

Current Trends in Worldwide Desulfurization

Roundtable on Low Sulfur and Alternative Fuels in Brazil

Michael P. Walsh

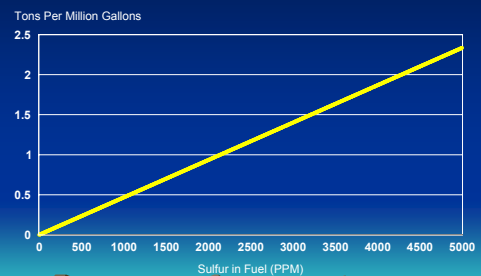
Overview

- Why Low Sulfur Fuels
- Worldwide Trends and Tendencies
- International Experience Regarding The Benefits and Costs of Reducing Sulfur

Why Low Sulfur Fuel?

- Lowers Emissions From Existing Vehicles
 - SO₂ From All Vehicles
 - PM From Diesel Vehicles
 - CO, HC, NOx, Toxics From All Catalyst Vehicles
- Enables Advanced Technologies & Tight Standards For New Vehicles
- Enables Retrofit Technologies To Clean Up Existing Vehicles

Tons of Directly Emitted PM From Diesel Fuels Sulfur

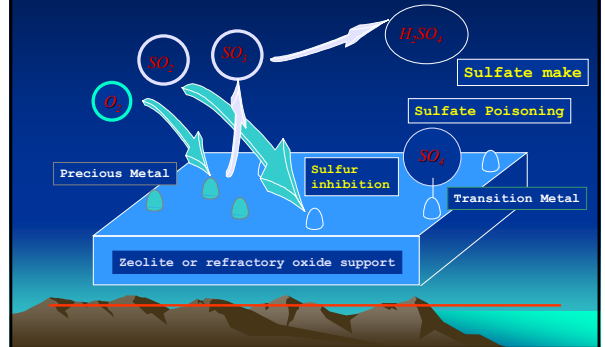


Derived From US EPA Data

Fuel Sulfur Negatively Affects All Catalyst-Based Emission Control Technology

- Impacts of Sulfur
 - SO₂ Sticks to Catalyst Sites (Chemisorption)
 - Inhibits Gaseous Catalytic Reactions
 - Catalytic Oxidation of SO₂ to SO₃
 - SO₃ Adds to Tailpipe PM Emissions – Up to 40 to 50% of SO₂ Can Be Oxidized to SO₃
 - SO₃ Reacts with Catalyst Base Metal Oxides to Form Metal Sulfate which reduces catalytic activity
- For Catalyst-Based Diesel Particulate Filters, Sulfur Adversely Effects the Regeneration of the Filter
- For NOx Adsorbers, Sulfate Clogs Up and Shuts Down the NOx Storage Mechanism

Sulfur Effects

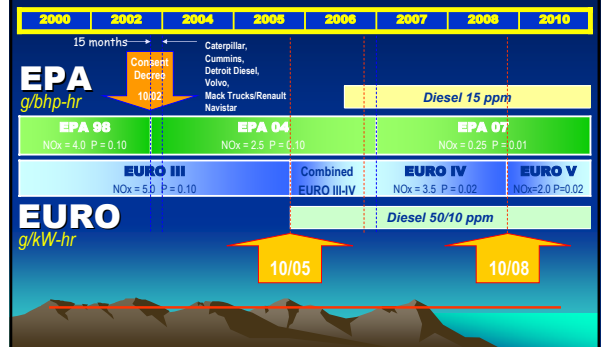


Summary of Influence of Fuel Sulfur on Diesel Exhaust Emission Control Devices

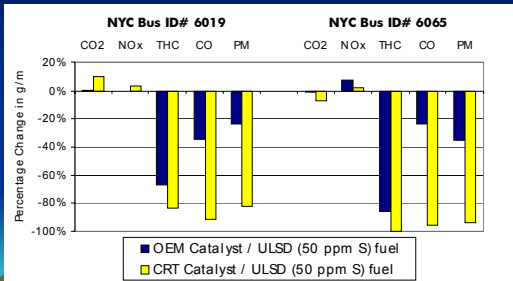
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| <ul style="list-style-type: none"> Control Technology <ul style="list-style-type: none"> Oxidation Catalyst Lean NOx Catalyst SCR with Urea Catalytic Filters NOx Adsorbers | <ul style="list-style-type: none"> Sulfur Effects <ul style="list-style-type: none"> Inhibition, form SO₃ PM Inhibition, form SO₃ PM Inhibition, form SO₃ PM Inhibition, form SO₃ and Affects Regeneration Clogging, form SO₃ and store as sulfate – requires periodic removal |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

