Successes and Challenges Reducing Urban Air Pollution and Addressing Climate Change

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This presentation addresses three subjects: 1) Progress reducing urban ozone and PM2.5 air pollution in California; 2) Issues concerning whether mass or particle number should be the form of PM2.5 standards; and 3) Efforts to reduce greenhouse gas emissions.

Progress Reducing Urban Air Pollution - Los Angeles has held the title of "city with the worst air pollution" in the USA for all but one year in the past 50 years. In the 1960s, ozone air pollution was more than five times the level considered safe today. Beijing currently experiences similar severity of PM2.5 air pollution in the winter. Fortunately air pollution in Los Angeles has been greatly reduced, and attaining the national ambient air quality standards for PM2.5 will occur by 2020, and by 2030 for ozone, ending urban air pollution in California and the USA.

Some statistics help illustrate the progress being made. The number of days in Los Angeles with unhealthy levels of ozone has decreased 39% in the past 22 years, even though population and vehicle travel has increased by 21 and 25% respectively. The highest measured ozone concentration today is 11 parts per hundred million, compared to the ambient standard of 7.5and historical values as high as 50. Annual average PM2.5 concentration in Los Angeles have decreased by 49% over the past 13 years, and the highest annual average is 15 ug/metre^3, compared to the ambient standard of 12.

The approach used to achieve these dramatic improvements in air quality is relatively straightforward. Identify all the sources of direct and precursor emissions, apply technology to reduce emissions, and set technology–forcing standards where the technology has not yet been commercialized. Behavior changes have played only a small role. Admittedly, implementation of this approach has been challenging and slower than desired due to resistance from affected parties and the cost of compliance.

PM2.5 Control Approach – California and the USA have focused on controlling the mass of PM2.5. Ambient standards, set based on health studies, have the form of mass per unit volume. The standards for emitting sources are also usually expressed in mass, such as grams/kw-hr for large diesel engines, and grams per mile for passenger vehicles, and this has been the case for many decades.

As our understanding of ultrafine particles improved, CARB and other agencies looked to the latest health studies to see if ultrafine particles were related to health impacts that differ from those associated with PM2.5 mass. Understanding the health impacts is a prerequisite to adopting any new or revised regulatory action, including the form of an ambient standard and a control limit on a source of emissions. In the past year two new reviews of the health impact of ultrafine particles compared to PM2.5 mass have been published in the USA. The Health Effects Institute (HEI), and the US EPA both have concluded that there is insufficient evidence to support a unique health effect of ultrafine particles not already associated with PM2.5. Until such evidence is produced, California will most likely continue to rely on mass based PM standards to protect public health.

Reinforcing this view are several factors. Progress is being made in reducing direct and precursor emissions such that the attainment of the mass based PM2.5 ambient standards (annual and 24 hour)

will be achieved this decade. Control technologies for heavy-duty vehicles are designed to require use of catalyzed particulate filters, which reduce mass and particle number by two orders of magnitude. The agencies are keeping their eyes on the ability of the filters to create ultrafine particles during certain operating conditions. In recently setting a 1 mg/mile PM standard for gasoline cars, the feasibility of measuring PM mass at such low levels was raised. Working with automobile manufacturers and the US EPA, CARB recently reported that the accuracy and precision of an improved mass measurement is adequate for determining compliance with a 1 mg/mile PM standard. Finally, recent modeling of ambient PM formation in Los Angeles' atmosphere has shown that control of directly emitted PM2.5 is the most effective way to reduce ambient PM2.5. However, to accelerate the rate of improvement, NOx emission reduction is also needed and effective.

Addressing Climate Change – One of the greatest challenges facing society is climate change, a view shared by California's leaders and the majority of its citizens. Although accounting for only 2 percent of the world's greenhouse gas (GHG) emissions, California has begun a comprehensive program with two goals: 1) return GHG emissions to 1990 levels by 2020; and 2) reduce GHG emissions by 80% by 2050, economy wide. The objective is to demonstrate leadership and what can be done to reduce GHG emissions. A plan to meet the 2020 goal was adopted and has been largely implemented, and thus it is clear the 2020 goal will be met. This short term plan included adoption of GHG emission standards for new passenger vehicles, GHG standards for in-use trucks and trailers, a low carbon fuel standard, a 33 percent renewable requirement for electricity generation, a source of funds to encourage increased energy efficiency in existing buildings and homes, recapture and destruction of fluorocarbon compounds previously used in foam insulation, and numerous other measures.

