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THE ENERGY CHALLENGE

Pollution From Chinese Coal Casts a Global Shadow



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Coal has given parts of China a Dickensian feel, with miners coated with black soot and air that is thick with pollution.

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HANJING, [China](#) — One of China's lesser-known exports is a dangerous brew of soot, toxic chemicals and climate-changing gases from the smokestacks of coal-burning power plants.

Coal-burning factories like the Gu Dian steel plant have given Shanxi Province in China a Dickensian feel.

In early April, a dense cloud of pollutants over Northern China sailed to nearby Seoul, sweeping along dust and desert sand before wafting across the Pacific. An American satellite spotted the cloud as it crossed the West Coast.

Researchers in California, Oregon and Washington noticed specks of sulfur compounds, carbon and other byproducts of coal combustion coating the silvery surfaces of their mountaintop detectors. These microscopic particles can work their way deep into the lungs, contributing to respiratory damage, heart disease and cancer.

Filters near Lake Tahoe in the mountains of eastern California "are the darkest that we've seen" outside smoggy urban areas, said Steven S. Cliff, an atmospheric scientist at the [University of California](#) at Davis.

Unless China finds a way to clean up its coal plants and the thousands of factories that burn coal, pollution will soar both at home and abroad. The increase in global-warming gases from China's coal use will probably exceed that for all industrialized countries combined over the next 25 years, surpassing by five times the reduction in such emissions that the Kyoto Protocol seeks.

The sulfur dioxide produced in coal combustion poses an immediate threat to the health of China's citizens, contributing to about 400,000 premature deaths a year. It also causes acid rain that poisons lakes, rivers, forests and crops.

The sulfur pollution is so pervasive as to have an extraordinary side effect that is helping the rest of the world, but only temporarily: It actually slows [global warming](#). The tiny, airborne particles deflect the sun's hot rays back into space.

But the cooling effect from sulfur is short-lived. By contrast, the carbon dioxide emanating from Chinese coal plants will last for decades, with a cumulative warming effect that will eventually overwhelm the cooling from sulfur and deliver another large kick to global warming, climate scientists say. A warmer climate could lead to rising sea levels, the spread of tropical diseases in previously temperate climes, crop failures in some regions and the extinction of many plant and animal species, especially those in polar or alpine areas.

Coal is indeed China's double-edged sword — the new economy's black gold and the fragile environment's dark cloud.

Already, China uses more coal than the United States, the [European Union](#) and Japan combined. And it has increased coal consumption 14 percent in each of the past two years in the broadest industrialization ever. Every week to 10 days, another coal-fired power plant opens somewhere in China that is big enough to serve all the households in Dallas or San Diego.

To make matters worse, India is right behind China in stepping up its construction of coal-fired power plants — and has a population expected to outstrip China's by 2030.

Aware of the country's growing reliance on coal and of the dangers from burning so much of it, China's leaders have vowed to improve the nation's energy efficiency. No one thinks that effort will be enough. To make a big

improvement in emissions of global-warming gases and other pollutants, the country must install the most modern equipment — equipment that for the time being must come from other nations.

Industrialized countries could help by providing loans or grants, as the Japanese government and the [World Bank](#) have done, or by sharing technology. But Chinese utilities have in the past preferred to buy cheap but often-antiquated equipment from well connected domestic suppliers instead of importing costlier gear from the West.

The Chinese government has been reluctant to approve the extra spending. Asking customers to shoulder the bill would set back the government's efforts to protect consumers from inflation and to create jobs and social stability.

But each year China defers buying advanced technology, older equipment goes into scores of new coal-fired plants with a lifespan of up to 75 years.

"This is the great challenge they have to face," said David Moskovitz, an energy consultant who advises the Chinese government. "How can they continue their rapid growth without plunging the environment into the abyss?"

Living Better With Coal

Wu Yiebing and his wife, Cao Waiping, used to have very little effect on their environment. But they have tasted the rising standard of living from coal-generated electricity and they are hooked, even as they suffer the vivid effects of the damage their new lifestyle creates.

