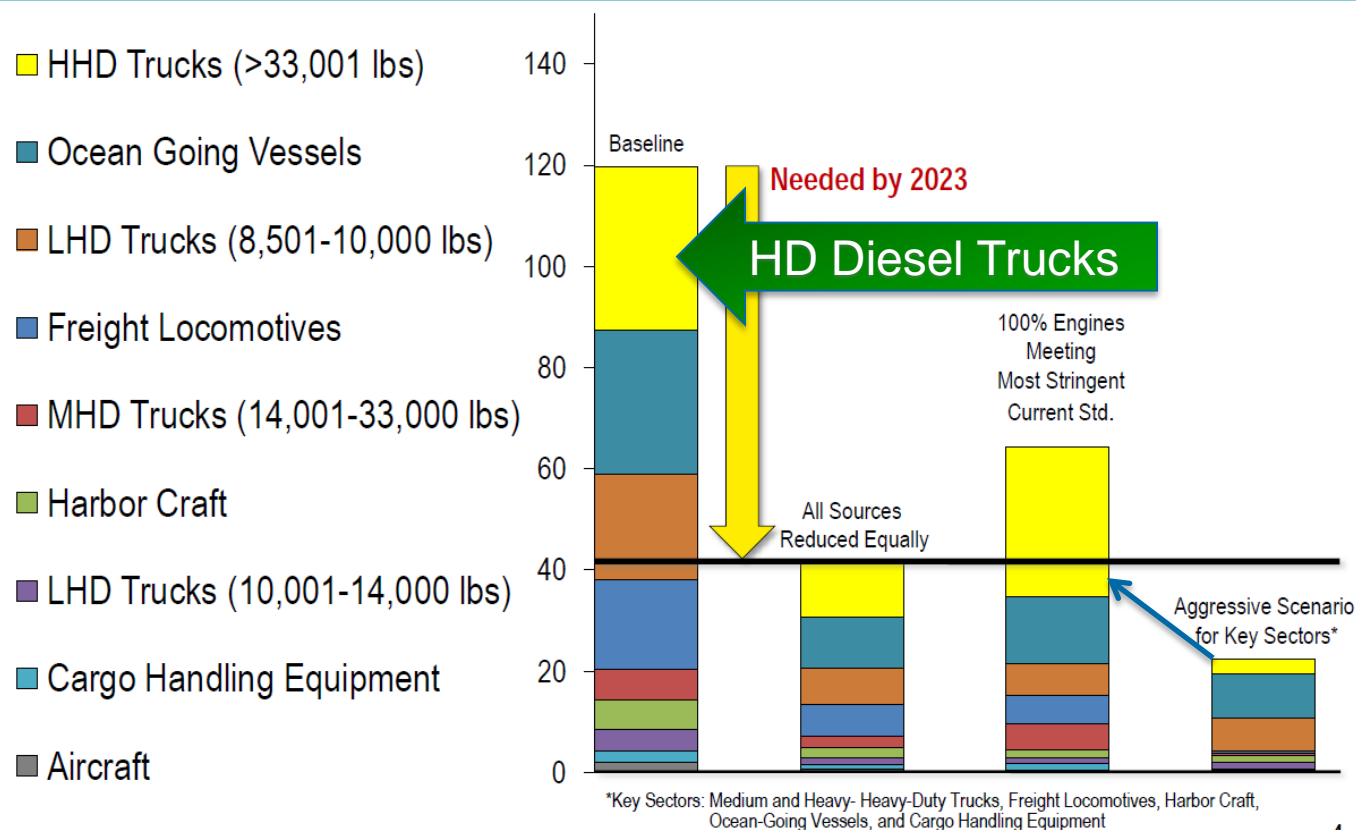
in g/bhp-hr	NMHC		NOx		NMHC		CO		PM		HCHO	
	FTP	SET	FTP	SET	FTP	SET	FTP	SET	FTP	SET	FTP	SET
STD	0.14		0.02	0.02	*	*	15.5	15.5	0.01	0.01	*	*
CERT	0.01	0.000	0.01	0.004	*	*	1.5	0.3	0.001	0.000	*	*
NTE	0.21		0.03		*		19.4		0.02		*	

<sup>4</sup> g/bhp-hr=grams per brake horsepower-hour; FTP=Federal Test Procedure; SET= Supplemental emissions testing; NTE=Not-to-Exceed; STD=standard or emission test cap; FEL=family emission limit; CERT=certification level; NMHC/HC=non-methane/hydrocarbon; NOx=oxides of nitrogen; CO=carbon monoxide; PM=particulate matter; HCHO=formaldehyde



