

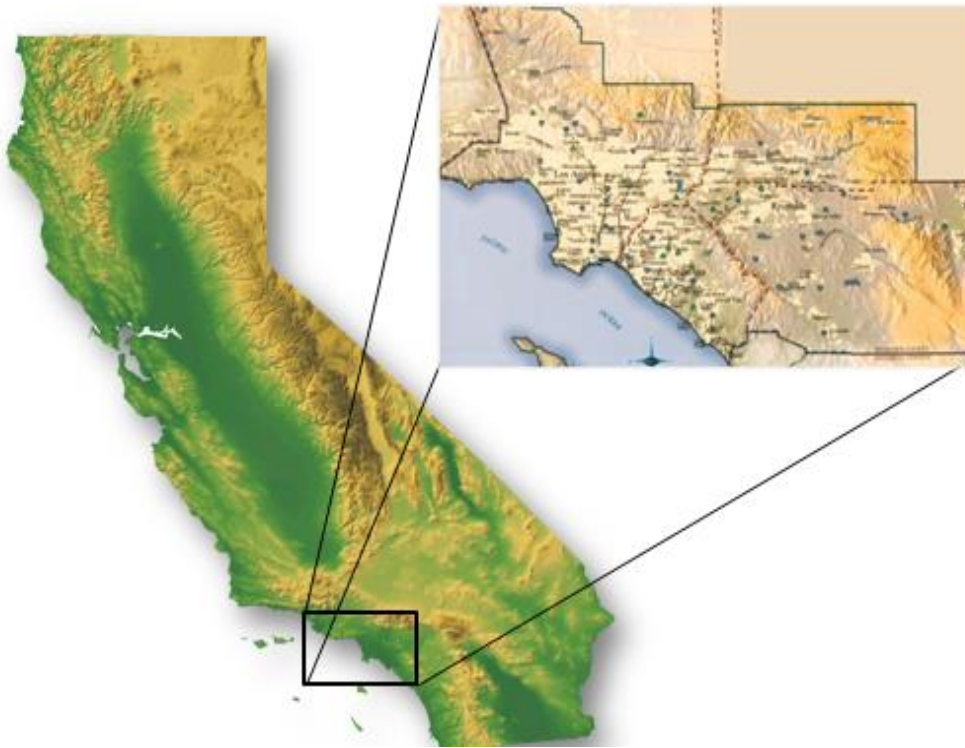
SCAQMD Ultra-Low Emission Natural Gas Heavy-Duty Engines Program

Natural Gas Vehicle Technology Forum
October 20 & 21, 2015

Adewale Oshinuga, Program Supervisor
South Coast Air Quality Management District

Cleaning the Air That We Breathe...