Years ago, the mountain village where they grew up had electricity for only several hours each evening, when water was let out of a nearby dam to turn a small turbine. They lived in a mud hut, farmed by hand from dawn to dusk on hillside terraces too small for tractors, and ate almost nothing but rice on an income of \$25 a month.



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The Er Pu coal mine in Shanxi Province, China. Coal use in China exceeds that of the United States, the European Union and Japan combined.



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Wu Yiebing, seated left, with his wife, Cao Waiping, right, their daughter, Wu Caoying, far left, and a family friend, center. Coal has given the family as much electricity as it needs, but a smog of sulfur particles hovers above their small town.

Today, they live here in Hanjing, a small town in central China where Mr. Wu earns nearly \$200 a month. He operates a large electric drill 600 feet underground in a coal mine, digging out the fuel that has powered his own family's advancement. He and his wife have a stereo, a refrigerator, a television, an electric fan, a phone and light bulbs, paying just \$2.50 a month for all the electricity they can burn from a nearby coal-fired power plant.

They occupy a snug house with brick walls and floors and a cement foundation — the bricks and cement are products of the smoking, energy-ravenous factories that dot the valley. Ms. Cao decorates the family's home with calendar pictures of Zhang Ziyi, the Chinese film star. She is occasionally dismissive about the farming village where she lived as a girl and now seldom visits except over Chinese New Year.

"We couldn't wear high heels then because the paths were so bad and we were always carrying heavy loads," said Ms. Cao, who was wearing makeup, a stylish yellow pullover, low-slung black pants and black pumps with slender three-inch heels on a recent Sunday morning.

One-fifth of the world's population already lives in affluent countries with lots of air-conditioning, refrigerators and other appliances. This group consumes a tremendous amount of oil, natural gas, nuclear power, coal and alternative energy sources.

Now China is trying to bring its fifth of the world's population, people like Mr. Wu and Ms. Cao, up to the same standard. One goal is to build urban communities for 300 million people over the next two decades.

Already, China has more than tripled the number of air-conditioners in the past five years, to 84 per 100 urban households. And it has brought modern appliances to hundreds of millions of households in small towns and villages like Hanjing.

The difference from most wealthy countries is that China depends overwhelmingly on coal. And using coal to produce electricity and run factories generates more global-warming gases and lung-damaging pollutants than relying on oil or gas.

Indeed, the Wu family dislikes the light gray smog of sulfur particles and other pollutants that darkens the sky and dulls the dark green fields of young wheat and the white blossoms of peach orchards in the distance. But they tolerate the pollution.

"Everything else is better here," Mr. Wu said. "Now we live better, we eat better."

China's Dark Clouds

Large areas of North-Central China have been devastated by the spectacular growth of the local coal industry. Severe pollution extends across Shaanxi Province, where the Wus live, and neighboring Shanxi Province, which produces even more coal.

Not long ago, in the historic city of Datong, about 160 miles west of Beijing, throngs of children in colorful outfits formed a ceremonial line at the entrance to the city's 1,500-year-old complex of Buddhist cave grottoes to celebrate Datong's new designation as one of China's "spiritually civilized cities."

The event was meant to bolster pride in a city desperately in need of good news. Two years ago, Datong, long the nation's coal capital, was branded one of the world's most-polluted cities. Since then, the air quality has only grown worse.

Datong is so bad that last winter the city's air quality monitors went on red alert. Desert dust and particulate matter in the city had been known to force the pollution index into warning territory, above 300, which means people should stay indoors.

On Dec. 28, the index hit 350.

"The pollution is worst during the winter," said Ji Youping, a former coal miner who now works with a local environmental protection agency. "Datong gets very black. Even during the daytime, people drive with their lights on."

Of China's 10 most polluted cities, four, including Datong, are in Shanxi Province. The coal-mining operations have damaged waterways and scarred the land. Because of intense underground mining, thousands of acres are prone to sinking, and hundreds of villages are blackened with coal waste.



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In Shanxi Province houses are coated with soot, miners' faces are smeared almost entirely black, and air is thick with the smell of burning coal.