# ***“Power Plant Equivalent” Engines Will Be Critical to Ozone Attainment***

## **Mobile Source NO<sub>x</sub> Emission Reductions to Achieve 8-Hr Ozone Air Quality Standards (2023)**

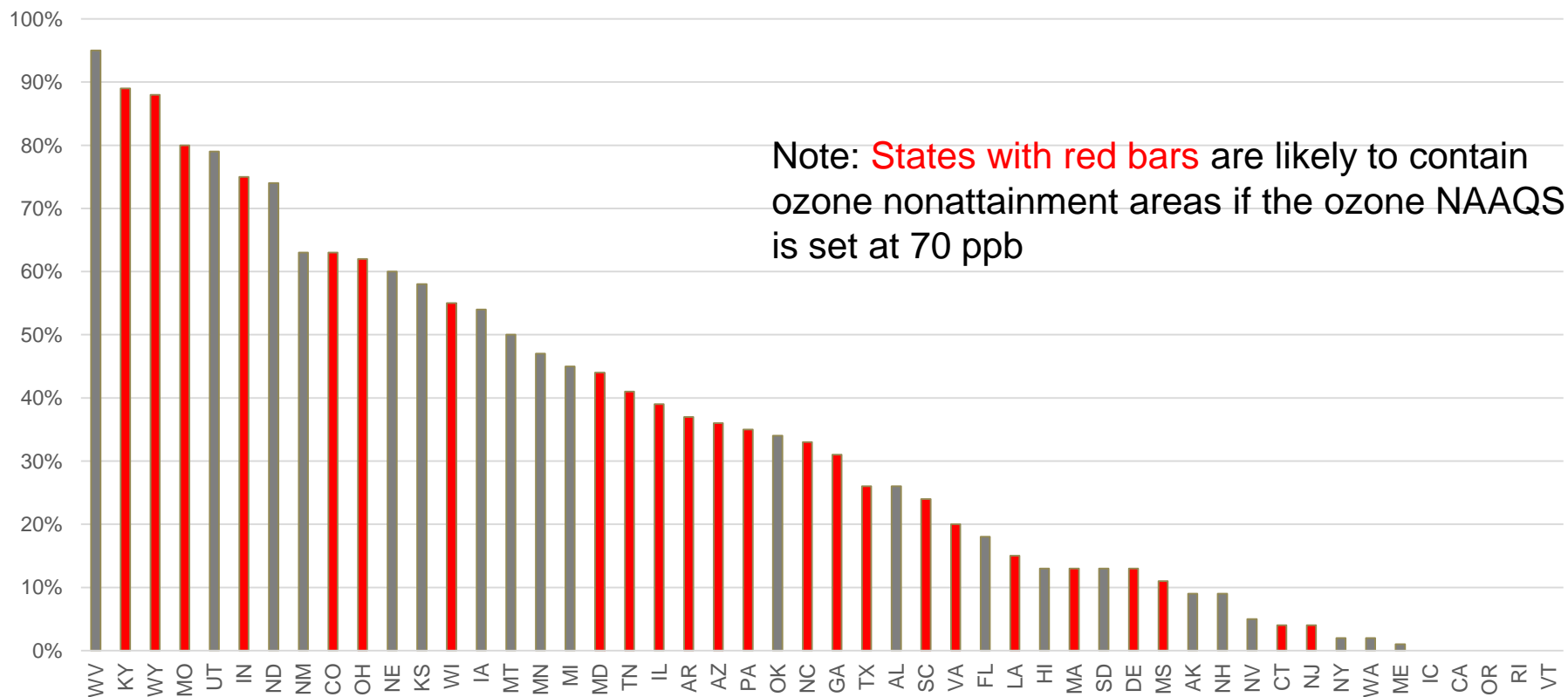


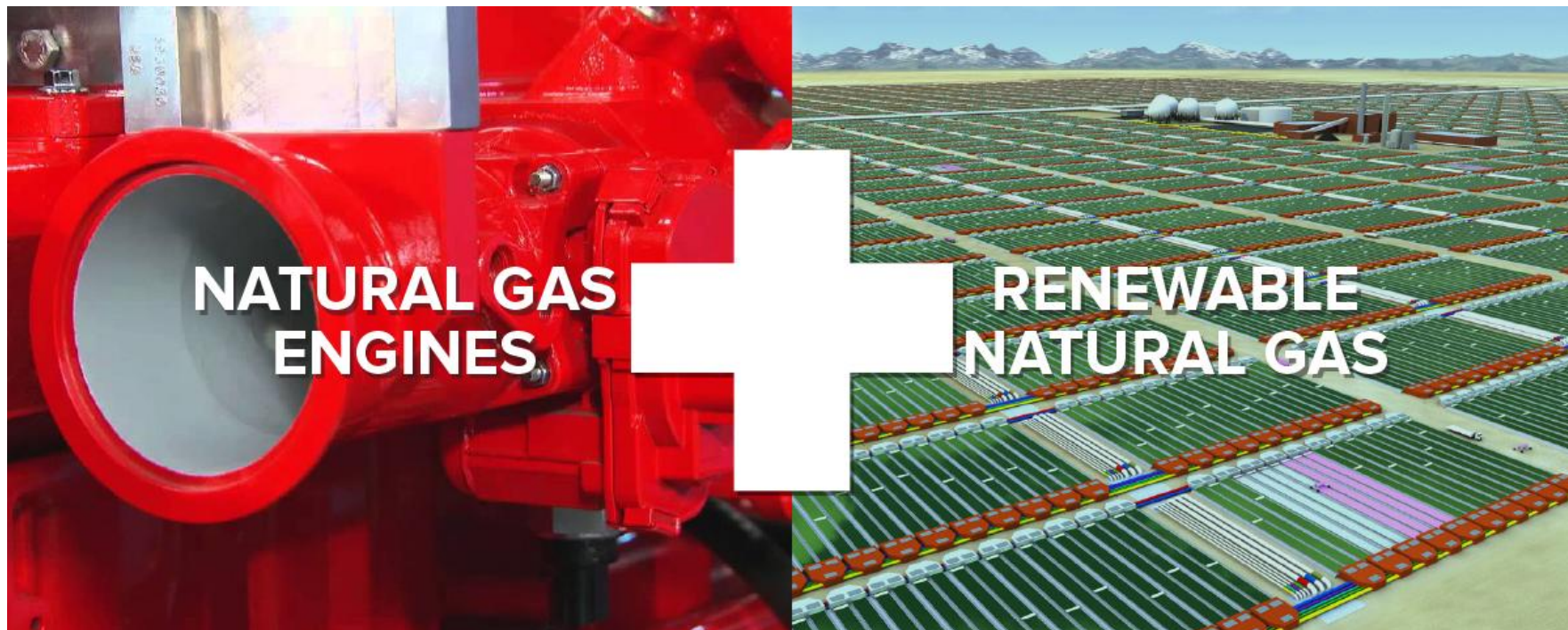
# ***“Power Plant Equivalent” Engines Can Provide Near-Term Smog Relief to Communities***



