

Costs and Benefits of Reduced Sulfur Fuels in China

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

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Authors:

Katherine Blumberg
Research Director
The International Council on Clean Transportation, USA

He Kebin
Professor of Environmental Engineering and Director of International Cooperation and Exchange
Tsinghua University, China

Zhou Yu
Department of Environmental Science & Engineering
Tsinghua University, China

Liu Huan
Department of Environmental Science & Engineering
Tsinghua University, China

Nancy Yamaguchi
President
Trans-Energy Research Associates, Inc., USA

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ICCT Review Team:

Dr. He Dongquan
Director of China Sustainable Energy Program
The Energy Foundation, China

Dr. Fu Lixin
Director of the Air Pollution Research Institute
Tsinghua University, China

Ms. Margo Tsirigotis Oge
Director, Office of Transportation and Air Quality
Environmental Protection Agency, USA

Mr. Michael Walsh
Chairman of the ICCT Board of Directors
The International Council on Clean Transportation, USA

Dr. Martin Williams
Head, Air and Environmental Quality Division
Department for Environment, Food and Rural Affairs, UK

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Motorized road transportation in China is growing at an incredible pace. The number of passenger cars in China more than doubled between 2000 and 2005, and fleets of large and small trucks, as well as motorcycles, posted similar gains.

While this exponential growth is a result and indicator of China's strong economy and rising standard of living, it carries with it a host of environmental and social challenges, including the growing toll that air pollution is taking on the health and well-being of the Chinese people. In 2005, 211 cities exceeded the second level of Chinese standards for particulate matter, intended to protect public health, and in 29 of these cities, particle concentrations exceeded the third level, indicating very serious air pollution.

Responding to this public health imperative, the State Environmental Protection Administration (SEPA) of China is requiring new light- and heavy-duty vehicles to meet increasingly stringent emissions standards in the coming years. These regulations will help allay the mounting human health impacts of increasing vehicle numbers but their air quality and public health benefits will not be fully realized until China adopts corresponding low sulfur standards for gasoline and diesel fuels.

It is within this context that the International Council on Clean Transportation (ICCT) and Tsinghua University undertook a cost-benefit analysis of cleaner fuels and improved vehicle standards in China. The analysis, done in cooperation with the China State Environmental Protection Administration (SEPA), is intended to help evaluate the benefits of current and future regulatory programs for vehicles and fuels.

GOVERNMENT ACTION

China has adopted an aggressive timeline for improved vehicle emissions standards, with a lag of only a few years behind European regulations. New cars will be required to meet Euro 4 standards by 2010, and commercial trucks will be required to meet Euro V standards by 2012. This analysis

finds that China's rapid adoption of these vehicle policies will substantially reduce air pollution and improve public health, particularly in China's most industrialized cities. We also find that the monetized social benefits of these policies will far outweigh manufacturer compliance costs.

At the same time, the low sulfur fuel standards, which are a critical component of the European regulatory program, are not yet in place. Advanced emissions control technologies needed to meet upcoming standards require the use of cleaner, especially lower sulfur, fuels. Sulfur in gasoline and diesel fouls emissions control technologies and produces sulfur dioxide (SO_2) and fine particle emissions. Reducing fuel sulfur content serves to decrease pollutant emissions from all vehicles, new and old. As vehicles meet increasingly stringent standards, use of fuels with higher sulfur content will produce in-use emissions well above the levels established by the standards and may cause important emission-control devices to fail.

Recognizing the interdependent relationship between pollution control technologies and fuel quality, authorities around the world—including Europe, Japan, and the United States—have set fuel sulfur standards to match emissions standards for vehicles. The Hong Kong Special Administrative Region also adopted this approach, which allowed for the development and implementation of a comprehensive diesel retrofit program for many older trucks and buses, in addition to enabling emissions standards to be met. Under current policies described in Table ES-1, in-use fuel sulfur levels in China will start to diverge from certification fuel sulfur levels starting in 2008.