There is a Dickensian feel to much of the region. Roads are covered in coal tar; houses are coated with soot; miners, their faces smeared almost entirely black, haul carts full of coal rocks; the air is thick with the smell of burning coal.

There are growing concerns about the impact of this coal boom on the environment. The Asian Development Bank says it is financing pollution control programs in Shanxi because the number of people suffering from lung cancer and other respiratory diseases in the province has soared over the past 20 years. Yet even after years of government-mandated cleanup efforts the region's factories belch black smoke.

The government has promised to close the foulest factories and to shutter thousands of illegal mines, where some of the worst safety and environmental hazards are concentrated. But no one is talking about shutting the region's coal-burning power plants, which account for more than half the pollution. In fact, Shanxi and Shaanxi are rapidly building new coal-fired plants to keep pace with soaring energy demand.

To meet that demand, which includes burning coal to supply power to Beijing, Shanxi Province alone is expected to produce almost as much coal as was mined last year in Germany, England and Russia combined.

Burning all that coal releases enormous quantities of sulfur.

"Sulfur dioxide is China's No. 1 pollution problem," said Barbara A. Finamore, a senior attorney at the [Natural Resources Defense Council's](#) China Clean Energy Program in Washington. "This is the most serious acid rain problem in the world."

China released about 22.5 million tons of sulfur in 2004, more than twice the amount released in the United States, and a Chinese regulator publicly estimated last autumn that emissions would reach 26 million tons for 2005, although no official figures have been released yet. Acid rain now falls on 30 percent of China.



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Pollution from China will contribute to a big increase in global warming.

Studies have found that the worst effects of acid rain and other pollution occur within several hundred miles of a power plant, where the extra acidity of rainfall can poison crops, trees and lakes alike.

But China is generating such enormous quantities of pollution that the effects are felt farther downwind than usual. Sulfur and ash that make breathing a hazard are being carried by the wind to South Korea, Japan and beyond.

Not enough of the Chinese emissions reach the United States to have an appreciable effect on acid rain yet. But, they are already having an effect in the mountains in West Coast states. These particles are dense enough that, at maximum levels during the spring, they account at higher altitudes for a fifth or more of the maximum levels of particles allowed by the latest federal air quality standards. Over the course of a year, Chinese pollution averages 10 to 15 percent of allowable levels of particles. The amounts are smaller for lower-lying cities, like Seattle, San Francisco and Los Angeles.

China is also the world's largest emitter of mercury, which has been linked to fetal and child development problems, said Dan Jaffe, an atmospheric scientist at the [University of Washington](#).

Unless Chinese regulators become much more aggressive over the next few years, considerably more emissions could reach the United States. Chinese pollution is already starting to make it harder and more expensive for West Coast cities to meet stringent air quality standards, said Professor Cliff of the University of California, slowing four decades of progress toward cleaner air.

Nothing Beats It

China knows it has to do something about its dependence on coal.

The government has set one of the world's most ambitious targets for energy conservation: to cut the average amount of energy needed to produce each good or service by 20 percent over the next five years. But with an economy growing 10 percent a year and with energy consumption climbing even faster, a conservation target amounting to 3.7 percent a year does not keep pace.

All new cars, minivans and sport utility vehicles sold in China starting July 1 will have to meet fuel-economy standards stricter than those in the United States. New construction codes encourage the use of double-glazed windows to reduce air-conditioning and heating costs and high-tech light bulbs that produce more light with fewer watts.

Meanwhile, other sources of energy have problems. Oil is at about \$70 a barrel. Natural gas is in short supply in most of China, and prices for imports of liquefied natural gas have more than doubled in the last three years.

Environmental objections are slowing the construction of hydroelectric dams on China's few untamed rivers. Long construction times for nuclear power plants make them a poor solution to addressing blackouts and other power shortages now.

