The Future of Biogas Engines in Extreme Ozone Non-Attainment Areas

SANITATION DISTRICTS OF LOS ANGELES COUNTY

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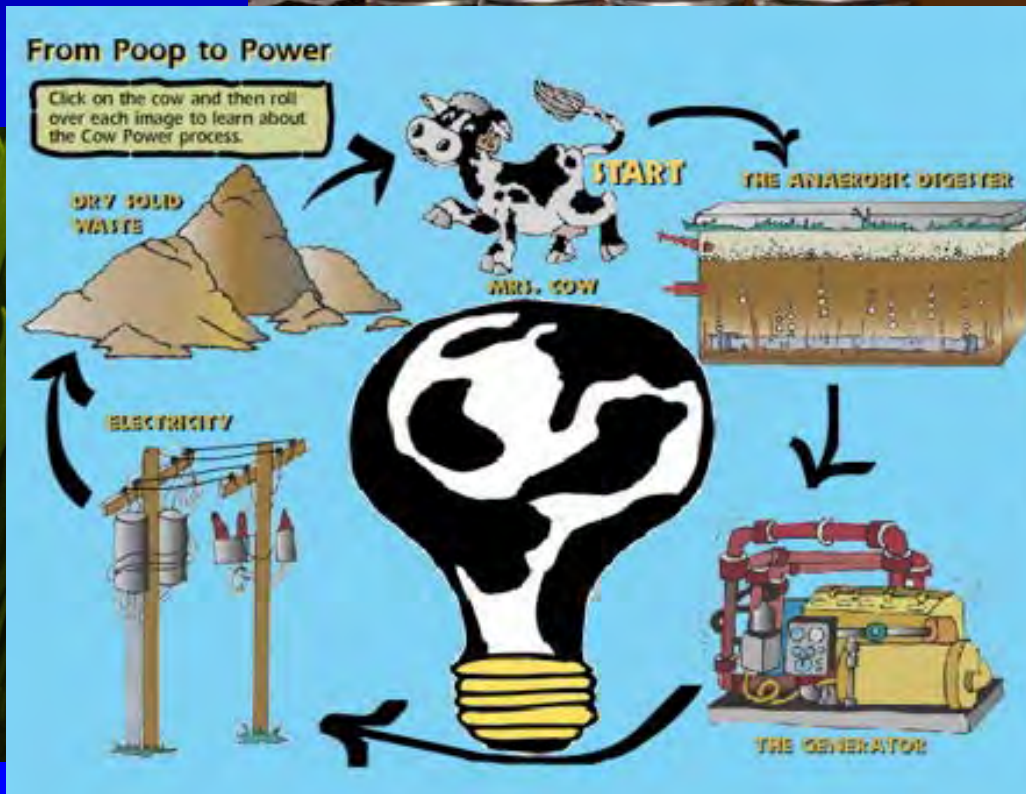
Why Regulate Biogas Engines?



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Ground level or "bad" ozone is not emitted directly into the atmosphere, but is created by chemical reactions of oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight.