All Catalyst Technologies
Adversely Affected

Close Linkage Between Vehicle Emissions Standards and Fuel Sulfur Levels

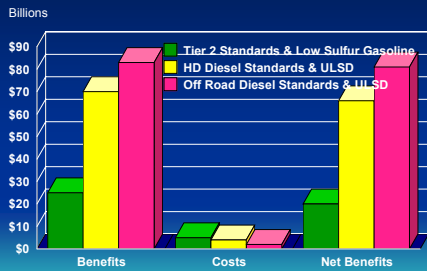


New York City Retrofit Experience



The Costs and Benefits of Shifting To Lower Sulfur Fuels International Experience

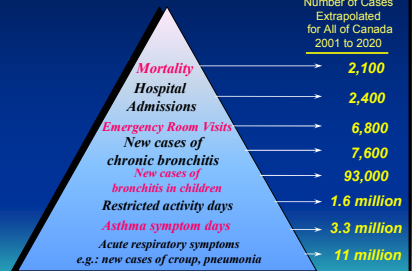
Results of Three Major US Rules



Canada Health Effects Consensus Findings (Independent Expert Panel)

Reducing sulphur to 30 ppm improves the health of Canadians

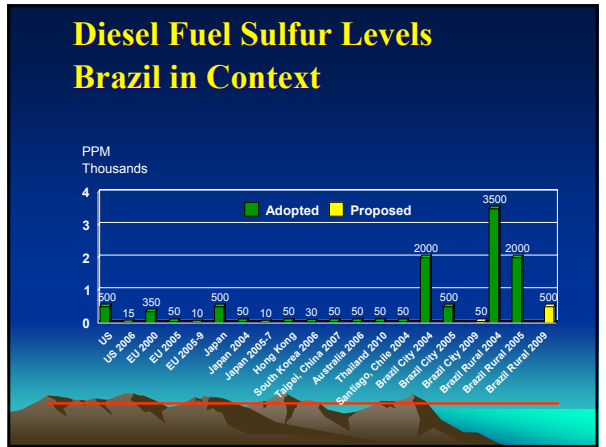
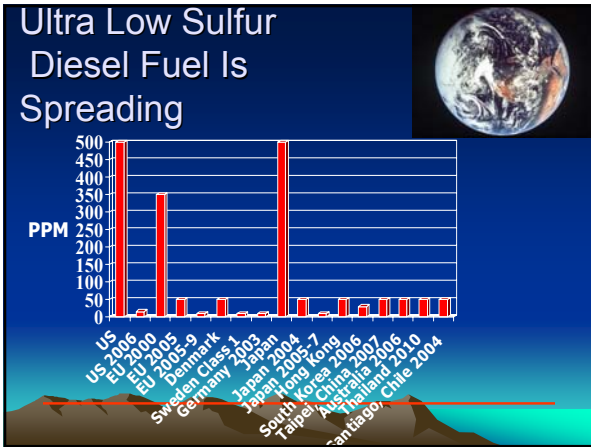
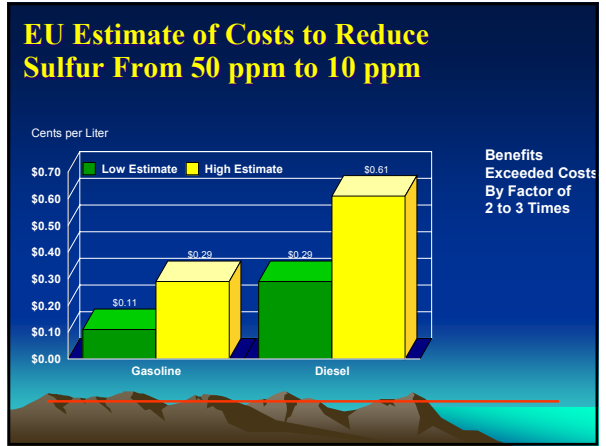
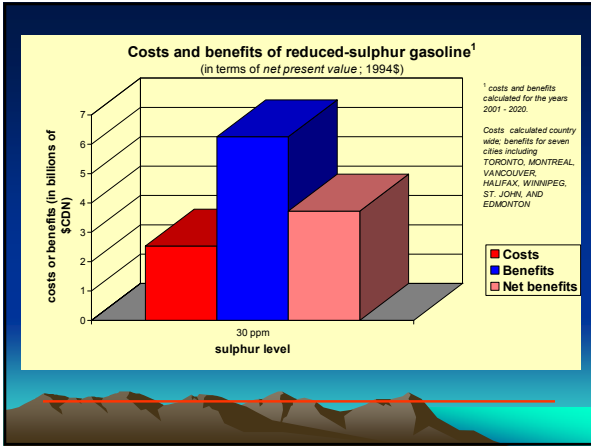
Health Effects of Pollution Mixture May Be Much Greater than Particles Alone