For the past three years, China has also been trying harder to develop other alternatives. State-owned power companies have been building enormous wind turbines up and down the coast. Chinese companies are also trying to develop geothermal energy, tapping the heat of underground rocks, and are researching solar power and ways to turn coal into diesel fuel. But all of these measures fall well short. Coal remains the obvious choice to continue supplying almost two-thirds of China's energy needs.

Choices and Consequences

China must make some difficult choices. So far, the nation has been making decisions that it hopes will lessen the health-damaging impact on its own country while sustaining economic growth as cheaply as possible. But those decisions will also add to the emissions that contribute to global warming.

The first big choice involves tackling sulfur dioxide. The government is now requiring that the smokestacks of all new coal-fired plants be fitted with devices long used in Western power plants to remove up to 95 percent of the sulfur. All existing coal-fired plants in China are supposed to have the devices installed by 2010.

While acknowledging that they have missed deadlines, Chinese officials insist they have the capacity now to install sulfur filters on every power plant smokestack. "I don't think there will be a problem reaching this target before 2010," said Liu Deyou, chief engineer at the Beijing SPC Environment Protection Tech Engineering Company, the sulfur-filter manufacturing arm of one of the five big, state-owned utilities.

Japan may be 1,000 miles east of Shanxi Province, but the Japanese government is so concerned about acid rain from China that it has agreed to lend \$125 million to Shanxi. The money will help pay for desulfurization equipment for large, coal-fired steel plants in the provincial capital, Taiyuan.

The question is how much the state-owned power companies will actually use the pollution control equipment once it is installed. The equipment is costly to maintain and uses enormous amounts of electricity that could instead be sold to consumers. Moreover, regulated electricity tariffs offer little reward for them to run the equipment.

In 2002, the Chinese government vowed to cut sulfur emissions by 10 percent by 2005. Instead, they rose 27 percent. If Chinese officials act swiftly, sulfur emissions could be halved in the next couple of decades, power officials and academic experts say. But if China continues to do little, sulfur emissions could double, creating even more devastating health and environmental problems.

Even so, halving sulfur emissions has its own consequences: it would make global warming noticeable sooner.

China contributes one-sixth of the world's sulfur pollution. Together with the emissions from various other countries, those from China seem to offset more than one-third of the warming effect from manmade carbon dioxide already in the atmosphere, according to several climate models.

But the sulfur particles typically drift to the ground in a week and stop reflecting much sunlight. Recent research suggests that it takes up to 10 years before a new coal-fired power plant has poured enough long-lasting carbon dioxide into the air to offset the cooling effect of the plant's weekly sulfur emissions.

Climate experts say that, ideally, China would cut emissions of sulfur and carbon dioxide at the same time. But they understand China's imperative to clean up sulfur more quickly because it has a far more immediate effect on health.

"It's sort of unethical to expect people not to clean up their air quality for the sake of the climate," said Tami Bond, an atmospheric scientist at the University of Illinois at Urbana-Champaign.

The Hunt for Efficiency

The second big decision facing China lies in how efficiently the heat from burning coal is converted into electricity. The latest big power plants in Western countries are much more efficient. Their coal-heated steam at very high temperatures and pressures can generate 20 to 50 percent more kilowatts than older Chinese power plants, even as they eject the same carbon-dioxide emissions and potentially lower sulfur emissions.

China has limited the construction of small power plants, which are inefficient, and has required the use of somewhat higher steam temperatures and pressures. But Chinese officials say few new plants use the highest temperatures and pressures, which require costly imported equipment.

And Chinese power utilities are facing a squeeze. The government has kept electricity cheap, by international standards, to keep consumers happy. But this has made it hard for utilities to cover their costs, especially as world coal prices rise.

The government has tried to help by limiting what mines can charge utilities for coal. Mines have responded by shipping the lowest-quality, dirtiest, most-contaminated coal to power plants, say power and coal executives. The utilities

have also been reluctant to spend on foreign equipment, steering contracts to affiliates instead.

"When you have a 1 percent or less profit," said Harley Seyedin, chief executive of the First Washington Group, owner of oil-fired power plants in Southeastern China's Guangdong Province, "you don't have the cash flow to invest or to expand in a reasonable way."