NOx + VOC + Sunlight

= OZONE

Ground-Level Ozone → SMOG

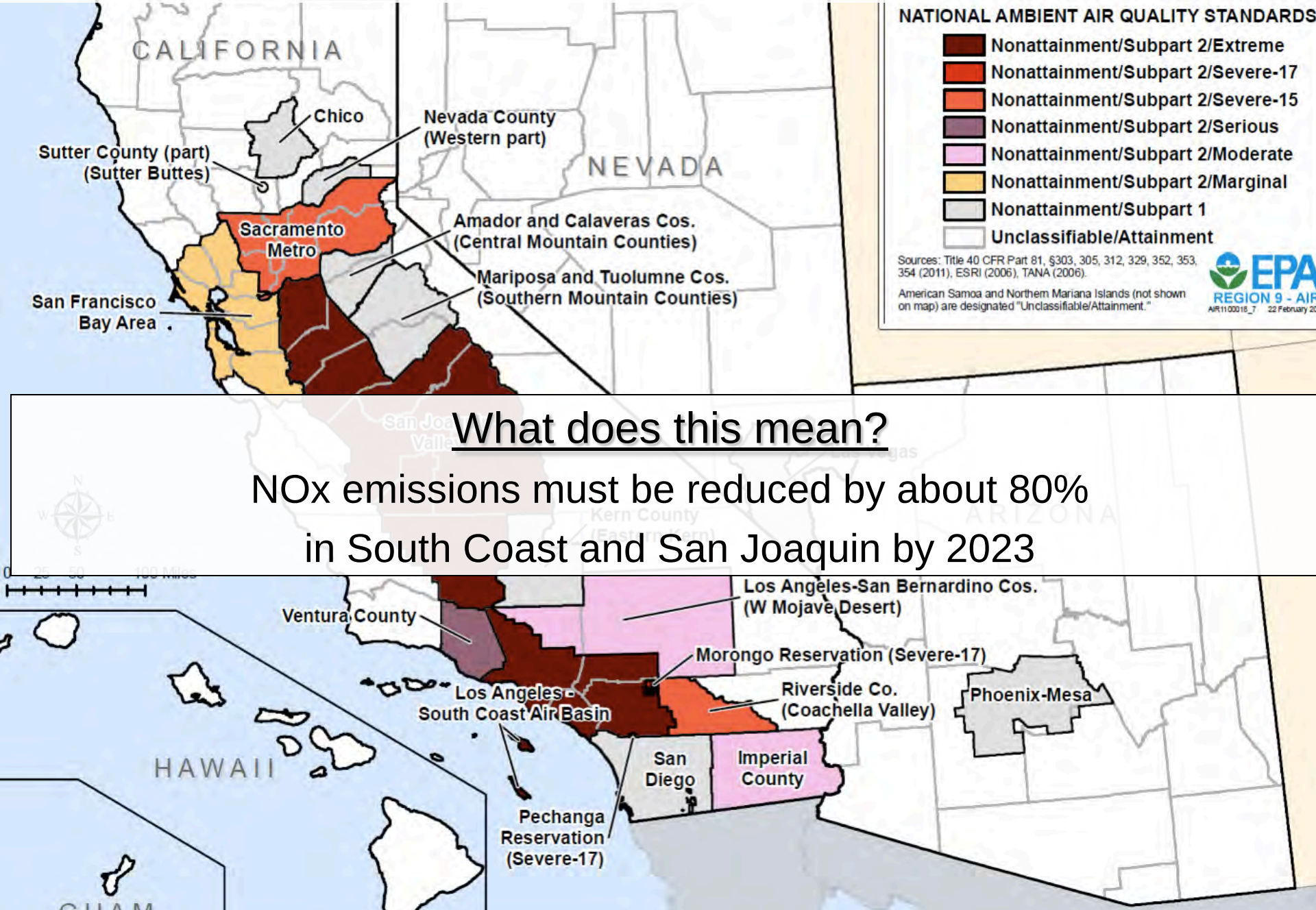
Ground-Level Ozone:

- Reduces lung function and increases respiratory symptoms
- Causes increased susceptibility to respiratory infections
- May contribute to premature death, especially in people with heart and lung disease

Clean Air Act:

- Created in response to serious smog incidents and to protect human health
- Established National Ambient Air Quality Standards (NAAQS)
- Requires EPA to review and, if appropriate, revise the NAAQS every five years