Table ES-1. Fuel Sulfur Standards and Timelines for Adoption

China's Schedule for Adoption of Vehicle Emissions Standards		European Certification Fuel Sulfur Level (ppm)		National China Fuel Sulfur Limits (ppm)	
LDV and HDV	Year	Gasoline	Diesel	Gasoline	Diesel
Euro 2	2005	500	500	500	2000 (500 recommended)
Euro 3	2008	150	350		
Euro 4	2010	50	50		
Euro 5 (HDV only)	2012	10	10		

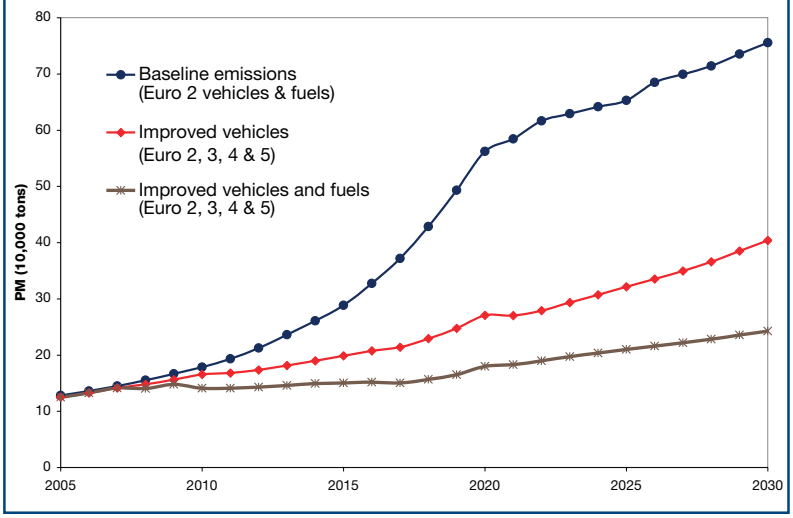
AIR POLLUTION BENEFITS

As an initial step, this study quantified the current and future air pollution benefits from China's adoption of light- and heavy-duty vehicle standards and the potential additional benefits that would flow from adoption of low sulfur fuels. In order to model the impacts of fuel quality emissions,

we developed emissions adjustment factors, which were based on short-term testing using the less sulfur-sensitive technologies available to meet forthcoming vehicle standards. Thus the analysis makes some assumptions that could be unrealistic over the long-term: that technologies developed for use with ultra-low sulfur fuels will function with higher sulfur fuels and that these fuels will not severely impact vehicle maintenance or durability.

In the absence of improved vehicle and fuel standards, total emissions of particulate matter (PM) in China would be expected to increase dramatically as rapid growth of the motor vehicle fleet continues, as illustrated by the top line in Figure ES-1. Stringent new vehicle standards are expected to cut vehicle PM emissions in half by 2020 (assuming they can be implemented with 500 ppm sulfur fuels). Adding compatible fuel sulfur standards to the vehicle standards would cut PM emissions by two thirds. Over the longer term, however, China will have to continue improving vehicle and fuel standards in order to stabilize or reduce vehicle emissions. Expected Euro VI standards for heavy-duty vehicles and Euro 5 and 6 standards for light-duty vehicles are likely to require particulate filters for diesels, which will provide significant health benefits in Chinese cities, provided ultra-low sulfur fuels are available.

Figure ES-1. National PM emissions with and without vehicle and fuel standards (2005 – 2030)



While national emissions may continue to rise somewhat even with cleaner fuels and vehicles, the local benefits of these regulations could be dramatic. In cities already burdened by excessive vehicle pollution, stringent vehicle standards and cleaner fuels could reduce vehicle emissions by 80 percent, providing tremendous air quality and public health benefits. A recent assessment of the health benefits of various pollution control and energy scenarios for Beijing found that a clean transportation program, including measures to improve both vehicles and fuels, had the most dramatic impact on reducing exposure to NO_x and PM (the most important pollutants from a health perspective). The full transportation program accounted for a larger share of overall health benefits in

2020 than all other measures combined, which included switching from coal to natural gas, reducing emissions from polluting industries, and dramatically increasing energy efficiency.

IMPROVEMENTS IN PUBLIC HEALTH

The next step in the analysis linked vehicle emissions reductions to public health endpoints such as mortality, bronchitis, asthma, and restricted activity days. As summarized in Table ES-2, avoided adverse public health impacts associated with forthcoming improvements in vehicle standards will be tremendous, and the additional benefits from improved fuel quality would add substantially to the current program. Over the years 2008 to 2030, approximately 1.1 million premature deaths will be avoided by vehicle standards, and an additional 370,000 premature deaths would be avoided if new fuel standards were also adopted. It is important to note that total avoided incidences of premature mortality include twenty thousand cases of infant mortality.

These estimates capture only a part of the benefits to fetal and children's health associated with reductions in air pollution. Air pollution endangers fetal health in a variety of ways, including reducing birth weight and increasing fetal genetic alterations that may be linked with future development of cancer. Air pollution can also have lifelong consequences on children, beyond causing asthma, bronchitis and restricting their daily activities. A recent long-term study in California found that children exposed to high levels of ambient air pollution had permanent reductions in lung development and function.

