The Benefits and Costs of Ultra-Low Sulfur Diesel in Mexico

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BACKGROUND

- Air quality is a public health concern. Ambient particulate matter (PM) leads to the most significant adverse health effects associated with air pollution.[1]
- Diesel PM and oxides of nitrogen (NO_x) emissions contribute significantly to PM in the atmosphere.
- Though technologies are available to reduce diesel PM and NO_x emissions, PEMEX must first provide ultra-low sulfur diesel, which requires significant capital investment in Mexico's refineries.

OBJECTIVE

To compare the social costs and health benefits of a fast and a slow schedule for reducing sulfur in diesel fuel and requiring stricter emissions standards for new diesel vehicles.

METHODS

Model Scenarios: Fast and slow ultra-low-sulfur diesel introduction scenarios were compared. In both scenarios, diesel sulfur is reduced to 15 ppm and U.S. EPA 2007 diesel emissions standards are phased in.

1) *Fast Introduction:*
- Diesel sulfur levels are reduced by 2009.

2) *Slow Introduction:*
- Sulfur in diesel is reduced by 2012.

Benefits:
- A model (*Modelo de Beneficios)* to estimate the health benefits of an emissions reduction program in Mexico was developed.
- The benefits model uses intake fractions (iFs) to estimate change in exposure to $PM_{2.5}$ only.
- The model quantifies the decrease in adult and infant mortality, and six morbid impacts, based on epidemiological studies of health and PM exposure. [2-5]
- A Mexican value of a statistical life (VSL) of U.S. $660,000 was used to value decreased mortality. Willingness to pay and cost of illness estimates were used to value morbid impacts.

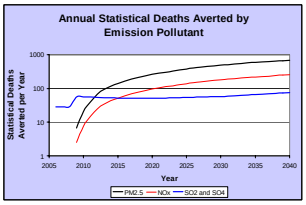
Costs:
- Capital investments and incremental operating costs were projected by PEMEX.[6,7]
- Capital and maintenance costs for new vehicles complying with EPA 2007 emissions standards were estimated by the U.S. EPA.[8]

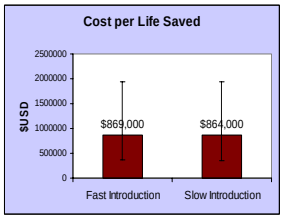
Uncertainty: Probabilistic distributions were placed on key uncertain variables used in calculating benefits.

Calculating Net Benefits:
- A Monte Carlo simulation was used to calculate results.
- A social discount rate of 3% was used to compare cost and benefit streams.

RESULTS

•Most health benefits result from decreases in PM and NO_x emissions achieved by advanced diesel control technology.

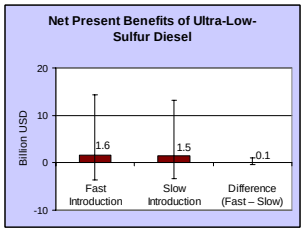




Uncertainty bars show 25th and 75th percentile over uncertainty

•Fast or slow introduction of ultra-low-sulfur diesel have approximately the same cost per life saved.

•Reducing sulfur in diesel is expected to have positive net benefits compared with a baseline of 500 ppm sulfur fuel. Uncertainty about both estimates is large. Because most of the uncertainty about benefits of the fast and slow scenarios is common to both, uncertainty about the incremental benefit of fast introduction over slow introduction ("Difference") is smaller.



Uncertainty bars show 25th and 75th percentile over uncertainty

What does this mean for an average person in 2030?

	Mexico City	Rest of Mexico
Projected Population	23M	100M
Δ Exposure (μg/m³)	2.2	0.2
Δ Adult Risk of Death	7/100,000	1/100,000
Δ Infant Risk of Death	13/100,000	1/100,000
WTP/year (U.S. $)	20	2
Cost/year (U.S. $)	4	4

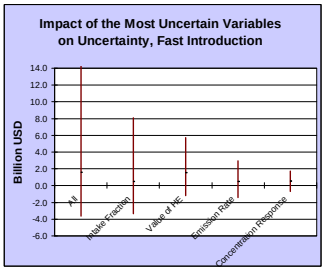
Δ Exposure is the decrease in average annual exposure to $PM_{2.5}$.

•Most benefits are expected to accrue in Mexico City, where average exposure to emissions is greater.

Why is a Statistical Life worth less in Mexico than in the U.S.?
- VSL does NOT measure how much a person is worth.
- VSL is a measure of how citizens prefer to allocate resources among reducing health risks and other competing needs, such as education or security.
- Mexican citizens have fewer resources than U.S. citizens, and therefore prefer to allocate fewer resources to reducing risks.

UNCERTAINTY ANALYSIS

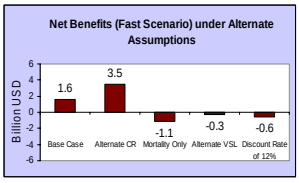
• Variables used in the calculation of benefits have the highest impact on the results of the analysis, specifically intake fraction (the exposure estimate), the monetary value of health risks, the emissions benefit, and the concentration-response coefficients.



Interquartile range of net benefits given each variable's uncertainty is shown. HE is health effect.

It is important to note that not all uncertainty associated with some parameters, such as the concentration-response coefficient, is easily quantified. In the case of the concentration-response coefficient, several sources of uncertainty were not quantified, including 1) whether the observed relationship between air quality and mortality is causal, and 2) whether the relationship observed in the U.S. holds in Mexico, where population characteristics and particulate matter components may be significantly different. Uncertainty associated with this variable is underestimated.

•In addition to uncertainty about parameter values, the model assumptions are uncertain. Using alternate assumptions to estimate costs and benefits can have a significant impact on the present value of net benefits.



"Alternate CR" uses a different epidemiological study (the "6 Cities" study)[9] to estimate changes mortality. "Mortality Only" excludes monetary benefits from reduced incidence of morbid outcomes. "Alternate VSL" uses the results of a preliminary Mexican wage study to estimate VSL ($260,000), rather than a U.S. VSL adjusted for Mexican income levels. A discount rate of 12% uses market interest rates to estimate the social discount rate.

CONCLUSIONS

•Introduction of ultra-low sulfur diesel and advanced emissions control is expected to have positive net benefits in Mexico, with a more rapid introduction schedule providing slightly greater net present benefits than a slower introduction schedule.

•Most benefits will accrue in Mexico City, where population exposure to emissions is greatest.

•Model results are sensitive to the values used to estimate benefits, particularly exposure estimation, concentration-response coefficients, and the monetary value of health impacts.

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