Ozone Non-Attainment Areas

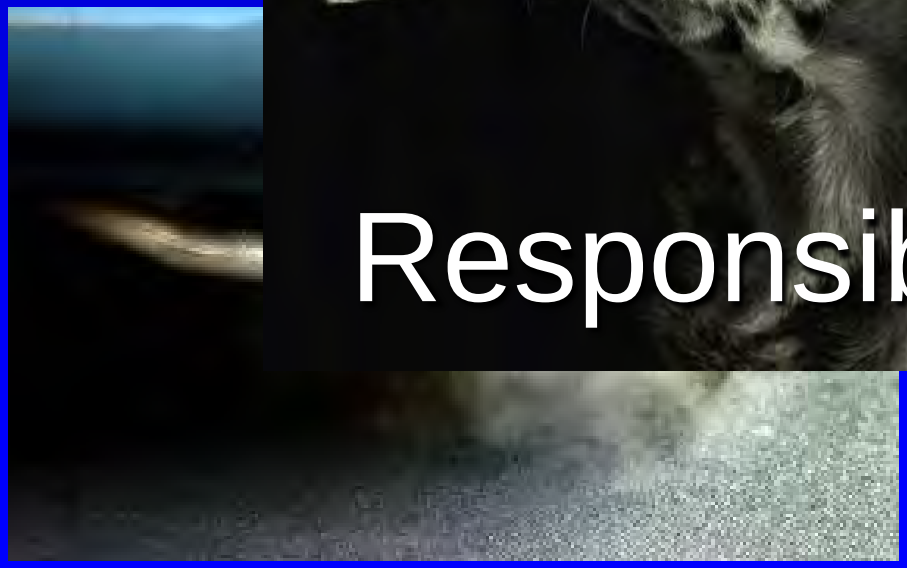


What does this mean?