A longer term plan aimed at achieving the 2050 goal is also being developed. At its core is a cap and trade program that has been adopted and three auctions have been held, yielding a price of about $14 a ton. With respect to transportation, more stringent GHG emission standards for 2026 models will be developed. However, to meet the 2050 goal of an 80% reduction of GHGs, most passenger vehicles, which in California currently account for about one quarter of all GHG emissions, will need to be electric drive vehicles using fuels with a low carbon footprint, such as renewable electricity and hydrogen. To achieve this goal, California has adopted a Zero Emission Vehicle (ZEV) mandate which by 2025 requires 15% of new vehicles sales to be zero or near zero emissions. The objective is to accelerate a commercial market for ZEVs, which hopefully will grow quickly to achieve the 2050 goal. Other technologies, such as gasoline hybrid electric and natural gas vehicles, do not have low enough life cycle GHG emissions to achieve an 80% reduction, and thus serve as an interim technology. Fueling infrastructure for plug-in and hydrogen fuel cell vehicles is being installed with state assistance.

Summary – The end of urban air pollution in the USA is in sight. Many megacities with severe air pollution can follow the approach used in California and the USA to address the public health consequences in a timely manner. California hopes its experience addressing climate change can be used to help accelerate efforts in the USA and worldwide to address this global problem.

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(retired)

17th ETH Conference – Nanoparticles
Zurich - June 25, 2013

Outline

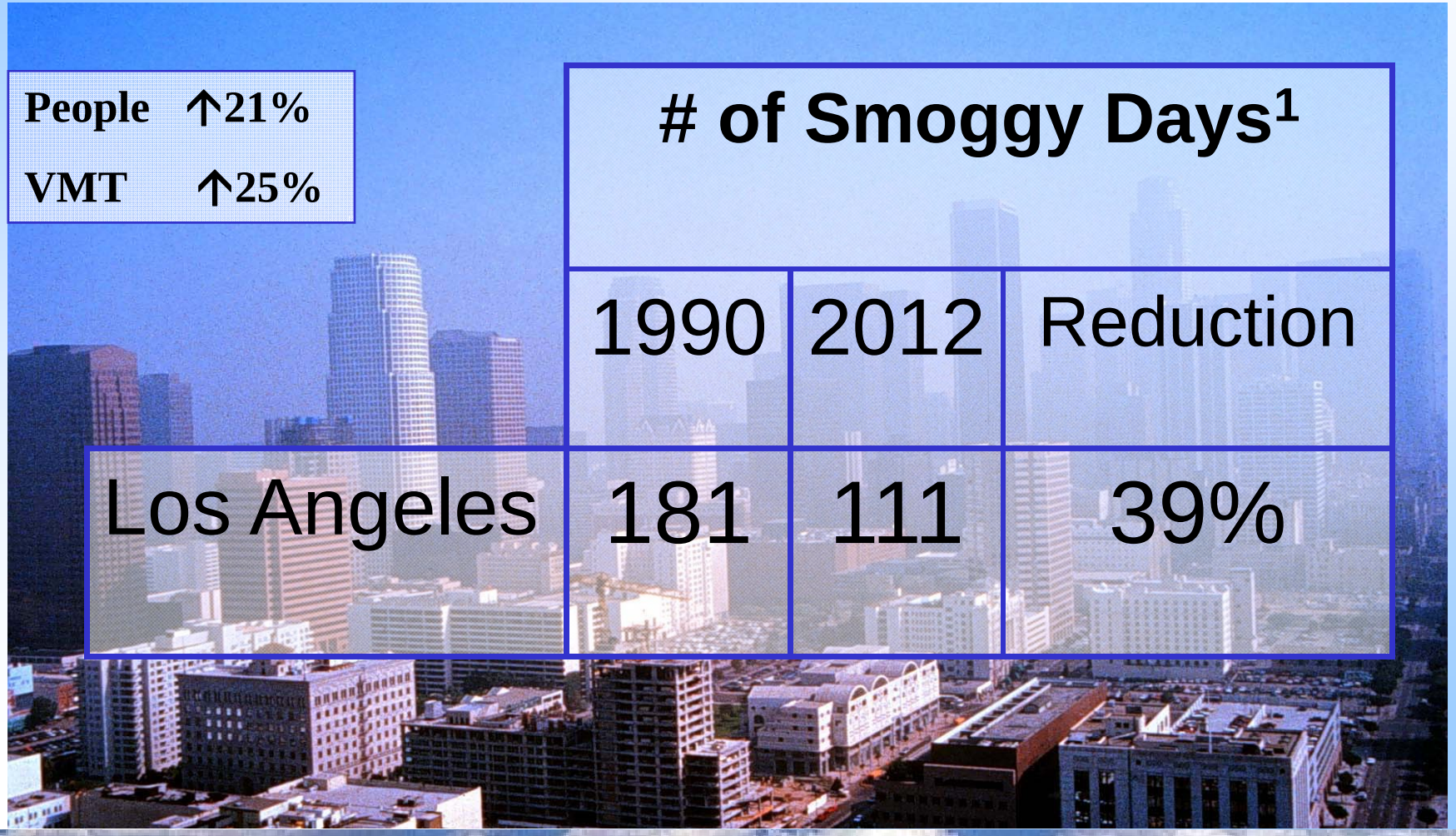
- **Reducing urban air pollution in California**
  - **Ozone**
  - **PM2.5**
- **Issues regarding PM2.5**
- **Addressing climate change**

