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The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics across its 9 member countries: Cambodia, China, Indonesia, Laos, Malaysia, Papua New Guinea, the Philippines, Thailand, and Viet Nam. Its goal is to strengthen local capacity for the economic analysis of environmental problems so that researchers can provide sound advice to pollcymakers.

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Battling Beijing's Ozone Crisis - Options for Action

EEPSEA POLICY BRIEF • No. 2009-PB7

Ground level ozone pollution is one of the most significant air pollution problems in Beijing. Because of the complex way in which ozone is formed, it is difficult for policy makers to decide which ozone control options are the most cost-effective. Recently, an EEPSEA report from China assessed a range of options for addressing this problem. The effectiveness and economic cost of these options are compared. →

A summary of EEPSEA Research Report No. 2009-RR7: 'Cost-Effectiveness Analysis Of Ground-Level Ozone Control In And Around Beijing' by XIE, Xuxuan and WU, Dan. Address: Room 309, Laodixuelou Building, Peking University, Beijing, China, 100871
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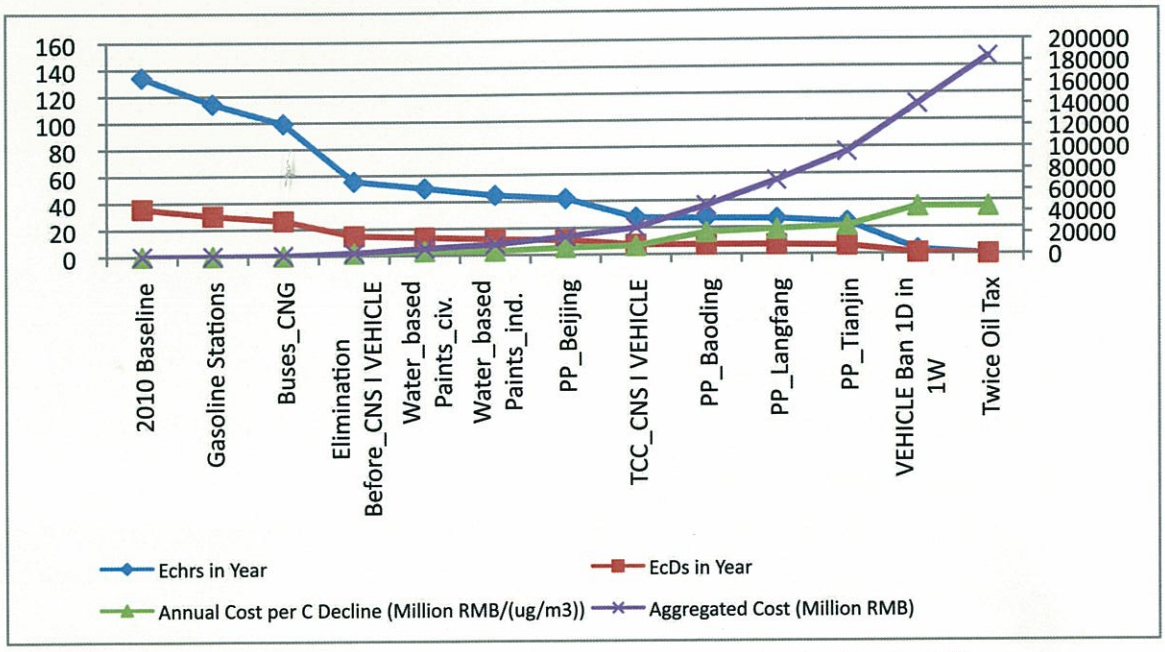
" cutting emissions from vehicles ...



ExHrs, ExDs, Marginal and Aggregated cost curves (under China Air Quality Standard II)

The study recommends the most effective sequence in which the options should be adopted to deliver the lowest cost pollution control.

The study was undertaken by Xie Xuxuan and Wu Dan at Peking University in China. It finds that the installation of oil gas recovery systems at Beijing's 1,446 gasoline stations would be the most cost-effective option. Overall, it is found that options to reduce ozone pollution by cutting vehicular emissions are much more cost-effective than options to clean up coal-fired power plants. The study recommends a series of options of controlling vehicular emissions, including substituting gasoline buses with clean fuel buses and phasing out high emission vehicles in Beijing.