NOx emissions must be reduced by about 80%

in South Coast and San Joaquin by 2023

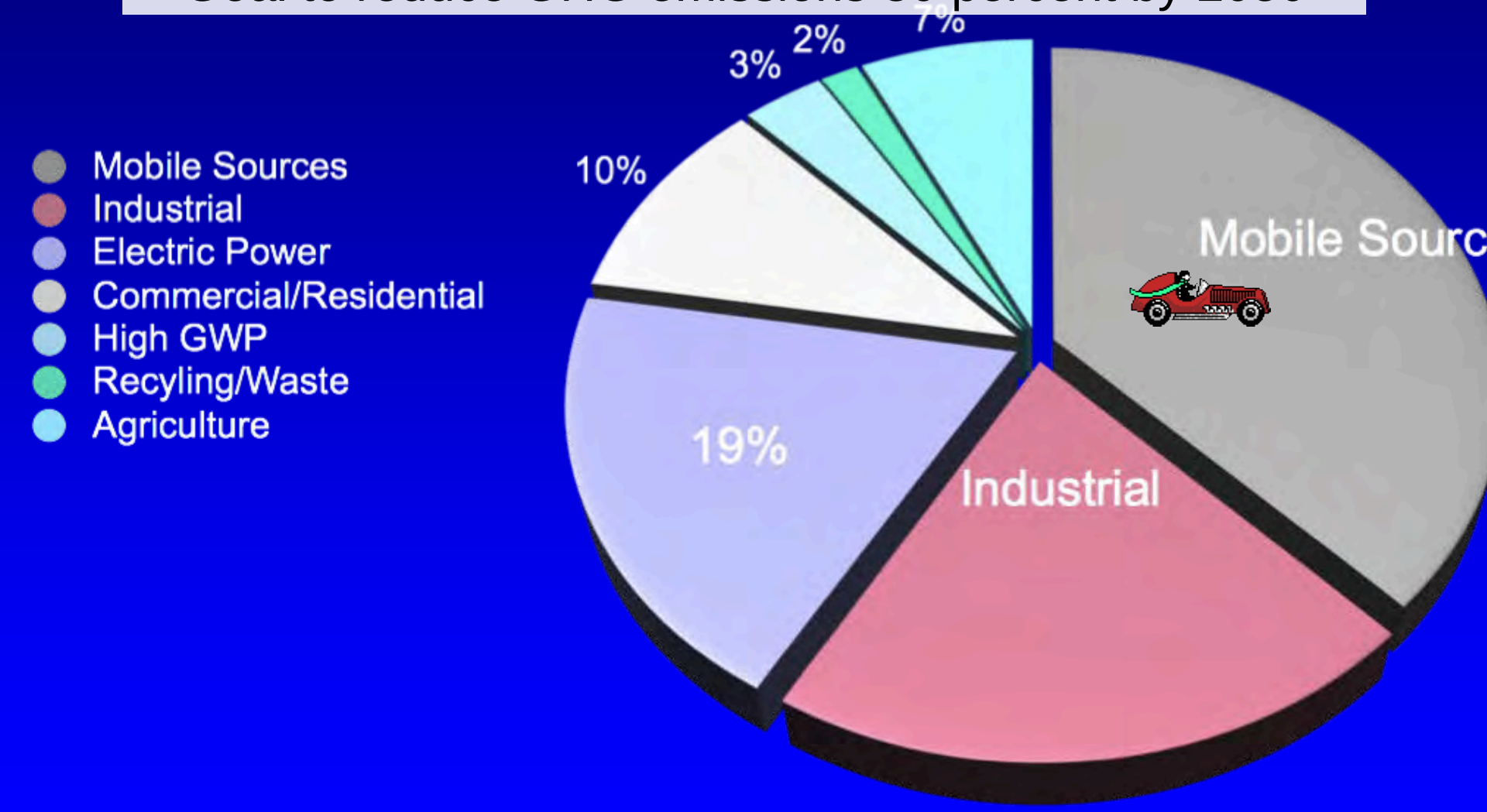
Sources of Ozone Forming Emissions



Sources of Ozone Forming Emissions

What About GHG Emissions?

Goal to reduce GHG emissions 80 percent by 2050



Source: 2011 California Air Resources Board Inventory

How to Climate Change Goals and Achieve Ozone Attainment?

- CARB, SCAQMD & SJVAPCD's Vision Plan:
  - Coordinated solutions to air quality and climate goals
  - Deploy zero- and near-zero technologies
  - A combination of strategies — technology, energy, and efficiency — applied to each sector
  - Transformation of the upstream energy sector and its greenhouse gas and smog forming emissions concurrent with the transformation to advanced technologies downstream

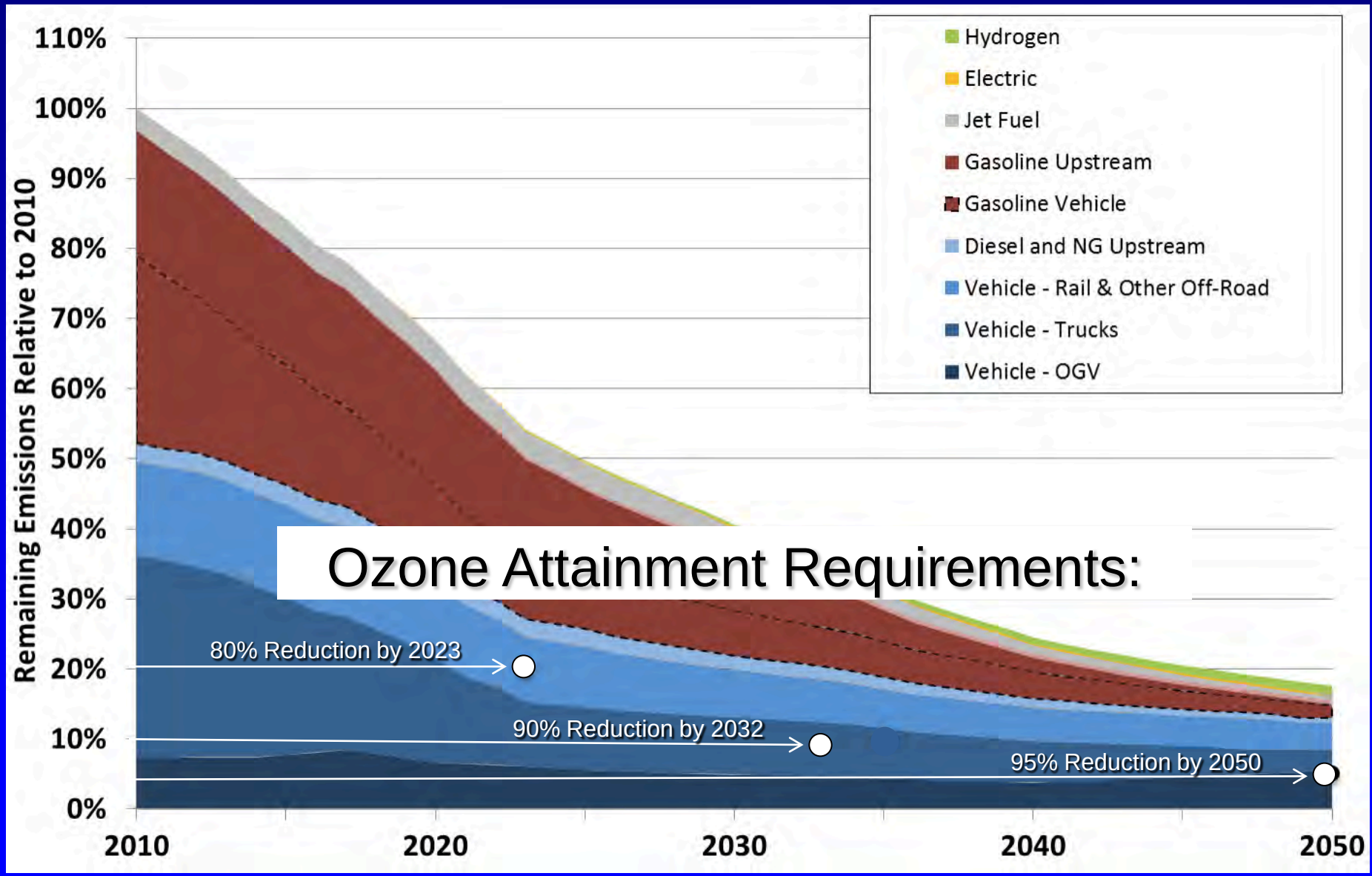
Source: Draft Vision for Clean Air: A Framework for Air Quality and Climate Planning, June 27, 2012