Summertime Smog Less Frequent

People ↑21%

VMT ↑25%

# of Smoggy Days[1]			
	1990	2012	Reduction
Los Angeles	181	111	39%



[1] Pollution exceeds 8 hour ozone standard

Control Program Has Reduced PM2.5

	Decrease in Particle Pollution[1] - 1999-2012
Los Angeles	49%
San Joaquin Valley	42%

[1] Annual average PM2.5, ug/m^3

Air Quality Has Improved Greatly

Highest Concentration in Period, Los Angeles

Year Period	O_3 8 hour, pphm	$PM_{2.5}$ annual, ug/m^3
1975-79	35	---
1980-84	34	---
1985-89	29	---
1990-94	22	---
1995-99	21	---
2000-04	15	31
2005-09	14	21
2010-12	11	15
Attain clean air	2032 (7.5 pphm)	~2025 (12 ug/m^3)

Policy Issues: $PM_{2.5}$ Control

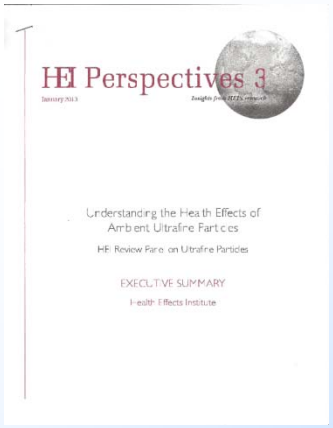
- **Policy question:**
  - Should the number of ultrafine particles be controlled in addition to or in place of PM mass?
- What do health studies say?

What Do Health Data Say?

- $PM_{2.5}$ mass strongly related to adverse health effects
  - Animal and human studies
  - Cardiovascular and respiratory impacts
  - Mortality
- Ultrafine particles (<100 nm)
  - Suggestive evidence UFP could have different effects that $PM_{2.5}$
  - Health studies inadequate to date