# ***“Power Plant Equivalent” Engines Should Actually Be Cleaner Than The Grid in Many States***

Percent Coal-Fire Generation by State

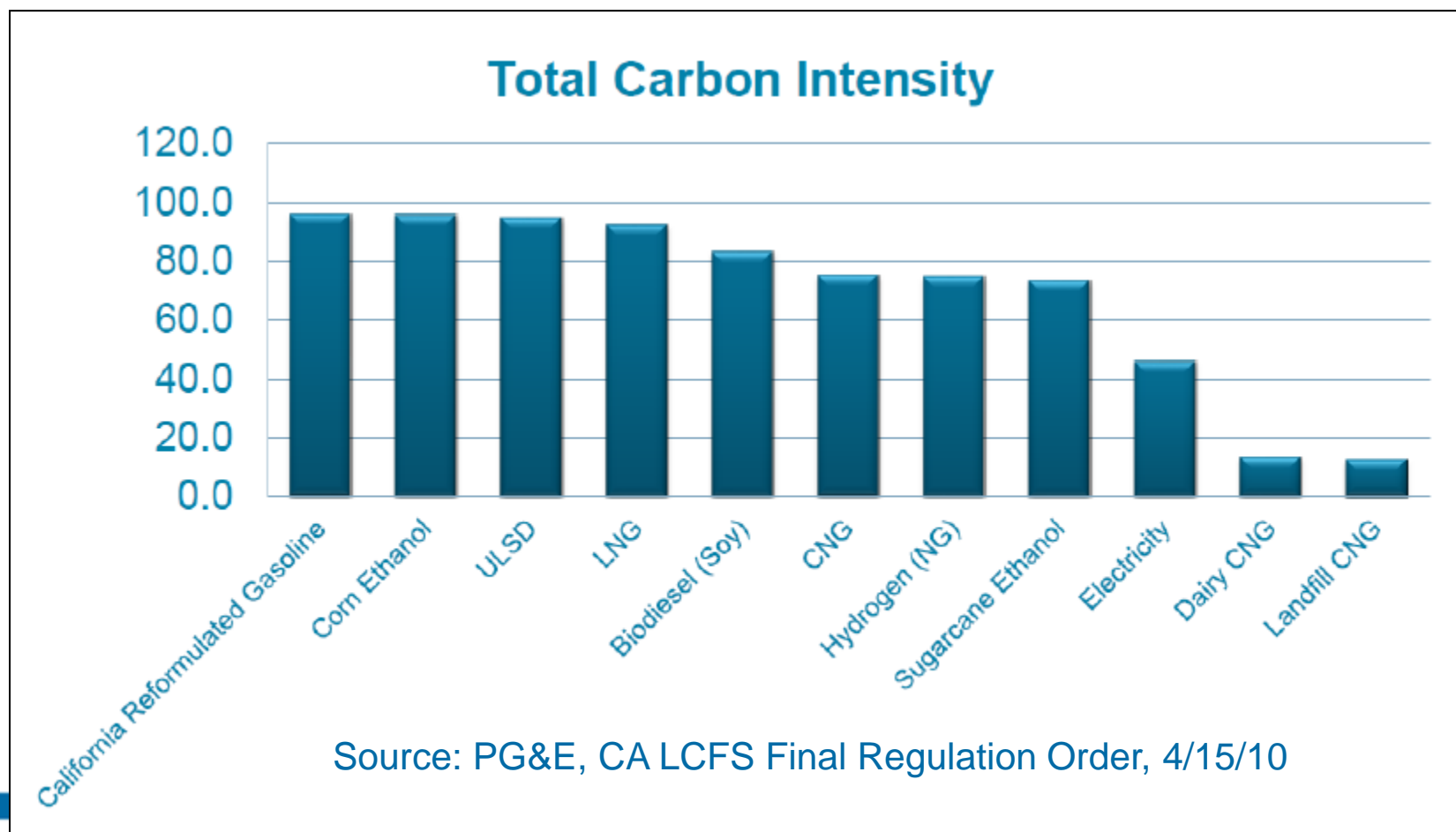




***Increasing renewable natural gas use creates  
an even greater opportunity for near-term,  
large-scale progress on multiple policy goals***



# ***RNG Outperforms All Other Options in Total Carbon Intensity***



# Adding RNG Helps California Meet its Petroleum Reduction Goal

California Environmental Protection Agency | AIR RESOURCES BOARD

## CALIFORNIA'S 2030 CLIMATE COMMITMENTS

### Cutting Petroleum Use in Half by 2030

*In order to meet federal health-based air quality standards and our climate change goals, we must cut in half the amount of petroleum we use in our cars and trucks over the next 15 years. We are already on our way, and building on current policies and trends that are providing Californians with more mobility options, more efficient vehicles, and a diverse set of cleaner fuels – we can meet this target, strengthen and grow our economy, and improve public health in our communities.*

#### Benefits from Cutting Petroleum Use in Half by 2030

##### Less Pollution

- In California, the production, refining, and use of petroleum accounts for almost half of greenhouse gas emissions, 80 percent of smog-forming pollution, and over 95 percent of cancer-causing diesel particulate matter

##### Stronger Economy

- Oil dependence costs the U.S. an estimated \$300-500 billion annually (\$33-55 billion in California)
- Reducing energy use and improving vehicle efficiency cuts costs and improves economic productivity and competitiveness
- A diverse mix of domestic and local fuel supplies stabilizes energy prices, improves economic resilience, and creates new investments, businesses, and jobs

##### Meet Health Standards and Climate Change Goals

- Studies show 45-55% petroleum reduction in 2030 sets California on path to meet its 2050 climate change goals
- Meeting federal health-based air quality standards likely requires additional petroleum reductions