How to Climate Change Goals and Achieve Ozone Attainment?

- By 2040, all passenger vehicles sold in California are zero-emissions vehicles
- By 2050, truck fuel economy doubles and NOx emission standards are 80 percent below the current standards
- Nearly all future locomotives are zero-emission or near-zero emission such as hybrid-electric
- Future jet engines are 75 percent cleaner in terms of NOx emissions and all burn renewable jet fuel
- By 2050, all liquid fuels are derived from renewable feedstocks

Source: Draft Vision for Clean Air: A Framework for Air Quality and Climate Planning, June 27, 2012

Vision Plan Scenario
(Transportation Sector NOx Reductions)



What about the Stationary Sources?

- Stationary Sources should expect further reductions will be imposed to achieve ozone attainment standards
- Existing requirements included in the State Implementation Plan (SIP) cannot be relaxed
- Expect higher emitting sources of ozone forming emissions will be regulated
- Ozone attainment requirements outweigh climate change goals

Biogas Engine Emissions SCAQMD Rule 1110.2

55x higher

74% reduction

Central Power Plants

Rule 1110.2 Current Limits

Rule 1110.2 2016 Limits

SCAQMD Rule 1110.2

- Retrofit requirements imposed because biogas engine emissions were deemed to be high
- Current biogas NOx limit 36 ppmvd
- In 2011, the proposed limit was achieved using pretreatment, oxidation catalyst and SCR
- SCAQMD revised rule on September 7, 2012
- By January 1, 2016, existing biogas engines must reduce NOx emissions to 11 ppmvd