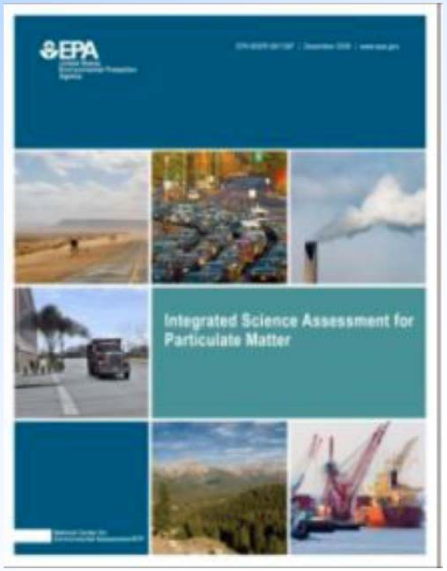
Health Effects Institute Review

- Understanding the Health Effects of
- Ultrafine Particles, January, 2013



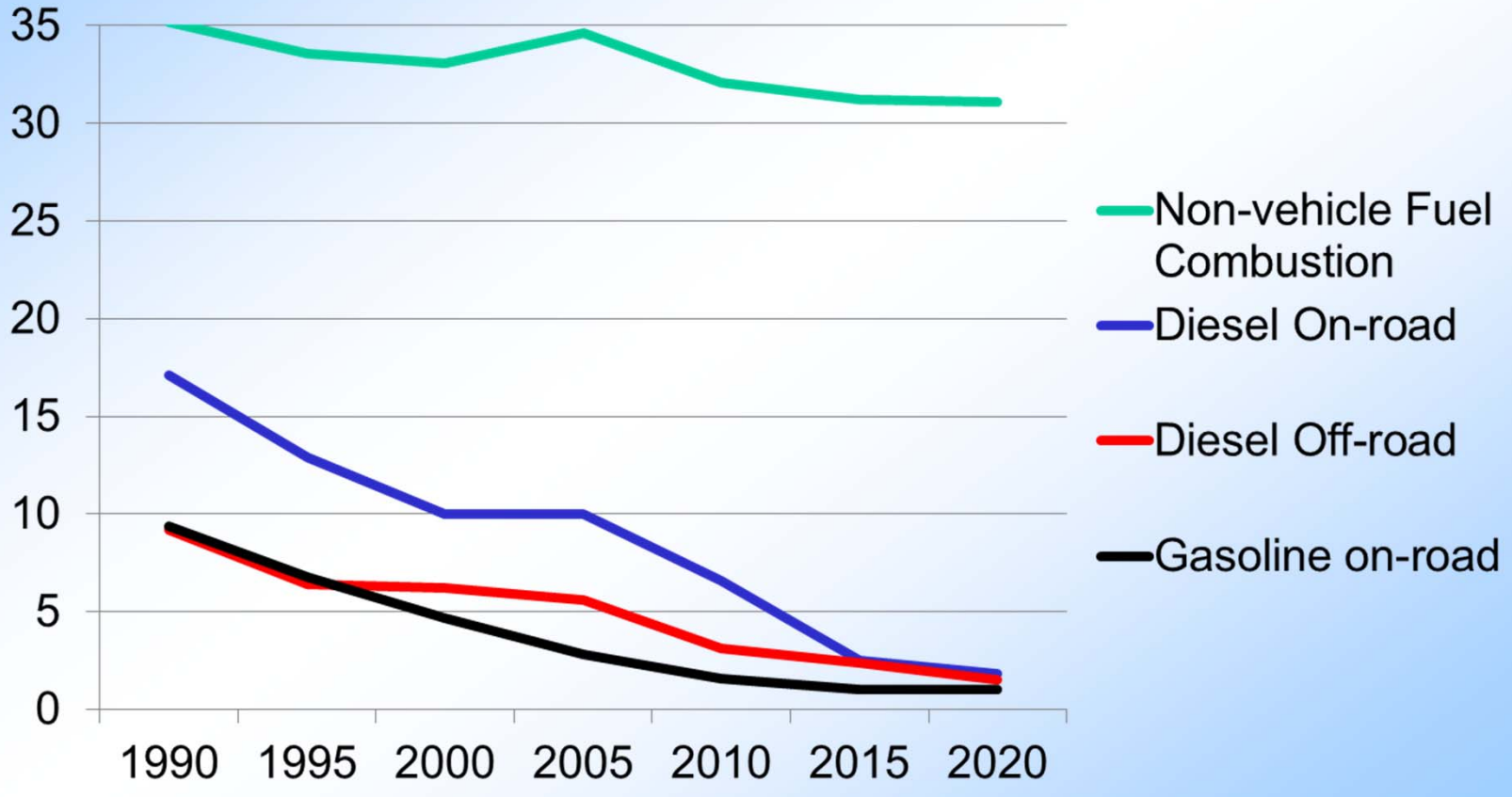
  - "The current evidence does not support a conclusion that exposures to UFPs alone can account in substantial ways for the adverse effects that have been associated with other ambient pollutants such as $PM_{2.5.}$"