#### How we get there

##### Already on Our Way

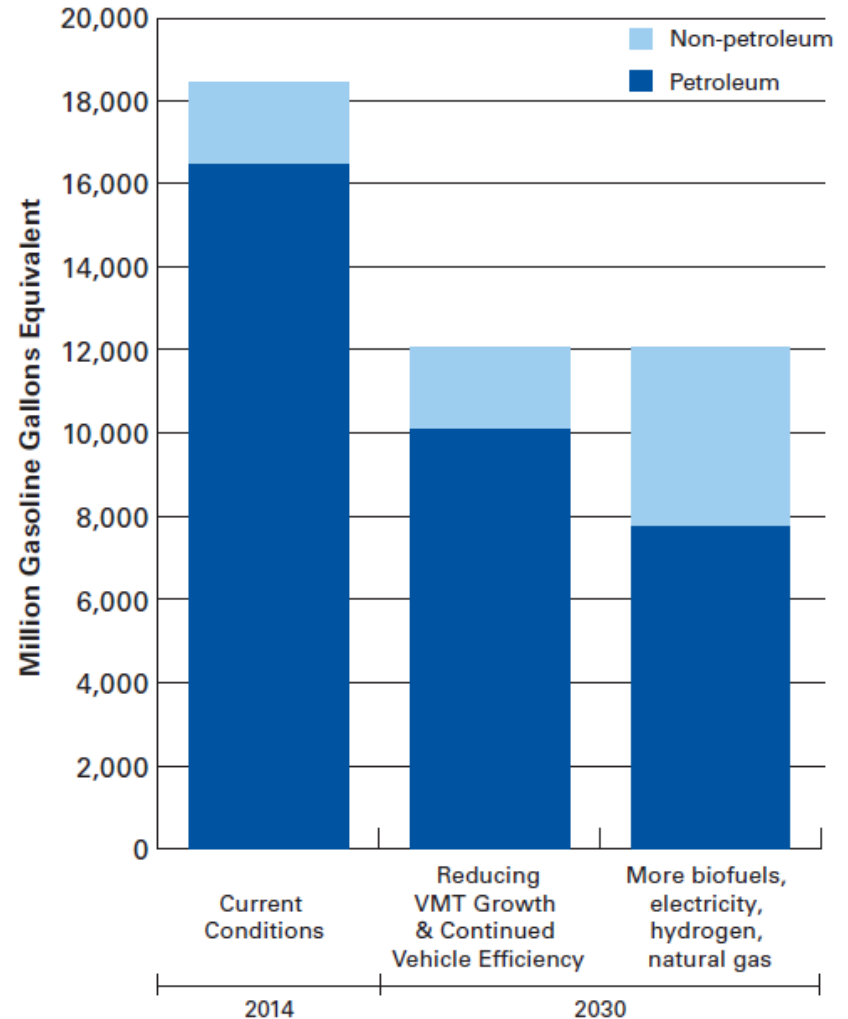
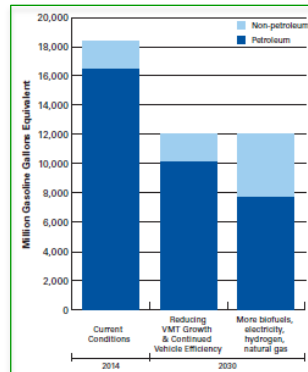
- Existing policies will reduce petroleum use in cars and trucks by more than 20% in 2030
- Planned activities over next two years can achieve significant additional petroleum reductions

##### Build on California's Climate Change and Air Quality Framework

- Building on existing efforts, California can cut petroleum use from cars and trucks in half by 2030:
  - Build high-speed rail and continue supporting community planning to reduce vehicle miles travelled
  - Continue current levels of light-duty and heavy-duty vehicle efficiency improvements
  - Strengthen the Low Carbon Fuel Standard to continue reducing fuel carbon intensity
  - Continue providing strong market support for zero emission vehicles and renewable fuel production through carbon pricing and other incentives

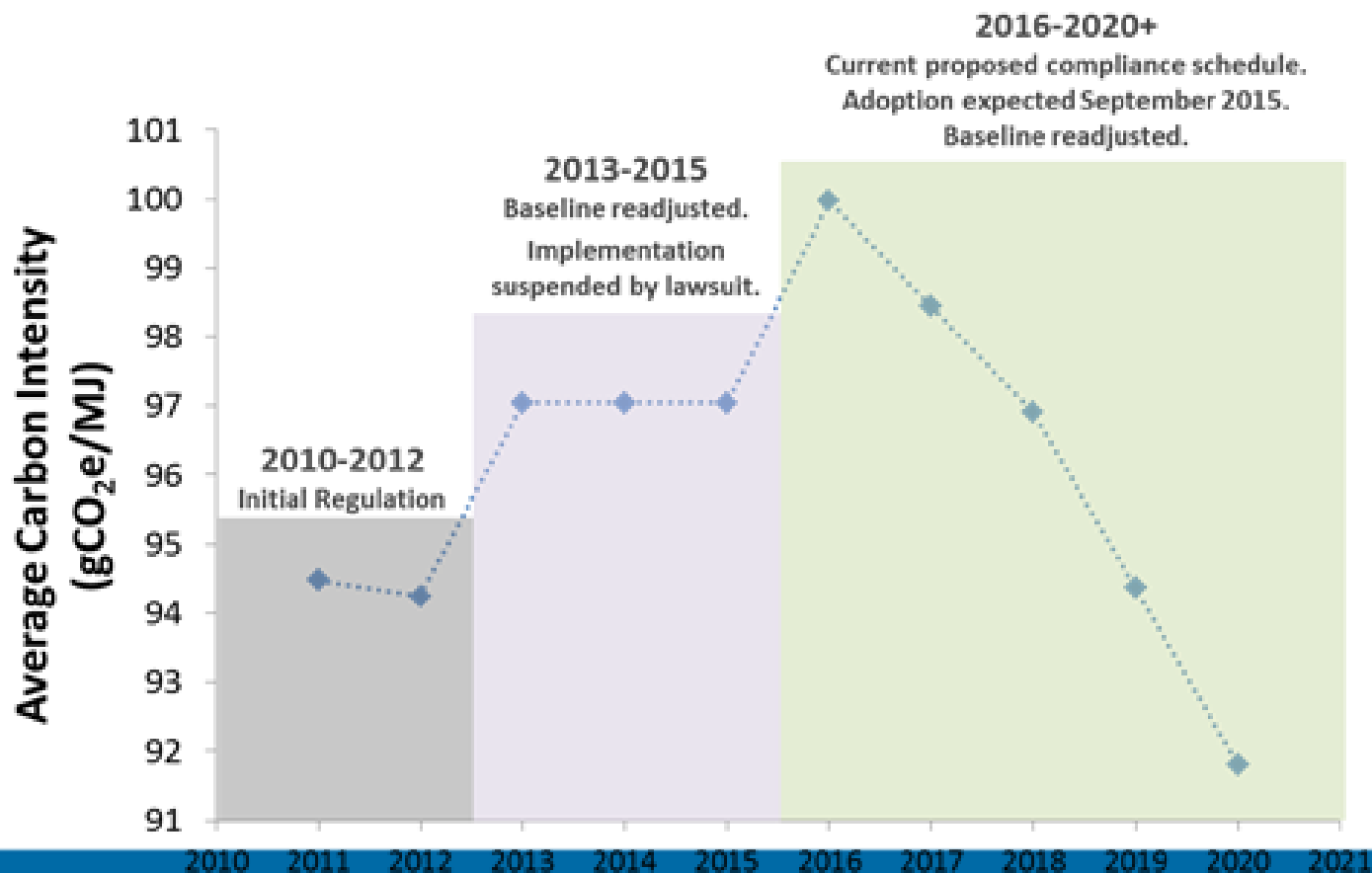
##### Sample path to 50% petroleum reduction in 2030