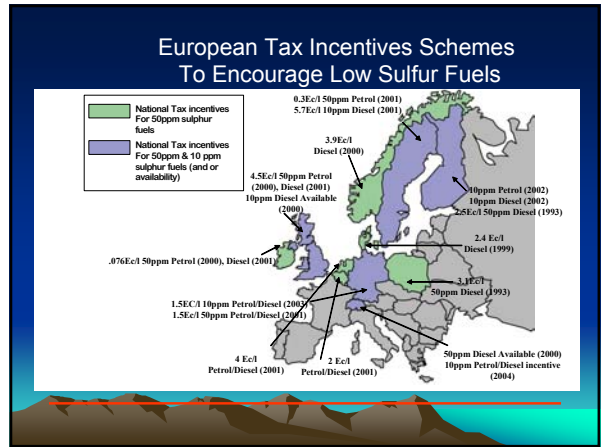
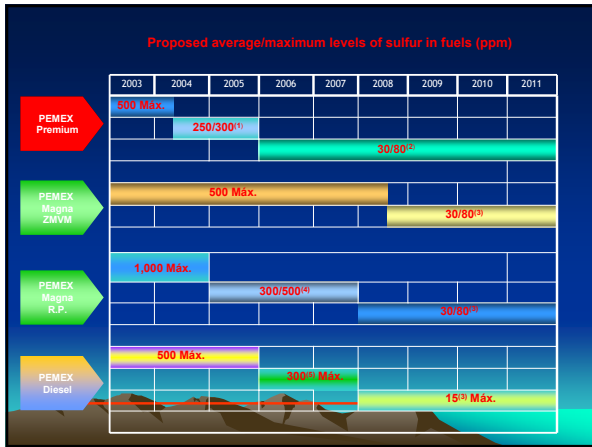


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Canadian Study of Health Impacts of Low Sulfur Gasoline

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Conclusion



- Fuel Quality Is an Integral Part of a Complete Emission Control System for Both Gasoline- and Diesel-Powered Vehicles
- Fuel Sulfur Adversely Effects All Catalyst-Based Emission Control Technology and Needs to Be Reduced
- Using a Systems Approach with Ultra-Low Sulfur Fuel Combined with Advanced Engine Designs and Advanced Emission Control Technology, Cars, Trucks, and Buses Will Emit 99% Less Pollution As Compared to Vehicles in the 1960s

Fuel Sulfur Content: The Lower, the Better

Conclusion (continued)

- Introducing Low Sulfur Gasoline Fuel Will Immediately Improve the Emission Control Performance of Existing Catalyst-Equipped Vehicles
- Introducing Low Sulfur Diesel Fuel Will Enable Existing Engines to be Retrofitted with Advanced Control Technology