USEPA Review of Health Effects of PM



Size fraction	Health Effect	Causality? Short term	Long term
PM2.5	Cardiovascular	**Causal**	**Causal**
	Respiratory	**Likely**	**Likely**
	Central nervous	Inadequate	
	Mortality	**Causal**	**Causal**
	Cancer		Suggestive
Ultrafine PM	Cardiovascular	Suggestive	Inadequate
	Respiratory	Suggestive	Inadequate
	Central Nervous	Inadequate	Inadequate
	Mortality	Inadequate	Inadequate

$PM_{2.5}$ Emissions
Fuel Combustion*



*** Greater Los Angeles**

Vehicle $PM_{2.5}$ Control Technology

- Diesel filters reduce both exhaust mass and number by >2 orders of magnitude
  - However nucleation of non-carbonaceous material can occur
- Gasoline DI vehicles can achieve <1 mg/mile
  - Aggregate gasoline $PM_{2.5}$ emissions comparable to diesel trucks in 2020 (trucks filter-equipped)

Measurement Issues
Passenger Vehicles

- Mass measurement at low levels (sub-1 mg/mile) has been demonstrated*
  - Not a barrier to mass-based emission standards
    - Detection > 0.28 mg/mile possible
    - Variability of tunnel suggests 0.2 mg/mile margin needed for compliance (~90% chance of passing at 1 mg/mile)
- Other measurement methods available
  - Real time soot measurement
  - Counting number of particles (solid+volatile)
  - Integrate particle size distribution

* CARB; 23rd CRC ON-ROAD VEHICLE EMISSIONS WORKSHOP, April 2013

$PM_{2.5}$ Considerations

- Controlling primary PM most effective in reducing ambient PM2.5 (Los Angeles)
  - 2X as effective compared to NOx (per % change in current inventory)
  - 15X as effective (per ton of emission reduction)
- Controlling NOx still helpful due to large emission inventory
- ZEVs the ultimate solution for mobility