An approach to 50 percent petroleum reduction could include: Reducing growth in vehicle-miles travelled to 4%; increasing on-road fuel efficiency of cars to 35 mpg and heavy-duty trucks to about 7 mpg; and at least doubling use of alternative fuels like biofuels, electricity, hydrogen, and renewable natural gas. (ARB analysis) See graph at right.



# ***RNG Can Help HD Sector Do Its Share To Meet Upcoming LCFS Requirements***

## **CA LCFS Compliance Schedule**



# Replacing Diesel with RNG Reduces BC and Captures Methane

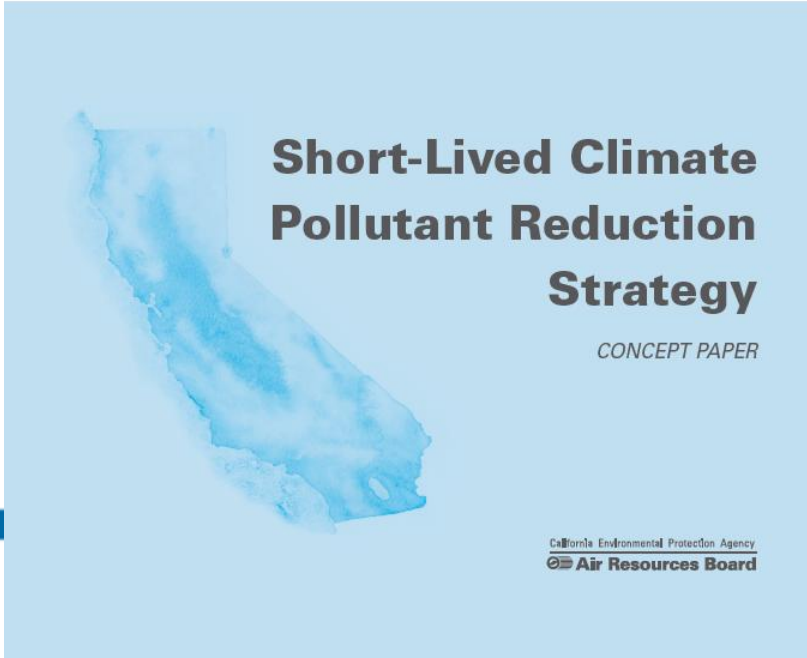
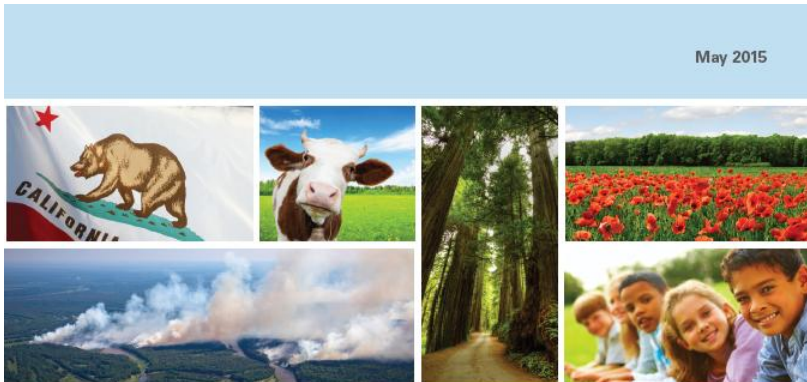