The Ozone Challenge

Ozone formations involves chemical reactions between NOx and VOCs in the atmosphere. Anthropogenic NOx sources include the emissions from coal-fired power plants, motor vehicles, the chemical industry, and other industrial boilers. VOC emissions mainly come from motor vehicles, non-point sources, industrial sources, paint and solvent use, oil storage and transportation. Under suitable weather conditions, ozone concentrations build up in air and ozone can be transported over considerable distances.

Ozone is a strong oxidant and can irritate the human mucous membrane system. Short-term exposure can cause coughing, chest pain, fatigue, nausea and other symptoms, while long-term exposure can significantly damage lungs and respiratory tract. High concentrations of ozone is also harmful to plants. In addition, photochemical smog can damage some materials and can seriously impair visibility (ozone is a major contributor to photochemical smog).

The underlying cause of ground level ozone pollution in Beijing is the city's rapid economic development. There has also been a lack of actions specifically aimed at controlling ozone pollution. Beijing has implemented "sixteen stages of control policies" to improve air quality since 1998, but all major efforts have been directed at abating conventional air pollutants (e.g. SO2, and TSP). Secondary pollutants such as ground level ozone and particulate matter (PM) have not been effectively controlled. This has meant that secondary pollution has been geting worse as economic development accelerates.

Options for Abating Ozone Pollution

Given the various sources contributing to the formation of ozone, there are many potential options for combating the problem. It is desirable for policymakers to know which options are the most cost-effective. To provide this information to policymakers, the researchers highlight the key sources of ozone pollution and spotlight a wide range of possible clean-up options. They then assess their cost-effectiveness to decide the order in which these options should

is the most cost-effective approach."

be implemented to deliver the lowest cost pollution control.

The emission source inventory used by the study was provided by the results of a previous project entitled "Research on the characteristics of pollutants' transportation and reaction in Beijing and its surrounding areas, and air quality control strategies", in which the authors of this report were also involved. Other necessary information was obtained from local agencies, environmental statistics bulletins, reports of environment quality, Environmental Yearbooks, and government environmental statistics, and via interviews. What is more, the implementation of a wide range of air quality improvement measures for the 29th Olympic Games gave the researchers a unique opportunity to see how effective these approaches can be. Once they had gathered the necessary information, the researchers indentified important emission sources of NOx and VOC, estimated the impact that cleaning up the different sources would have on levels of NOx and VOC and thus on levels of ozone. They then identified the most cost-effective clean-up options.

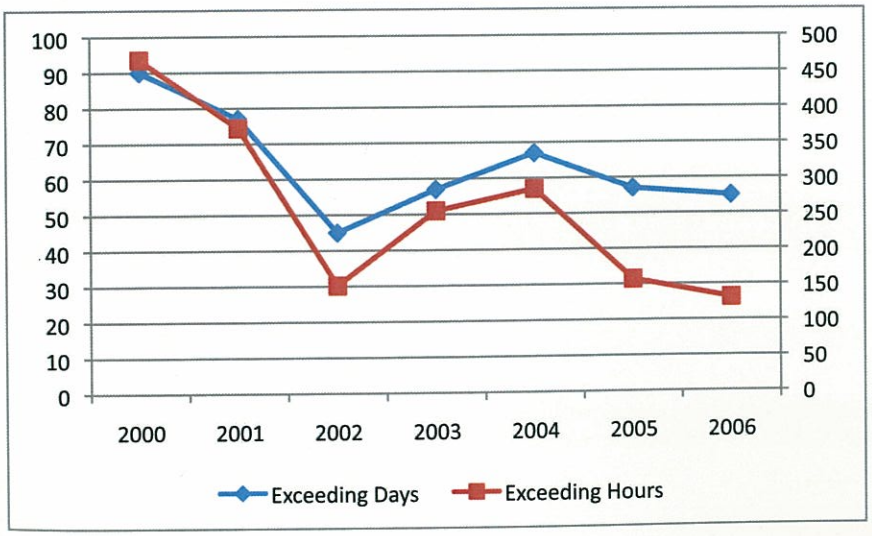
Assessing the Options

In all, 72 options were assessed. These options can be classifed into technical options (e.g. adopting low NOx burning techniques in coal-fired power plants) and non-technical options (e.g, phasing out high emission vehicles). Different approaches were required to estimate the costs incurred by the different clean-up options. For options that involve technical equipment, costs were generally estimated by summing up investment costs, operation and maintenance costs and other variables. For non-technical options, estimating the costs was more of a challenge, since it was often difficult to decide which costs should be considered, and it was sometimes difficult to estimate the costs themselves. For example, one of the non-technical options involved phasing out all the vehicles that failed to meet the country's least stringent emission standard. To estimate the cost of this option, subsidies from the government were used as the lower boundary of the cost.Subsidy levels were estimated using the average prices of used cars in Beijing's second-hand market.