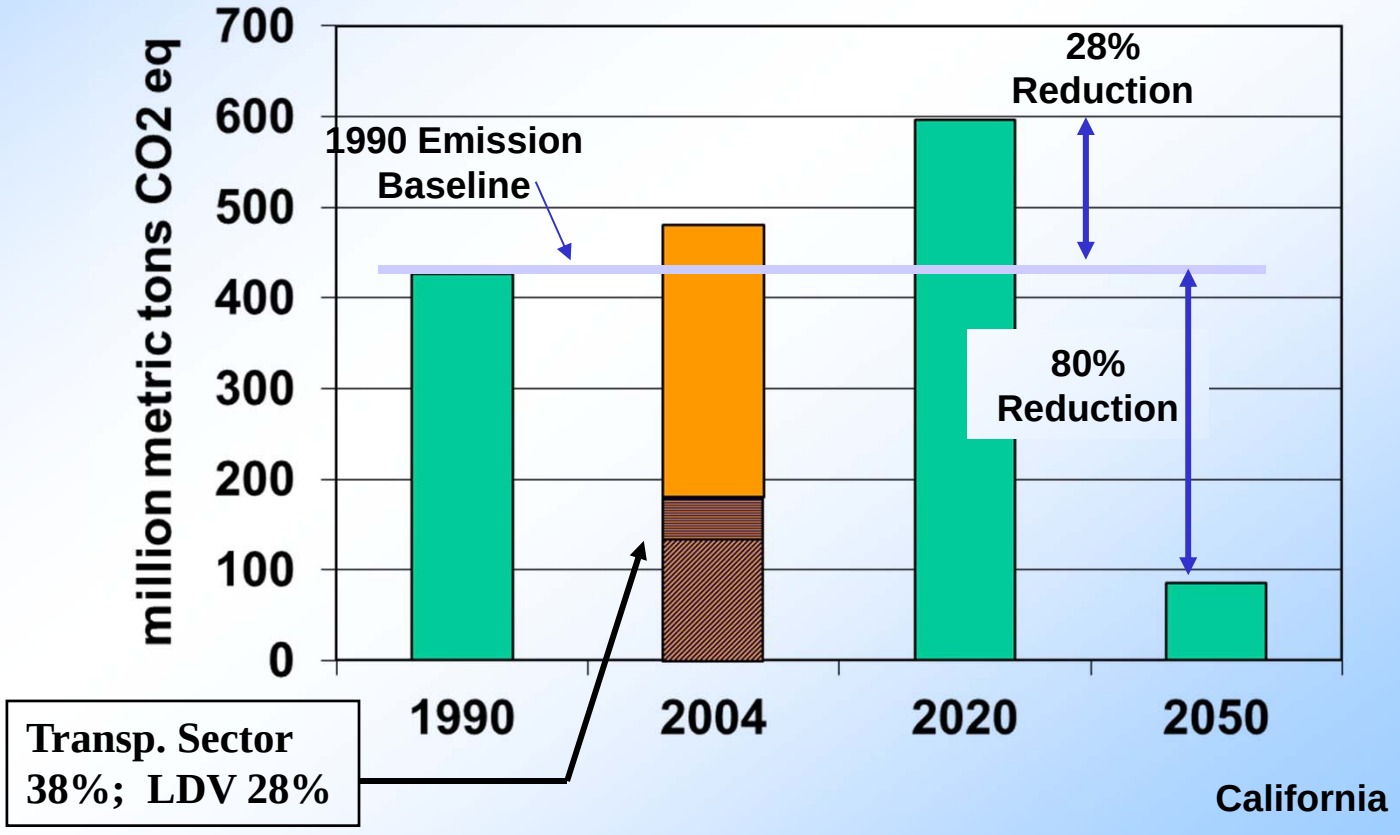
How is California Addressing Climate?

- **Comprehensive program to address climate**
  - Objective is leadership (California only 2% of world GHG emissions)
- **Goals:**
  - 1990 GHG emission levels by 2020
  - 80% GHG reduction by 2050 (from 1990)

- **Strong legislation adopted in California**
  - Responsibilities assigned to CARB
  - Blend of regulation and market mechanisms
  - US effort lagging