Figure 2: California 2013 Methane Emission Sources

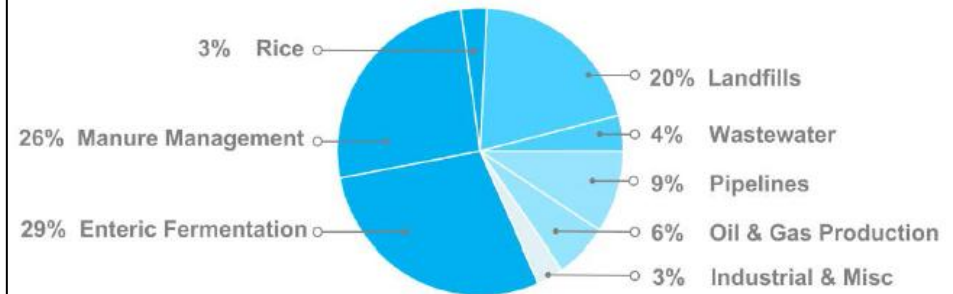
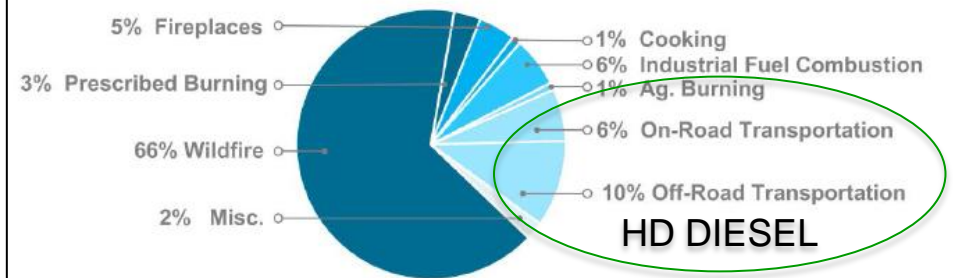


Figure 3: California 2013 Black Carbon Emission Sources



**CLEAN TRANSPORTATION & ENERGY CONSULTANTS**

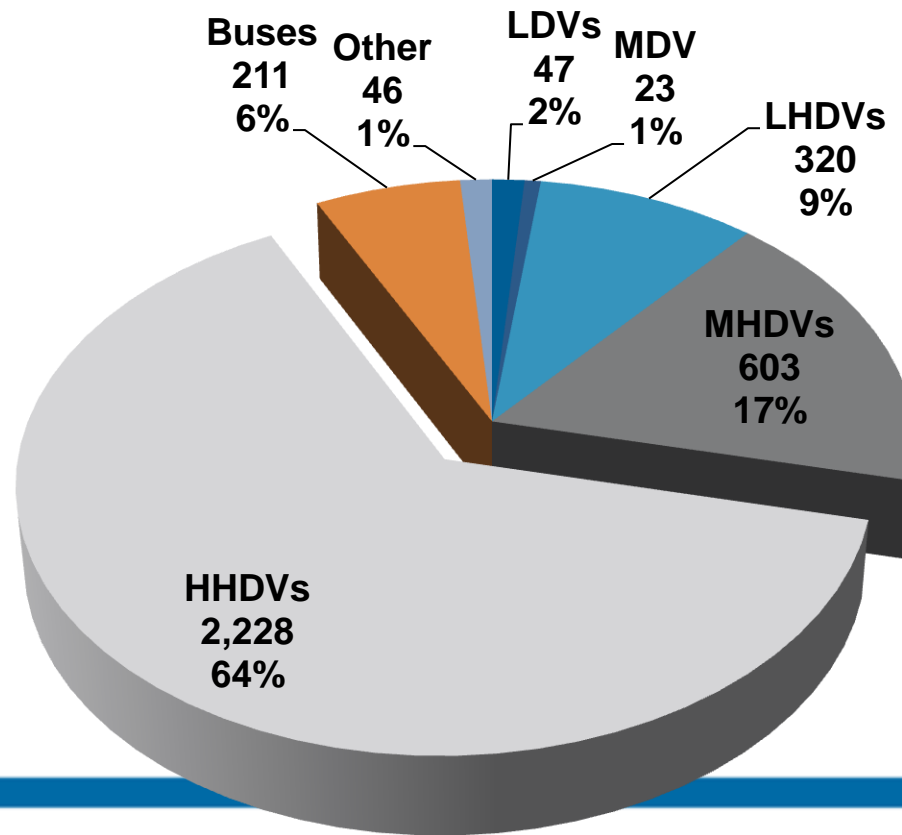
Santa Monica, CA • New York, NY • Irvine, CA

310.314.1934 • [www.gladstein.org](http://www.gladstein.org)