COMPLIANCE COSTS

The costs that would be accrued as a result of new vehicle and fuel standards needed to achieve the health benefits in Table ES-2 are very reasonable. Of course, there are additional costs that are likely to occur if fuels are not improved. Given the upcoming vehicle standards, we would expect that continued use of higher sulfur fuels would add many costs that were not addressed in this analysis, including higher maintenance

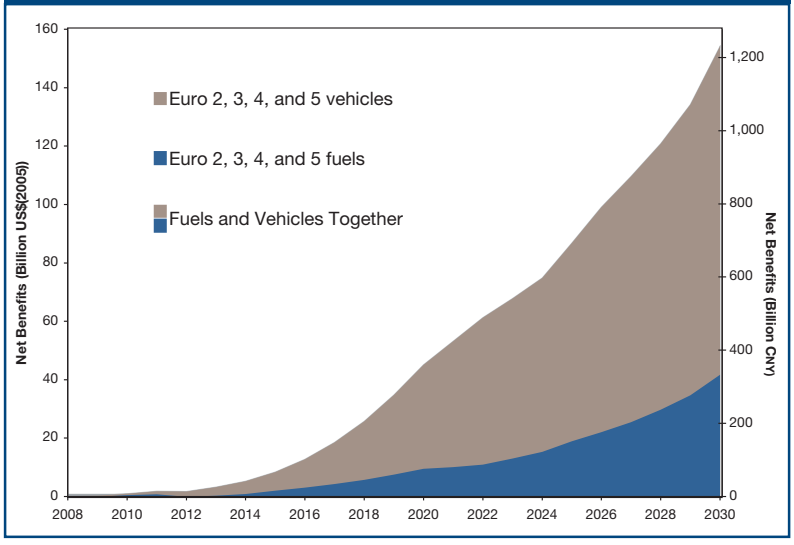
Table ES-2. Avoided health impacts over the years 2008 to 2030

Health outcome	Improved Vehicles	Improved Fuels	Total Avoided Incidences
Total mortality	1.1 million	370,000	1.5 million
Chronic bronchitis	2.8 million	930,000	3.7 million
Acute bronchitis	79 million	27 million	106 million
Asthma	10 million	3.5 million	14 million
Restricted activity days	740 million	250 million	990 million

and replacement costs for vehicle owners and increased compliance costs for manufacturers.

Upcoming vehicle standards will require improvements in emissions controls that will add less than 1 percent to the price of most passenger cars, an average increase of ¥1–¥3 ($0.10–$0.40) in the weekly cost of driving. While higher incremental costs are expected for diesel cars (up to five times) compared to gasoline vehicles, the advanced technologies are even more critical for reducing the health impacts. Most existing diesels have at least ten times higher PM emissions than gasoline vehicles. Without complete regulations that include stringent standards for both fuels and vehicles, an increasing market share for diesel vehicles will only exacerbate pollution problems in China.

Figure ES-2. Net benefits of improved fuels and vehicles in upcoming years



Incremental costs associated with improved fuel standards would be very similar to the costs of the vehicle standards. Car owners would expect to see an average increase in weekly gasoline or diesel bills of 1 to 3 percent, approximately ¥1–¥3 ($0.10–$0.40). These increases are dwarfed by the costs of rising world oil prices: Chinese drivers paid approximately ¥17–¥21 ($2–$3) more per week in 2004 than they did in 2002 to drive the same distance.

MONETIZING PUBLIC HEALTH BENEFITS

Economic valuations of public health endpoints were used to translate the social benefits of fuel and vehicle regulations into monetary amounts. The compliance costs for refiners and vehicle manufacturers were subtracted from the monetized social benefits to derive the net benefits of the regulatory program. As illustrated in Figure ES-2 vehicle standards are expected to provide a net benefit of ¥900 billion ($110 billion) in the year 2030 and improved fuel standards would add another ¥340 billion ($40 billion) in net benefits. Adoption of the complete Euro regulatory package, including both fuel and vehicle standards, could result in net benefits of ¥1,200 billion or $150 billion in the year 2030.