A New Technology

The third big choice involves whether to pulverize coal and then burn the powder, as is done now, or convert the coal into a gas and then burn the gas, in a process known as integrated gasification combined combustion, or I.G.C.C.

One advantage of this approach is that coal contaminants like mercury and sulfur can be easily filtered from the gas and disposed. Another advantage is that carbon dioxide can be separated from the emissions and pumped underground, although this technology remains unproven.

Leading climate scientists like this approach to dealing with China's rising coal consumption. "There's a whole range of things that can be done; we should try to deploy coal gasification," said Dr. Rajendra K. Pachauri, chairman of the [United Nations](#)-affiliated Intergovernmental Panel on Climate Change.

The World Bank in 2003 offered a \$15 million grant from the Global Environment Facility to help China build its first state-of-the-art power plant to convert coal into a gas before burning it. The plan called for pumping combustion byproducts from the plant underground.

But the Chinese government put the plan on hold after bids to build the plant were higher than expected. Chinese officials have expressed an interest this spring in building five or six power plants with the new technology instead of just one. But they are in danger of losing the original grant if they do not take some action soon, said Zhao Jian-ping, the senior energy specialist in the Beijing office of the World Bank.

Another stumbling block has been that China wants foreign manufacturers to transfer technological secrets to Chinese rivals, instead of simply filling orders

to import equipment, said Anil Terway, director of the East Asia energy division at the Asian Development Bank.

"The fact that they are keen to have the technologies along with the equipment is slowing things down," he said.

Andy Solem, vice president for China infrastructure at [General Electric](#), a leading manufacturer of coal gasification equipment, said he believed that China would place orders in 2007 or 2008 for the construction of a series of these plants. But he said some technology transfer was unavoidable.

Western companies could help Chinese businesses take steps to reduce carbon-dioxide emissions, like subsidizing the purchase of more efficient boilers. Some companies already have such programs in other countries, to offset the environmental consequences of their own carbon-dioxide emissions at home, and are looking at similar projects in China. But the scale of emissions in China to offset is enormous.

For all the worries about pollution from China, international climate experts are loath to criticize the country without pointing out that the average American still consumes more energy and is responsible for the release of 10 times as much carbon dioxide as the average Chinese. While China now generates more electricity from coal than does the United States, America's consumption of gasoline dwarfs China's, and burning gasoline also releases carbon dioxide.

An Insatiable Demand?

The Chinese are still far from achieving what has become the basic standard in the West. Urban elites who can afford condominiums are still a tiny fraction of China's population. But these urban elites are role models with a lifestyle sought by hundreds of millions of Chinese. Plush condos on sale in Shanghai are just a step toward an Americanized lifestyle that is becoming possible in the nation's showcase city.

Far from the Wu family in rural Shaanxi, the Lu Bei family grew up in cramped, one-room apartments in Shanghai. Now the couple own a large three-bedroom apartment in the city's futuristic Pudong financial district. They have two television sets, four air-conditioners, a microwave, a dishwasher, a

washing machine and three computers. They also have high-speed Internet access.

"This is my bedroom," said Lu Bei, a 35-year-old insurance agency worker entering a spacious room with a king-size bed. "We moved here two years ago. We had a baby and wanted a decent place to live."

For millions of Chinese to live like the Lus with less damage to the environment, energy conservation is crucial. But curbing that usage would be impossible as long as China keeps energy prices low. Gasoline still costs \$2 a gallon, for example, and electricity is similarly cheap for many users.

With Chinese leaders under constant pressure to create jobs for the millions of workers flooding from farms into cities each year, as well as the rapidly growing ranks of college graduates, there has been little enthusiasm for a change of strategy.

Indeed, China is using subsidies to make its energy even cheaper, a strategy that is not unfamiliar to Americans, said Kenneth Lieberthal, a China specialist at the [University of Michigan](#). "They have done in many ways," he said, "what we have done."

Keith Bradsher reported from Hanjing and Guangzhou, China, for this article and David Barboza from Datong and Shanghai.