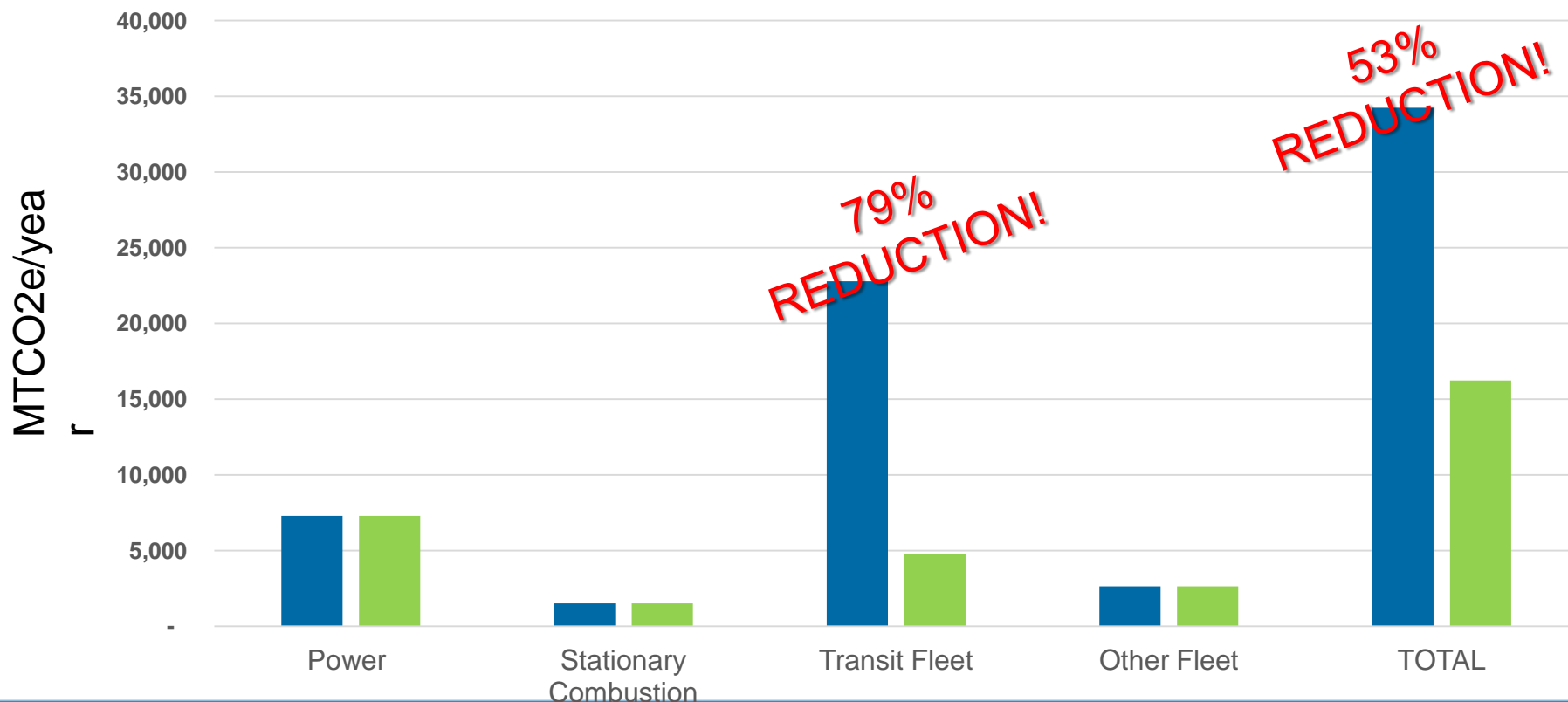
# ***In-State, Technically Recoverable RNG Can Displace >2/3 of Annual Diesel Use***

## **Statewide Diesel Fuel Consumption** (million gallons per year)



# Adding RNG to “Big Blue Bus” Fleet Was Key To Meeting Santa Monica’s Sustainability Goals

City of Santa Monica GHG Inventory



# Conclusions

- EPA and California policy initiatives will drive reductions in heavy-duty diesel emissions and fuel consumption in years to come
- Natural gas engines are starting to meet the Optional Low-NOx Emission Standard (0.02 g/bhp-hr) –equivalent to a CCGT power plant
- Power plant equivalent engines will be needed to meet upcoming ozone requirements and provide relief to communities with chronic ozone problems
- These natural gas engines should be cleaner than the grid in many states
- Combining ultra-low NOx engines with renewable natural gas is a strategy that can help achieve multiple policy goals at once—and is available to cities and fleets now
- California policy and funding should support increased near-term deployment of power-plant equivalent technologies and RNG fuels to meet these objectives

## ***For More Information...***

- Rich Kassel
  - [Rich.kassel@gladstein.org](mailto:Rich.kassel@gladstein.org)
  - (212) 849-6861