Measurements of CO2 and CO in China's air indicate sharply improved combustion efficiency

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A collaborative, six-year study of carbon dioxide (CO_2) levels in Beijing and surrounding provinces suggests that combustion efficiency, a component of overall energy efficiency, is improving in the region.

The findings, published in the September 21 issue of Atmospheric Chemistry and Physics, are generally consistent with official Chinese government statistics and could bolster their credibility as international negotiations proceed on commitments of China and other nations to combat climate change.

A team of atmospheric scientists and environmental engineers from Harvard University and Tsinghua University in Beijing have continuously measured atmospheric CO_2 and carbon monoxide (CO) levels in rural Miyun, about 100 km northeast of Beijing, since November 2004.

Weather observations such as wind speed and direction (with other evidence) allowed researchers to identify plumes of polluted air from the Beijing urban area and population centers to the south, as opposed to relatively clean air arriving from the north.

The measurements provide the most detailed look at carbon emissions for a specific urbanized and industrialized region of China to date. Moreover, the resulting analysis of CO_2 and CO levels is generally

consistent with China's official statistics, showing an upward trend in overall energy efficiency.

"The Chinese government committed to improve energy efficiency in its 11th Five-Year Plan (2006-2010), and this study shows how independent quantitative evidence of its progress can be inferred from the chemistry of its air," said co-author Chris P. Nielsen, Executive Director of the Harvard China Project, based at Harvard's School of Engineering and Applied Sciences (SEAS).

The Harvard and Tsinghua researchers analyzed the ratio of CO_2 to CO at Miyun to evaluate energy efficiency in Beijing.

"Fuel combustion releases energy by converting carbon to CO_2, but some is only converted to CO, losing some of the available chemical energy. High-efficiency combustion processes, such as modern power plants and cars that meet current standards, produce little or no CO, and are thus both more energy-efficient and cleaner," said co-author J. William Munger, Senior Research Fellow at SEAS and at Harvard's Department of Earth and Planetary Sciences (EPS). "Inefficient processes like wood- and coal-burning in domestic stoves convert less than 90 percent of the carbon fuel to CO_2, releasing the remainder as CO and wasting some of the energy. The combustion of outmoded industrial processes can fall somewhere in the middle. Knowing this, there's a lot we can learn from this chemical ratio in the air about combustion efficiency on the ground."

Over the period of study—and while controlling for daily, seasonal, and weather-induced fluctuations—the data trends indicated increasing combustion efficiency in the Beijing region. Modernization of industrial boilers, replacing old vehicles with new ones meeting stricter standards, and closing of older industrial facilities can all contribute to this trend. (For more information, see the supplementary materials.)

"The data indicate a trend toward cleaner, more efficient combustion in the Beijing region over several years leading up to the 2008 Olympics "—when the government instituted particularly strict controls on pollution—"and as far as we can tell so far, these gains have been maintained since the Olympics," said Munger.

The lead author of the study, Yuxuan Wang, is an Associate Professor in the Department of Environmental Science and Engineering at Tsinghua University and Principal Investigator of the Miyun atmospheric observatory. She completed her Ph.D. and postdoctoral studies at EPS and SEAS, at Harvard.

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