Difficult to achieve because biogas is not natural gas

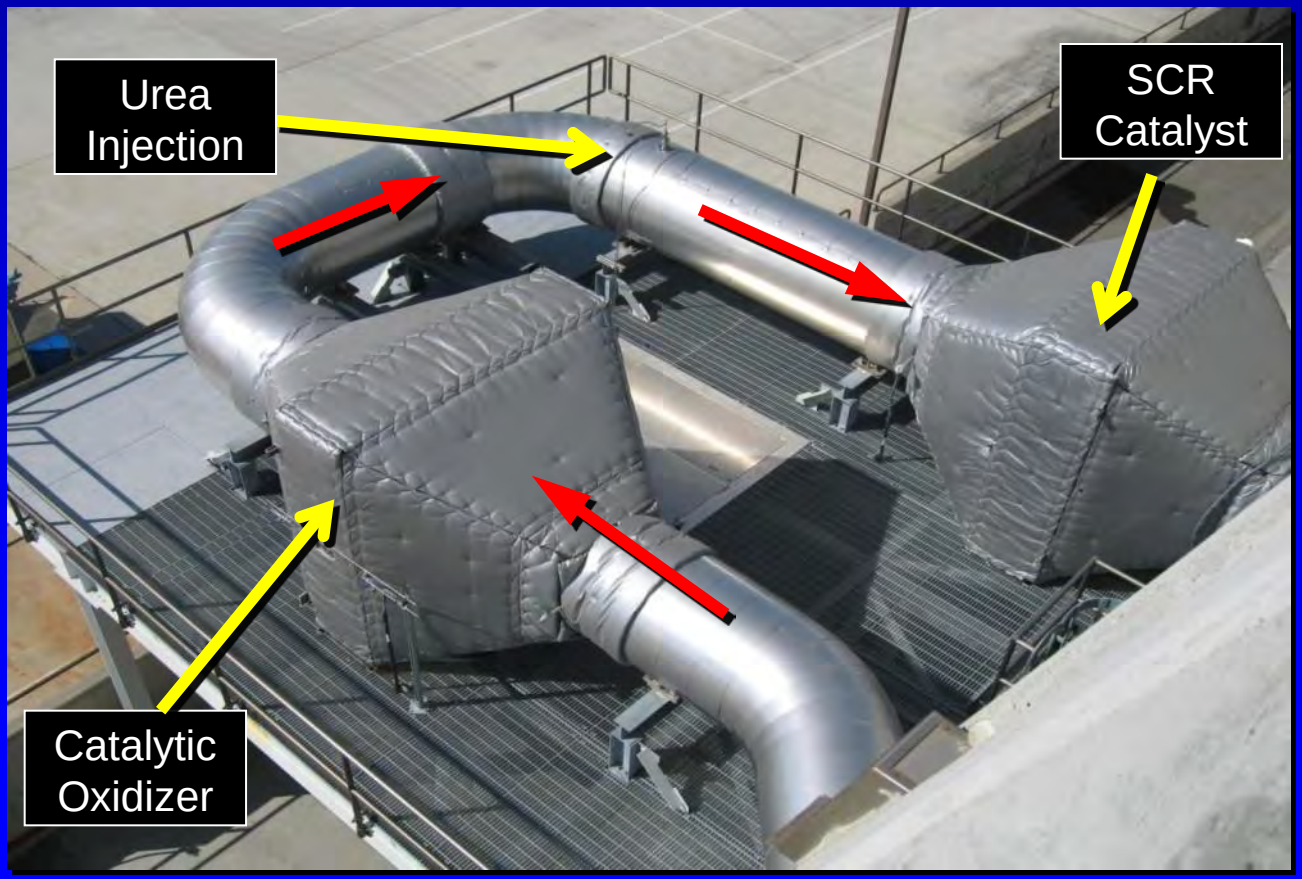
Siloxanes

The hidden threat to biogas systems

Ralph B. ("Rusty") Schroedel Jr.,
Peter V. Cavagnaro, and Jerald W. Peterson

Biogas Engine Retrofit Options Catalytic Oxidizer/SCR

- Pretreatment needed
- Only proven retrofit technology
- Costly

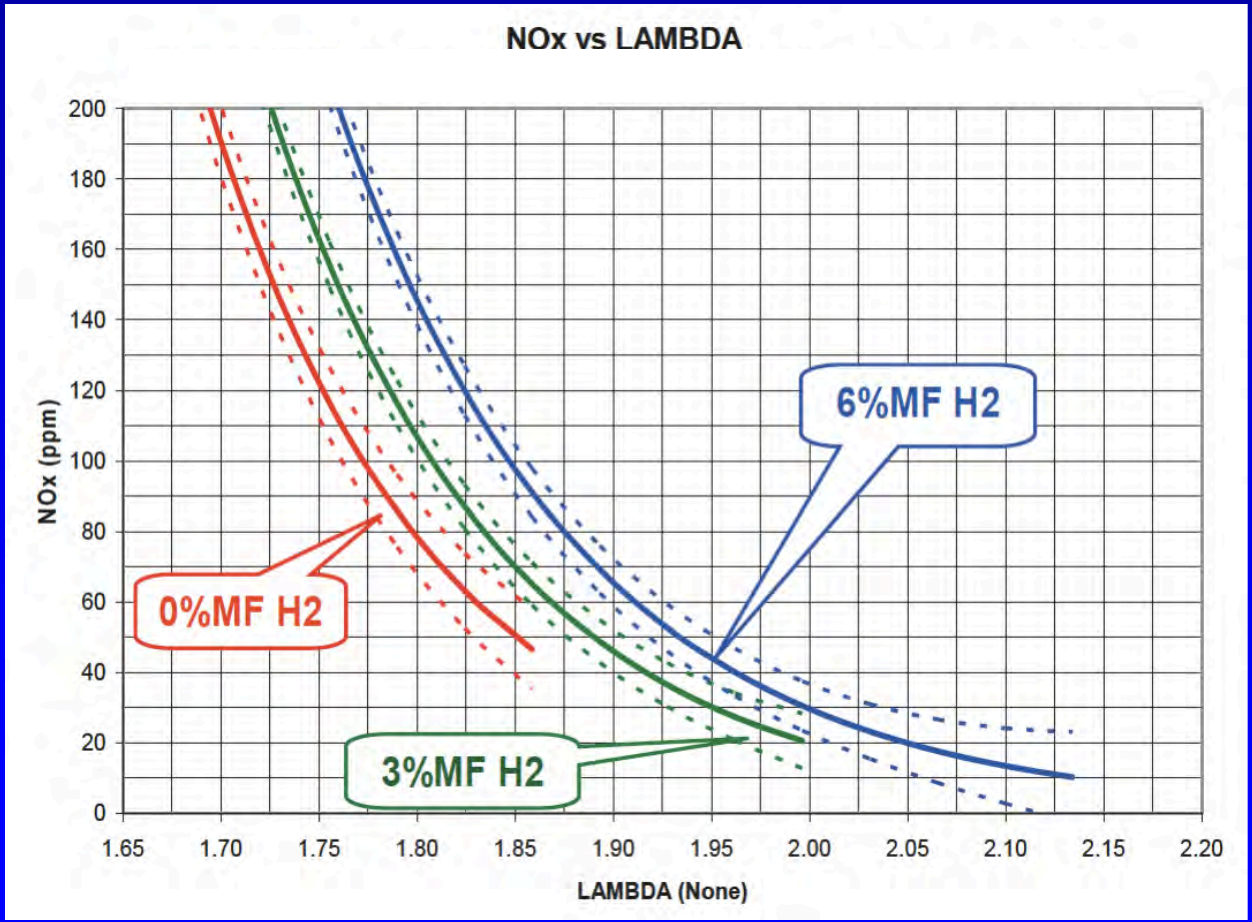


Biogas Engine Retrofit Options Selective Non-Catalytic Reduction

- No pretreatment needed
- Biogas demonstration to be completed by 2015
- Potentially Cost Effective

Biogas Engine Retrofit Options
Hydrogen Assisted Lean Operation

- No pretreatment needed
- Demonstration to be completed by 2015
- Potentially
  Cost Effective



Other Compliance Options

Shutdown Existing Biogas Engines by 2016 and:

- Replace with Fuel Cells or Turbines
  - May trigger BACT
  - Contaminant pretreatment needed
  - Costly
- Flare
  - Low or no capital expense
  - Waste of renewable fuel
- Pipeline Injection or Transportation Fuel
  - Few air regulations
  - Other biogas opportunities

Biogas Opportunities

- Anticipated increased demand for renewable fuels

- Climate Change benefit
  - One of the lowest carbon emitting fuels*
  - To achieve California's climate change goals, greater financial incentives may be necessary

- Ozone Formation
  - Potential for 90% reduction in NOx emissions

* - Carbon intensity value of 11.26 for landfill gas compared to 99.18 (gCO_2e/MJ) for gasoline

Conclusions

- Stationary Source requirements are increasing the cost of biogas energy projects
- Without cost-effective retrofit options many biogas engines in South Coast will shutdown by 2016
- To achieve California's climate change goals, additional renewable fuel incentives may be required
- Ozone attainment will require significant lifestyle changes in California
- Ozone standards may not be achievable in the South Coast and San Joaquin Valley Air Basins

Questions?

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