California's South Coast Air Basin

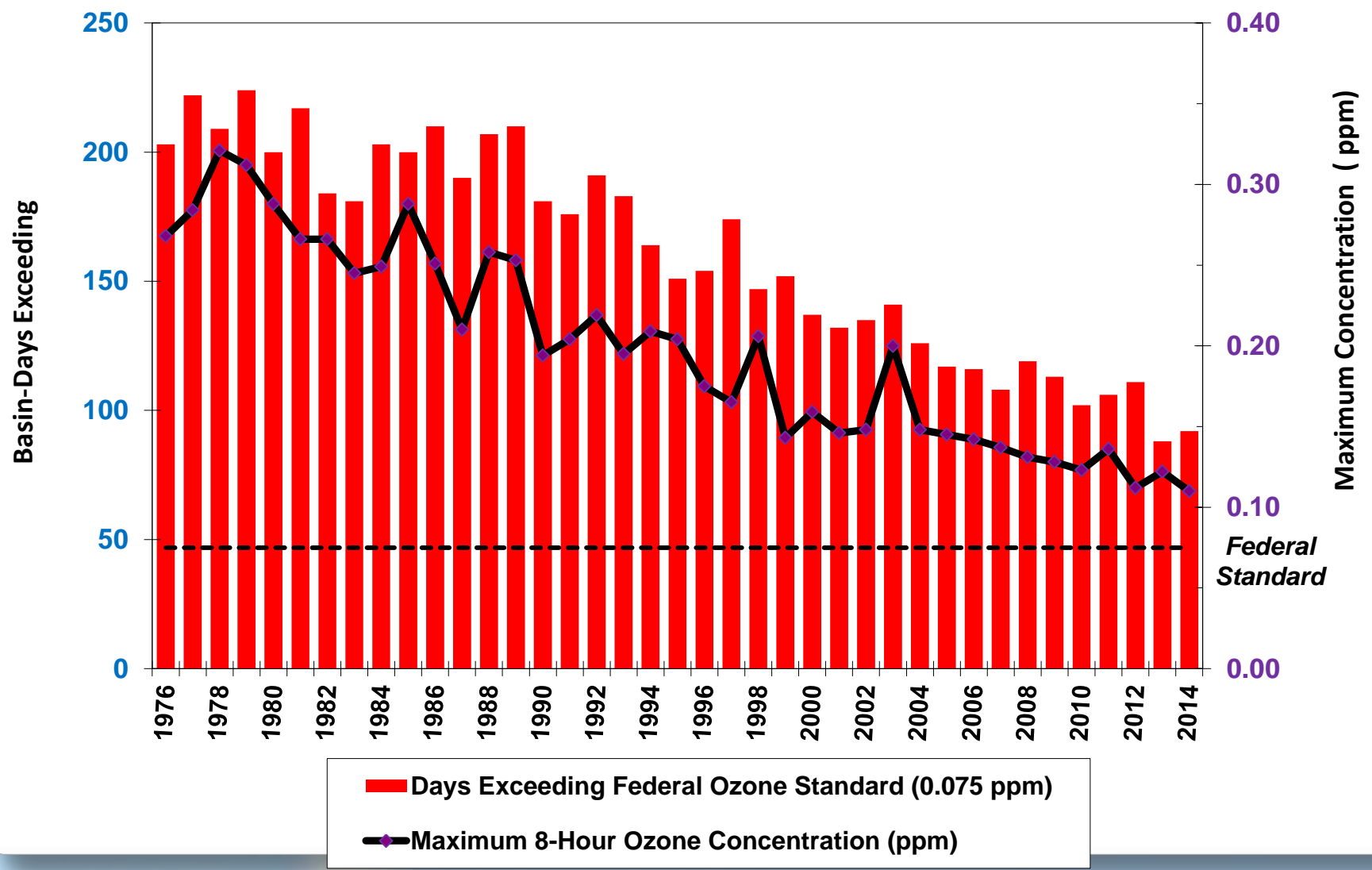


- Substantial Air Quality Progress, But Still Serious Health Impacts
- Nation's Largest Containerized Freight Gateway

4-county Region
16+ Million People

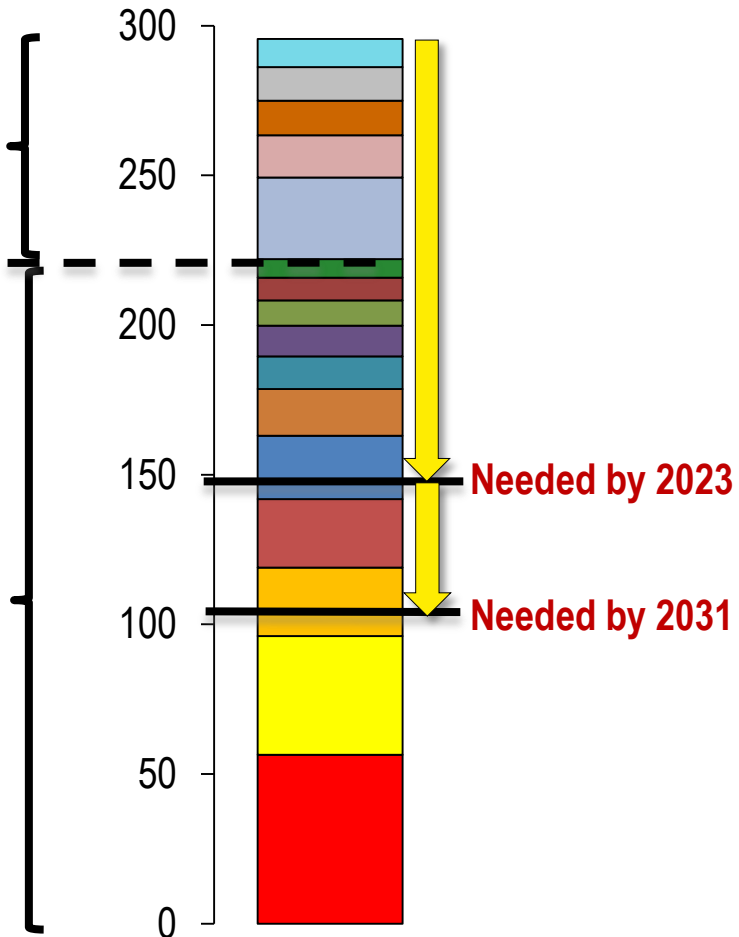
261,000+ Diesel Vehicles
11+ Million Gasoline Vehicles