The monetized social benefits of these vehicle and fuel programs outweigh

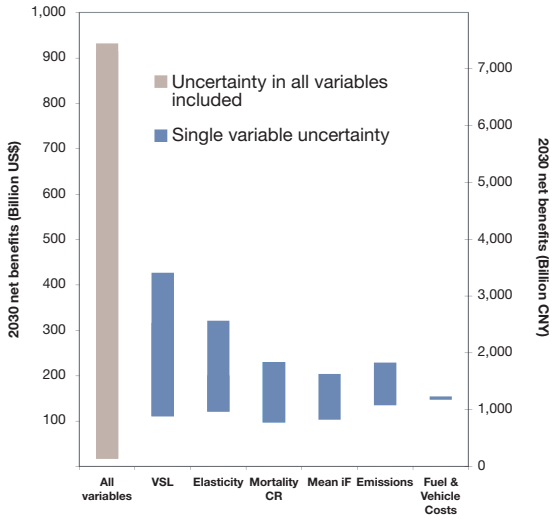
compliance costs by a factor of 20 in the year 2030. Program costs and benefits are of the same magnitude as estimated for the complete package of recent U.S. fuel and vehicle regulations. Indeed, putting in place cleaner fuel and stringent vehicle standards appears to be a highly cost-effective strategy to reduce pollutant emissions in China. If total annual emissions are combined, the weighted cost per ton of emission reductions ranges from ¥7,200 ($900) per ton in the early years to ¥2,400 ($300) per ton in 2030, much lower than recent programs in Europe and the United States.

SENSITIVITY ANALYSIS

There were a number of assumptions made in this analysis, each adding some uncertainty to the result. In order to be able to compare the relative importance of the various sources of uncertainty, we conducted a Monte Carlo simulation to test the sensitivity of the outcome to a number of the inputs. Figure ES-3 shows range of net benefits for the full fuel and vehicle program in the year 2030 that could be estimated given the uncertainty in all and each of the variables considered, with 90 percent certainty. This gives an idea of the most important sources of uncertainty in the analysis and the direction of the uncertainty.

This step demonstrates that the findings in this analysis are much more likely to under-predict the net benefits of clean fuels and vehicles than to over-predict these benefits. With the uncertainties in all the variables included, as illustrated in the first bar in Figure ES-3, the net benefits for 2030 could be in the range of ¥140–7,300 billion ($17–910 billion). Value of a statistical life (VSL) and elasticity, two variables which help set a monetary value for each case of avoided premature death, are the next two bars in Figure ES-3. These two variables are largest sources of uncertainty in the analysis and their ranges skew towards higher values for net benefits. As a result of the conservative values used for these variables, the ranges for the all variables and for most individual variables show that there is a strong likelihood that actual net benefits would be larger than predicted in the main analysis.

Figure ES-3. The possible range of net benefits in 2030 (with 90% certainty) considering the uncertainty in different variables



Net benefits appear to be highly insensitive to uncertainty in costs, as illustrated in the last bar in the figure, giving the smallest possible range. The benefits of improving vehicle and fuel standards so dramatically outweigh costs that even a tripling of costs for both fuels and vehicles has little impact on the net result. And historical experience has shown that the opposite is much more likely to be the case, i.e., the actual costs tend to be much lower than those estimated before a program is implemented.

CONCLUSIONS

This study finds that the current suite of motor vehicle emission standards already adopted in China will generate substantial public health benefits: 1.1 million avoided premature deaths by 2030, at a minimal increase in the retail cost of new vehicles. Low sulfur fuel standards would ensure that the vehicle standards can be fully implemented, protect the investment in clean vehicle technologies, and reduce an additional 370,000 premature deaths by 2030. The costs of cleaner fuels would also be very reasonable—an increase in the retail cost of gasoline and diesel fuel of only 1 to 3 percent. But time is short. Current sulfur levels can severely damage and even permanently destroy some of the most effective technologies to control emissions from diesel vehicles, technologies which may be used to meet Euro 4 standards for diesel passenger cars in 2010 and Euro V standards for heavy-duty vehicles in 2012.

These findings highlight the need for China to continue to act aggressively to reduce vehicle emissions in the face of continued growth in the vehicle fleet. While non-motorized and public transportation options will play an important role in addressing mobility and air quality challenges in China's rapidly growing cities, improving fuel quality and vehicle emissions standards is absolutely critical. In order to maximize emissions reductions from both the new and the existing vehicle fleet, China must not only adopt cleaner fuel standards, but also continue to update vehicle standards to reflect the state of the art and ensure manufacturer compliance. This analysis demonstrates that a complete regulatory program, which addresses both fuels and vehicles, is the most effective approach to reduce air pollution, improve public health, and prolong productive lives throughout China.

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www.theicct.org

Washington DC
1250 I St., Suite 350
Washington, DC 20005
United States of America
phone: +1 (202) 347-8932

San Francisco
1 Hallidie Plaza, Suite 503
San Francisco, California 94102
United States of America
phone: +1 (415) 399-9019