O. BALILTY/AP

Rapid economic growth means that the air in some Chinese cities, such as Beijing, contains more fine particles than the World Health Organization recommends.

Cleaning China's air

To reduce airborne soot, organics and sulphates, tailored strategies for each must be established and coal use limited, say **Qiang Zhang**, **Kebin He** and **Hong Huo**.

On 29 February this year, China's State Council approved its first national environmental standard for limiting the amount of fine particles in air that measure less than 2.5 micrometres in diameter. It requires the country to implement the World Health Organization's recommended interim target of an annual average of 35 micrograms per cubic metre ($\mu g\,m^{-3}$) for such particles by the end of 2015.

Fine particles — including soot, organics and sulphates — have a severe effect on human health and are implicated in climate change. They are emitted by combustion and industrial processes, and formed from the reactions of gaseous pollutants. If implemented properly, China's air-quality standard would have far-reaching benefits: as well as protecting human health, it would reduce air and mercury pollution in the Northern Hemisphere and slow global warming.

Achieving this goal will be a challenge. Some Chinese cities currently have fine-particle concentrations that are well above the proposed standard: levels of more than 100 $\mu g\,m^{-3}$ have been reported[1]. To meet the ambitious air-quality limits, China will have to overcome two major hurdles: its relentless increase in fossil-fuel use, which quickly wipes out any efforts to reduce emissions, and its decentralized system of environmental enforcement, which gives undue influence to local officials who favour economic development.

Controlling air quality in China will address global environmental issues. For example, pollutants from east Asia that travel across the Pacific increase ozone concentration in the western United States[2]. This could be relieved if China reduces emissions of nitrogen oxides (NO_x), which are precursors of fine particles and ozone. Cross-border pollution by airborne particles would similarly be reduced by cutting China's emissions of sulphur dioxide (SO_2). The use of technologies such as desulphurization, selective catalytic reduction or electrostatic precipitators to reduce Chinese emissions of SO_2, NO_x and fine particles, respectively, can remove global pollutants such as mercury, which is released by the burning of coal.

Limiting particle pollution will also affect drivers of climate change — but not always for the better. On the one hand, reducing soot emissions by cutting coal use or using cleaner stoves will lessen radiative forcing and thus limit warming, benefiting both the climate and public health[3]. A stricter emissions standard for diesel vehicles, which produce soot, is another win–win solution[4]. On the other hand, reductions in SO_2 emissions from power plants would reduce atmospheric sulphate concentrations, thereby increasing radiative forcing, which has a short-term detrimental effect on climate[3]. Thought is therefore needed as to how the various pollutants and sources should be best controlled, and a multi-pollutant abatement strategy must be developed.

A CLEAN CHALLENGE

The control of air pollution in China is in a race with the economy. The country has maintained an annual economic growth rate of more than 8% for years, largely through the energy-intensive construction of infrastructure such as highways, railways and cities. Between 2005 and 2010, China increased its thermal-power generation by 63%, pig-iron and cement production by 74% and 76%, respectively, and vehicle production by 220% (ref. 5).

Although China has made tremendous efforts to limit air pollution, such as requiring coal-fired power plants to install flue-gas desulphurization systems and strengthening vehicle-emissions standards, these measures have not kept up with the growth of its economy and fossil-fuel use. We estimate that new equipment reduced SO_2 emissions from China's power plants by 1.5 million tonnes in 2005 and by 17.5 million tonnes in 2010 — 54% of the country's total SO_2 emissions in 2005 (32.3 million tonnes). But nationwide, total SO_2 emissions only decreased by 11% (to 28.7 million tonnes in 2010) because

those from other sectors grew (see 'China's emissions battle'). Coal usage rose by 44% (955 million tonnes), more than one-third of which was consumed by industrial facilities (such as iron, steel and cement works) that have no desulphurization systems.

The low priority given to environmental protection and the lack of cooperation among various government agencies also hampers air-quality control. China's Ministry of Environmental Protection (MEP) manages pollutant discharge, but it is a weak player within the government system. Its decisions are often obstructed for economic reasons. For instance, in late 2011, Chinese oil companies caused a delay in the planned 2012 implementation of a stricter vehicle-emissions standard (equivalent to Europe's Euro IV standard) because they were unable to provide the necessary low-sulphur oil. Any delay is a big strike against the environment, particularly as vehicle emissions continue to rise.

Such stories are rife in local governments, which like to promote heavy industry to stimulate regional economies. Local environmental agencies are often forced to back these projects just because they are affiliated to local governments. Yet, pushed by the public, the willingness and enthusiasm of China's government for curbing air pollution has never been so strong. It is a golden opportunity for the nation to make a change — to free itself from the trap between economic development and environmental pollution.

CONSTRAIN COAL

Because China will continue to rely on fossil fuels for the next 20 years, the government should change its thinking. Instead of trying to use more energy to ensure economic growth regardless of the consequences, it should promote development with constrained fossil-fuel use. A cap could be set for national total coal consumption, and economic plans developed under this constraint. Otherwise, emissions from increased energy use will offset any gains from emissions control. Tertiary service industries and high-technology projects could be promoted instead of energy-intensive ones.

Greater authority should be given to environmental agencies at various levels of government. The MEP should be granted more power to implement its policies and enforce regulations. A vertical administrative structure would ensure that local environmental agencies report directly to the MEP.

The impact on the global environment should be considered when formulating China's air-quality strategies, and balanced plans should be developed for each pollution source. As well as reducing SO_2 emissions, the government should endorse measures to limit soot. Controlling emissions from diesel vehicles should be a priority, and oil companies should be brought into accordance with environmental standards. For future facilities that will control SO_2 and NO_x emissions, the government should equip them with specific technologies to remove mercury, such as activated carbon injection.

Addressing air pollution in China is a unique platform for researchers in atmospheric chemistry. Many scientific issues — such as secondary organic aerosol formation — remain to be explored. Practical control technologies for ultrafine particles and volatile organic compounds must be developed. Multinational collaboration is urgently needed; the government should make funds available to bring outstanding international scientists to China to help combat its air-pollution challenges. We all stand to benefit. ■

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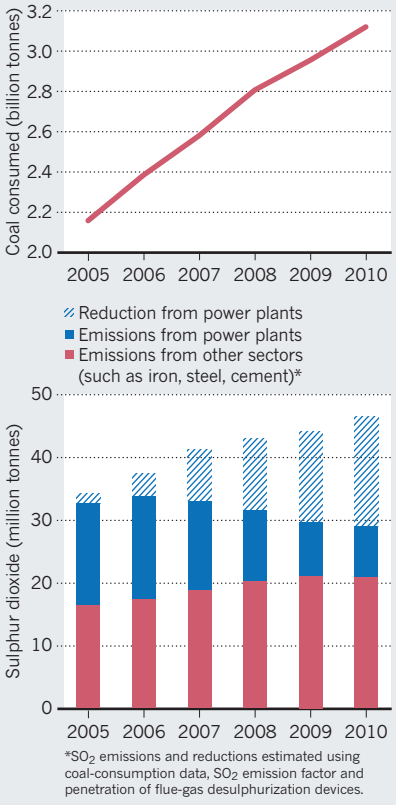
CHINA'S EMISSIONS BATTLE

Rising coal use (top) has increased emissions of sulphur dioxide from some sectors, even though power plants emit less than in 2005 (bottom).



*SO_2 emissions and reductions estimated using coal-consumption data, SO_2 emission factor and penetration of flue-gas desulphurization devices.

SOURCE: CHINA ENERGY STATISTICAL YEARBOOK