South Coast Air Basin Ozone Trend



Needed Pollution Reduction to Meet Ozone Air Quality Standards

- Service and Commercial
- Residential Fuel Combustion
- Other
- Manufacturing and Industrial
- RECLAIM
- Recreational Boats
- Medium-Duty Trucks
- Buses
- Commercial Harbor Craft
- Heavy-Duty Gas Trucks
- Aircraft
- Cars/Light-Duty Trucks/SUVs
- Locomotives
- Ocean Going Vessels
- Off-Road Mobile Equipment
- Heavy-Duty Diesel Trucks



Going Beyond Current Technologies

- Battery Electric
- Fuel Cell/Hybrid
- Natural Gas/Hybrid
- Extended Range Catenary/Wayside
- Alternative Fuels/
90% Cleaner than Current
2010 Emission Standards



Development Objectives

- 0.02 g/bhp-hr NO_x
- 0.01 g/bhp-hr PM
- 0.14 g/bhp-hr HC
- 10 ppm ammonia
- Minimal energy economy penalty
- Equivalent performance as diesel
- Durable system

Project Requirements

3 Step Program



Engine
Development



Chassis
Integration



On-Road
Demonstration

Selected Projects

<u>Manufacturer</u>	<u>Engine</u>	<u>Target Vehicles</u>
Cummins, Inc. (CI)	15L	Class 8 HHDD
Cummins-Westport (CWI)	8.9L	Class 7-8 MHDD
CWI	11.9L	Class 8 MHDD
Power Solutions Int'l., Inc.	8.8L	Class 4-7 LHDD

Engine Configuration

	CI	CWI	CWI	PSI
Approach	New Design	Enhance	Enhance	Enhance
Size	15L I-6	8.9L	11.9L	8.8L
Fuel Injection	SFI	TBI	TBI	SFI
Ignition	Spark	Spark	Spark	Spark
AFR	Stoic.	Stoic.	Stoic.	Stoic.
EGR	Cooled	Cooled	Cooled	Cooled
Turbocharger	Yes	Yes	Yes	Yes
Charge Cooling	Yes	Yes	Yes	Yes
Catalyst	TWC	TWC	TWC	TWC

Funding Sources

<u>Sponsor</u>	<u>Amount</u>
SCAQMD	\$2,750,000
California Energy Commission	\$4,000,000
Southern California Gas Company	\$1,250,000
TOTAL	\$8,000,000

Development Status

Engine	Status
CWI 8.9L	<ul style="list-style-type: none">● Hardware and calibrations finalized● EPA/CARB certifications issued for 0.02 g/bhp-hr NOx● FC/GHG equal or better than 0.2 g NOx NG engines
CI 15L	<ul style="list-style-type: none">● Technology alternatives evaluated● Technology strategies selected● Test engines built and tested
PSI 8.8L	<ul style="list-style-type: none">● Contract executed● Kick-off meeting planned
CWI 11.9L	Scheduled for public hearing on 11/6/15

8.9L Demonstration

Vehicles:

- 1 truck for first on-road trial of about 3 months
- 9 transit buses in revenue service (San Diego and Los Angeles)
- 7 trash collection trucks in revenue service (Los Angeles & Oakland)

Integration/Installation

- Same envelope as current 0.2 g NO_x engine
- Retrofit vehicle with enhanced engine/after-treatment components
- Installation by fleets with assistance from Cummins dealer

Operations

- Minimum 6 months operation
- Monitor and record performance and fuel economy
- 1 vehicle selected for chassis dynamometer emission tests

Commercialization

CWI 8.9L Engine

- May update control software based on demonstration
- Pilot production in 2015
- Commercial production in 2016
- Initial focus on transit buses
- Trash collection and other truck applications follow
- Informational marketing to California dealers/customers in 2015

CI 15L Engine

- Complete development activities in 2015
- Defer commercialization to 2020-2023 due to market conditions
- Apply technology elements to other engine platforms

Next Step

Engine	Activity
CWI 8.9L	<ul style="list-style-type: none">• Fleet marketing beginning in 2015• Integration with vehicle OEMs in 2015/2016• Ammonia reduction development in 2016• HD OBD development in 2016/2017
CWI 11.9L	<ul style="list-style-type: none">• Build and test prototype engines in 2016• Conduct demonstrations in 2016/2017• Complete EPA/CARB certification in 2016• Integration with vehicle OEMs in 2016/2017• HD OBD development in 2016/2017
PSI 8.8L	<ul style="list-style-type: none">• Build and test prototype engines in 2016• Complete engine development in early 2017• Prepare commercialization plan early 2017