Magnitude of the Climate Challenge

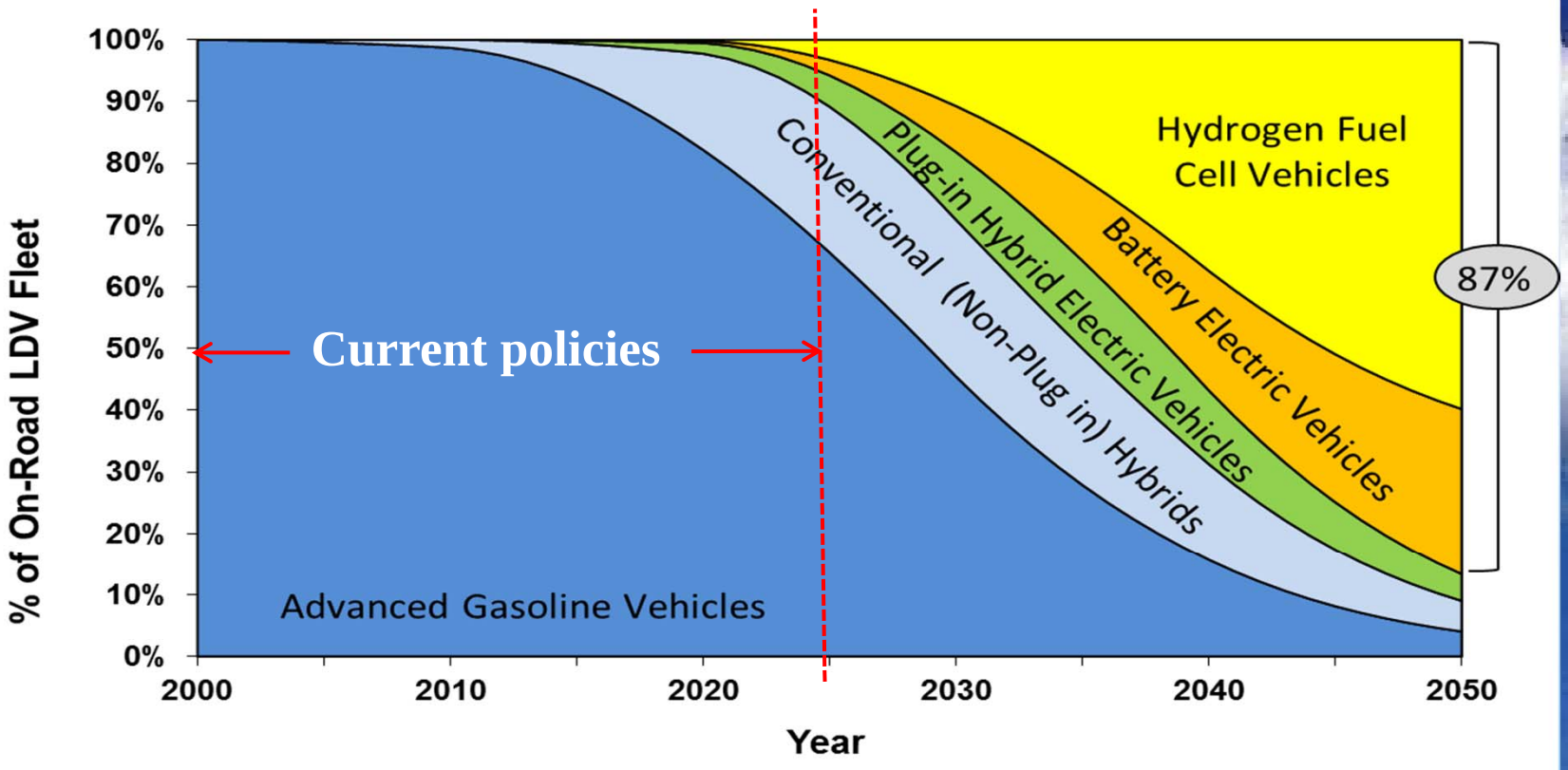
All Sources: California



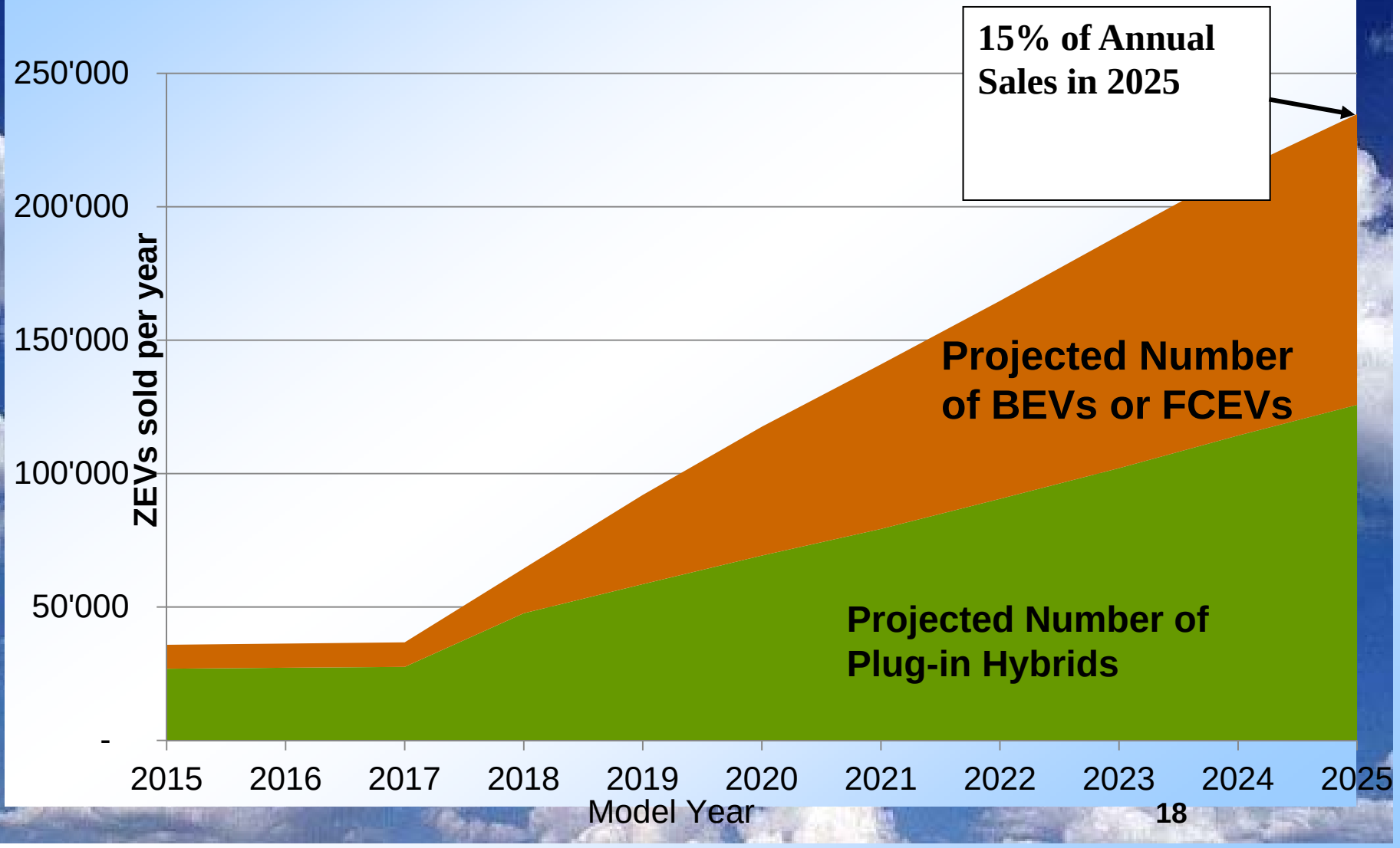
California Climate Action Program Near Term Goal Will Be Met

Major Source of GHG	Actions Taken
Passenger vehicles (LDV)	GHG emission standards: 50% reduction by 2025 ZEV mandate: 15% of new sales by 2025
Heavy trucks (new)	National standards for engines/tractors: 9-23% reduction by 2017
Heavy truck (in-use, California)	Trailer aerodynamic devices: 5% reduction by 2016
Electricity	33% renewable by 2020
Fluorocarbons	Recapture and destroy
Combustion, fuels	Cap and trade program, 3 auctions, $14/ton

Meeting Long Term GHG Goal: Passenger Vehicles



ZEV Regulation - 2015-2025



ZEVs for Sale - 2012-2015

Plug-In Hybrids





Fuel Cell Vehicles




Battery Electric Vehicles










Summary of Fuel Infrastructure Development Progress

Number of Public Refueling Stations Available

Year	Hydrogen stations	Public Electric Charging
2012	8	~3000
2017	68	>15,000

California Climate Action Program Longer Term Goal

Major Source of GHG	Planned Actions
Passenger vehicles	Major conversion to electric drive
	Reduce growth of VMT by 20%
Heavy trucks	Drop-in renewable bio-diesel; or DME
Electricity (for transportation)	60-70% renewable
Combustion, fuels, others	Expanded cap & trade

Summary

- **Improvements in urban air quality a success story**
  - Driven by technology-forcing regulations
  - Exceptional technology development by industry
  - Strict enforcement of rules
  - Clean air for everyone in USA achievable soon

Summary

- **Climate change remains a huge challenge**
  - Emissions increasing worldwide
  - Transformation to electric drive and low carbon fuels necessary
    - Must accelerate transformation soon