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Just How Polluted Is China Anyway?

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Decades ago, I wrote the first comprehensive books on China's energy and environment. I have not been surprised by the country's continuing environmental degradation; even so, I could not have predicted such a deterioration of air quality.

In 2008, the U.S. embassy in Beijing (located in the northeastern part of the city's downtown area) installed an air quality monitoring device that measures concentrations of airborne particles with diameters of less than 2.5 microns. These tiny particles are the main cause of health problems after long-term exposure, and their monitoring provides a much better appreciation of health risks than the measurement of large (10 microns and above) particles. The Chinese authorities began to release their own measurements of smaller particles only in January 2013, but the tweeting of the hourly concentrations by the American embassy has been a perfect example of subversive information — although the city's citizens have always known, without having the actual numbers, that they are breathing a grossly polluted air.

At 8 p.m. on January 12, 2013, the American device registered 886 micrograms per cubic meter ($\mu g/m^3$). To people unfamiliar with air pollution monitoring that is just a number, moreover one given in units not commonly used in the United States. Precisely for that reason, the U.S. Environmental Protection Agency developed an air quality index (AQI) that converts those measures into readily comprehensible numbers.

An AQI less than 50 means good air quality; 51–100 indicates moderately polluted air; 101–150 is considered unhealthy for adults with lung diseases; at "generally unhealthy" 151–200, everybody should reduce any prolonged outdoor exercise; at "very unhealthy" 201–300, adults with heart and lung diseases, the elderly, and children should avoid any outdoor physical activity; and when the index goes beyond 300 and all the way to 500, the best choice is to stay inside.

The peak concentration of 886 μg/m^3 reached on January 12 translates to an AQI of 755, far beyond the defined scale. Beijing's AQI rose above 500 by 2 a.m. on January 13 and remained above that level until 6 a.m. the next day.

Perhaps the best way to indicate how extraordinarily high such levels are is to note that regular monitoring at nearly 650 sites in the United States showed a mean concentration of 10 μg/m^3 (AQI 32), with 10 percent of sites having levels below 7 and only 10 percent of places having concentrations above 13 μg/m^3 (AQI 42). Peak Beijing levels on January 12 were thus nearly 90 times the U.S. mean, and even the city's common winter levels of 250–350 μg/m^3 are 25–35 times the U.S. mean.

High air pollution levels require a combination of two factors: high emissions and a limited mixing layer (the thickness of the atmosphere available for the dilution of airborne pollution). The first has been a Chinese constant, the second is bound to happen again and again during winter, when thermal inversion makes the atmosphere colder near the ground and hence limits the depth of the mixed layer, often to just a few hundred meters. As long as these inversions persist (sometimes just for a few hours, sometimes for several days) the near-ground concentration of pollutants soars.

Nothing can be done about recurring inversions, but, obviously, it is possible to reduce emissions. That is precisely what the Chinese have been doing, as they closed most of the polluting coal-fired boilers in the capital and have made Beijing a city increasingly dependent on clean natural gas.

Why has this not worked? Because China has become so extraordinarily dependent on burning coal that since the year 2000 it has increased its annual coal consumption nearly 3.5 times to roughly 3.5 billion tons (U.S. output is 1 billion tons). Beijing may be burning much less coal than a decade ago, but the region surrounding it (Hebei province and Tianjin, another megacity) and coal-mining areas of Shanxi and Inner Mongolia that are immediately upwind of the capital, burn much more. This part of North China, covering roughly 500,000 km^2 (an equivalent of Spain) now houses about 150 million people and it burns annually about 800 million metric tons of coal. That is nearly 40 percent more than does India and more than the aggregate hard coal and lignite consumption of the entire European Union (with 500 million people).

Most of China's coal combustion is now in large coal-fired electricity-generating plants built since 1990; indeed, in some recent years China was adding annually as much coal-fired capacity as the total installed capacity of Germany or the United Kingdom! Obviously, these new plants are here to stay, and small particles are also generated by record high levels of iron, steel, and cement production — and by cars in what has now become the world's largest car market. Chinese car sales have been above the U.S. level since 2009 (they reached nearly 15 million passenger vehicles in 2012), with the capital having such a disproportionately high increase (with as many as 60,000 cars sold in one month) that the city began issuing a maximum of 20,000 new permits per month.

North China thus has the dubious distinction of being the region with the world's most intensive air pollution from coal and the fastest increase of emissions from automobiles. That is combining the classical smog from burning coal (emitting large and small particulates and sulfur and nitrogen oxides) with photochemical smog from automotive traffic (generated by atmospheric reaction of released nitrogen oxides, carbon monoxide, volatile hydrocarbon, and small particles, especially from diesel engines).

There are no easy or rapid solutions for such a combination. Hong Kong offers a sobering example of the challenge: even as the city has greatly reduced its emissions, more than 90 percent of its air pollution comes from the surrounding region of coastal Guangdong province, the world's greatest concentration of manufacturing. Similarly, even once Beijing burns only natural gas and enforces the sales of only low-emission cars, it will remain surrounded by the world's largest concentration of coal burned for industrial use and electricity generation, and served by hundreds of thousands of heavy diesel trucks (here is its famous multiday traffic jam). All that is needed is another pronounced thermal inversion and AQI will, once again, go off the scale.

Decades ago, I wrote the first comprehensive books on China's energy and environment, and hence I have not been surprised by the country's continuing environmental degradation; even so, I could not have predicted such a deterioration of air quality. And, unfortunately, a clichéd old adage applies here only too well: it may get still worse before it gets better.

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