Vehicles and Power Plants

The study finds that coal-fired power plants are the biggest emitters of NOx, followed by vehicles, and industrial activities in the chemical sector. VOC emissions sources such as solvent and paint use, gasoline stations, and laundries are treated as one group, and, as such, are found to be the biggest VOC source. Vehicles and power plants are the second and the third most significant sources of VOC emissions, respectively. As already discussed, the researchers highlighted and assessed a number of pollution control options for each of the key emission sources they identified.

The options assessed for reducing vehicular emissions included: substituting gasoline buses with clean fuel buses (such as CNG); phasing out high emission vehicles; retrofitting three-way catalytic converters in some vehicles; and ensuring that onroad taxis meet the highest emission standards. Other measures such as a traffic-control policy and a tax policy were also considered. The traffic control policy involved a ruling under which vehicles would be required to be offroad for one day each week based on the last digit of their license plates; while the tax policy involved doubling the tax on gasoline for vehicle use. For power plants, the study assessed a number of options for cutting NOx emissions. These included adopting Low NOx Burning (LNB) technology, and a number of other options such as adopting Smock Denitrification Technology. The study assessed the effect of these types of technologies on curbing the emissions of coal



Ozone exceeding status in Beijing from 2000 to 2005

power plants in Beijing, Baoding, Langfang and Tianjin.

Paint and Petrol Consumption

In Beijing, thousands tons of paint is used every year, but less that 30% of this paint is water-based (compared with more than 80% in Europe). Therefore, paint is another important source of VOC. This study assessed the effect of raising the percentage of water-based paint usage by 20%. The VOC control options that were assessed for gasoline stations included the installation of various systems to recover volatile gas emitted from underground tanks and during refuelling.

The Most Cost-effective Options

When the cost-effectiveness of the different options are compared, it is found that there are significant differences between the options for different sources and geographical areas. The most cost-effective control option is to install advanced oil gas recovery system for the 1,446 gasoline stations in Beijing. The average cost is 1.92 million RMB/(ug/m3). The next most cost-effective option would be subsituting those buses currently in use with buses run on compressed natural gas (CNG). A 20% increase in the use of water based paint would be the next most cost effective thing to do.

Generally, it is found that options to control pollution from vehicles (cars, buses and taxis) are more cost effective than options to control pollution from coal-fired power plants. The reasons are: firstly, the contribution to NOx and VOC pollution made by vehicles in Beijing is greater than that made by power plants in the surrounding areas. Secondly, the ozone concentration in Beijing is linked most strongly to levels of VOC, and VOC pollution is mainly from vehicular emissions. Thirdly, the cost of cleaning up power plants is more expensive than most options for abating emissions from vehicles. The study also draws the general conclusion that market-based policies should be more cost-effective than command and control measures. That said, the study does find that doubling the gas tax for vehicles in Beijing (a market-based policy) would be more cost-effective than the one-day-a-week car ban (a command and control regulation).

Through field interviews and surveys, it was also discovered that some simple changes in public behaviour could reduce pollution without incurring any costs. For example, when refilling vehicles, people could achieve a 10%-30% reduction in pollution by simply refilling fuel tanks by only 90%, putting the gas guns tightly into their fuel tanks, and closing their filler covers as soon as they have finished refilling their cars. Although this kind of behavioural change is very cost effective, it will require a public education campaign which may take some time to have an effect.

The study also finds, even without any of the measures and policies that it assesses, structural and technical changes will have a significant impact on air pollution. For example, in the vehicle sector, as advanced technologies evolve, total NOx and VOC emissions will increase slowly (or even decrease), even though the total number of vehicles will increase by around 10% each year. This has implications for policy. For example, in 2007, old, polluting cars accounted for large quantities of NOx and VOC emissions, so the elimination or substitution of old cars is currently a cost-effective policy. But in 2015, with new, low-emission cars being in the majority, the elimination of older cars will achieve little improvement in air quality. At this point in time, control strategies should be changed to reduce overall car numbers and improve new car emission limits. In conclusion, eliminating old cars (using a subsidy approach) or replacing old cars with new cars are good short-term policy strategies. However, in the long term, policies aimed at reducing vehicle use and ratcheting up the environmental performance of new cars should be the main focus.

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