Low-Sulfur Gasoline & Diesel: The Key to Lower Vehicle Emissions

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Executive Summary

It is impossible to clean the air, or in particular to reduce air pollution from the transportation sector, without getting sulfur out of fuels. Sulfur is a pollutant directly, but more importantly, sulfur prevents the adoption of all major pollution control technologies. No significant air pollution reduction strategy can work without reducing sulfur to near-zero levels.

This paper addresses the need to reduce sulfur in transportation fuels and the benefits that can be realized in terms of total pollutant emissions. Sulfur fouls conventional and advanced technologies to control vehicle emissions, including carbon monoxide (CO), particulate matter (PM), nitrogen oxides (NO_x) and hydrocarbons (HC). Low-sulfur fuels are the key to reducing emissions from existing vehicles and enabling advanced control technologies and fuel-efficient designs for new vehicles.

Sulfur is a naturally occurring component of crude oil and is found in both gasoline and diesel. When those fuels are burned, sulfur is emitted as sulfur dioxide (SO_2) or sulfate particulate matter. Any reduction in fuel sulfur immediately reduces these sulfur compounds and, as sulfur levels decline past a certain point, the benefits increase to include total pollutant emissions.

Impact of Sulfur on Vehicle Emissions
Reduced sulfur fuel (~150 ppm) makes existing vehicles cleaner. Reduced sulfur fuel decreases emissions of CO, HC, and NO_x from catalyst-equipped gasoline vehicles and PM emissions from diesels, with and without oxidation catalysts. These benefits increase as vehicles are designed to meet higher emissions standards and sulfur levels are reduced further.

Low sulfur fuel (~50 ppm) allows for the further benefit of advanced control technologies for diesel vehicles. Diesel particulate filters can be used with low sulfur fuel but only achieve approximately 50% control efficiency. Selective catalytic reduction can be used for over 80% control of NO_x emissions.

Near-zero sulfur fuel (~10 ppm) allows for the use of NO_x adsorbers, increasing NO_x control to over 90% in both diesel and gasoline vehicles. This enables more fuel-efficient engine designs, designs that are incompatible with current emissions control systems. Particulate filters achieve the maximum efficiency with near-zero sulfur fuels, approaching 100% control of PM.

Costs and Benefits of Reducing Fuel Sulfur

The technologies required to reduce sulfur to near-zero levels are in use in many areas of the world. Current costs are reasonable and the refining industry continues to make progress in developing more active catalysts and novel processes for removal of sulfur, reducing costs even further.

Studies show the benefits of sulfur reduction far outweigh the costs, even though required refinery investments continue to be significant. The U.S. EPA found human health and environmental benefits due to sulfur reduction were ten times higher than the costs. (This study assumed stricter emissions standards contingent on low-sulfur fuels.) Furthermore, a European study showed that near-zero sulfur fuels significantly reduce total fuel costs by increasing fuel economy. The considerable potential for greenhouse gas emission reductions adds further to the health, environmental, and social benefits of sulfur reduction.

Global Trends toward Low-Sulfur Fuels

In the developed world, auto makers and fuel refiners have had to apply their impressive technical and organizational capabilities to meet increasingly strict environmental regulations. The result has been reduced sulfur levels and ratcheted-down emissions standards for all types of vehicles. Meanwhile, long-term environmental challenges and the prospect of still stricter requirements in the future are spurring further research and technology development.

In developing countries, where vehicle numbers are increasing exponentially, high-sulfur fuels continue to be the norm and to inhibit the introduction of new vehicle technologies. By instituting early policies to lower sulfur levels and set strict emissions standards, these countries can allay the mounting human health impacts of increasing vehicle numbers and reduce the burden associated with cleaning up existing vehicles. In doing so, countries relatively new to sulfur regulation may wish to build on the experience of countries that have achieved, and taken advantage of, low-sulfur fuels.

Further, countries should be increasingly willing to help each other overcome the fuel-quality barrier and move to low emission vehicles. Local health and environmental benefits, though themselves sufficient reason to require cleaner fuels, are no longer the only issue: vehicle emissions are of increasing global significance. Pollutants traditionally of local concern—such as PM and ground-level ozone—now appear to impact the global climate. Reducing sulfur in transportation fuels, and encouraging advanced emissions control and fuel-efficient vehicle technologies, are the necessary first steps to reduce the local and global impact of vehicle emissions.

Key Conclusions

In evaluating sulfur reduction options, several observations may be of use to policymakers.

1. While costs and benefits vary from region to region—depending on the state of existing refineries, current fuel quality and emissions standards, local air quality and other factors—studies have shown that the costs of sulfur reduction are affordable and are dwarfed by the benefits.
2. Both regulations and tax incentives have proven effective tools for moving the refining industry to low-sulfur products.
3. The schedule for upgrading refineries for higher quality fuel production has significant cost implications. (For example, timing upgrades to coincide with needed refinery expansions can reduce costs.) Production and distribution of low-sulfur fuels must also be carefully coordinated with the introduction of new and retrofit vehicles that require low-sulfur fuels.
4. It is cost-effective and highly advantageous to make the jump to near-zero sulfur diesel in a single step. The total emissions benefits of further sulfur reductions from diesel fuel accrue most rapidly as levels decline from low to near-zero—both in terms of the retrofit potential for existing vehicles and emissions controls for new vehicles. Because of the large increase in incremental benefits between these sulfur levels, but relatively flat incremental costs, it makes sense to directly mandate near-zero sulfur diesel.
5. Measures should be taken to prevent sulfur extracted from one fuel stream from being diverted into another. For example, heavy fuel oil used in marine vessels can become a "dumping ground" for very high-sulfur feedstocks.