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China Beats U.S. With Power From Coal Processing Trapping Carbon

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Chemist Unlocks Coal Chemical That Helps Clean Air

After studying chemistry at Shanghai's Fudan University, Jane Chuan and Wang Youqi pursued doctorates in the U.S. She got hers from what's now the University of Buffalo in 1988, the year they married. Wang graduated in 1994 from the California Institute of Technology.

A few years later, they were cashing in stock options in Silicon Valley companies they'd co-founded, one of which created a luminescent chemical to store X-ray images. Their home in Atherton, California, had seven bedrooms, 11 bathrooms and an acre of land, Bloomberg Markets magazine reports in its May issue.

Greg Girard/Bloomberg Markets via Bloomberg

The Huaneng's Dalate coal-fired-electricity-generating station towers stand near Ordos, Inner Mongolia, China, on Jan. 6, 2012.

The Huaneng's Dalate coal-fired-electricity-generating station towers stand near Ordos, Inner Mongolia, China, on Jan. 6, 2012. Photographer: Greg Girard/Bloomberg Markets via Bloomberg

March 28 (Bloomberg) -- Bloomberg's Margaret Conley reports on Yashentech Corp. founders Jane Chuan and Wang Youqi, scientists who have discovered a catalyst that would help cut 90 percent of black carbon soot from the tailpipe emissions of 1,800 Shanghai buses. Their emissions-busting effort is one way in which China is racing to solve its clean-energy riddle: How can a country that's hooked on coal mitigate environmental damage from the dirtiest of fossil fuels? The story will be featured in the May issue of Bloomberg Markets magazine. (Source: Bloomberg)

March 28 (Bloomberg) -- Huang Yiping, the Hong Kong-based chief economist for emerging Asia at Barclays, talks about emerging market economies. Heads of state from Brazil, Russia, India, China and South Africa will discuss the possibility of jointly supporting a candidate to lead the World Bank when they meet this week in New Delhi for a summit of the BRICS group of major emerging markets. Huang speaks with Susan Li on Bloomberg Television's "First Up." (Source: Bloomberg)

By 2000, Wang was convinced that the research methods he was patenting could help stave off the environmental nightmare he saw unfolding during return visits to his homeland. China, already reeling from pollution, was poised to more than double coal consumption during the decade. That would choke cities with smog and exacerbate global warming.

Chuan, 61, bespectacled and smiling in her white lab coat, remembers pounding the pavement to pitch U.S. investors on cleaning China's coal. Only a handful of California's Internet- obsessed venture capitalists bit, she says.

Leveraging Brainpower

So, in 2003, the couple moved back to Shanghai, the city from which they had emigrated 18 years earlier. They crammed into a 1,100-square-foot (100-square-meter) apartment that was hot in the summer, cold in the winter and crowded with two teenage children home from boarding school on weekends.

By 2006, Wang had his breakthrough in sight. He'd found a way to unlock a chemical stored in the coal that was poisoning his country and to put it to an unlikely use: cleaning China's air.

The catalyst he discovered speeds reactions that convert methanol extracted from coal into a substance called dimethyl carbonate. By adding dimethyl carbonate to diesel fuel, Wang now plans to cut 90 percent of black carbon soot from the tailpipe emissions of 1,800 Shanghai buses by year-end.

"We said, 'Let's go to China, where we can leverage brainpower that's cheaper and do something important for mankind," says Wang, 55, a wiry, self-described workaholic who, on this January day, is taking a break from his laboratory to greet visitors in a conference room at Yashentech Corp., the couple's Shanghai-based company.

Hooked on Coal

Yashentech's (0214009D) emissions-busting effort is one way in which China is racing to solve its clean-energy riddle: How can a country that's hooked on coal mitigate environmental damage from the dirtiest of fossil fuels?

China passed the U.S. as the top carbon polluter in 2007; it now emits more than the U.S. and India combined, according to the U.S. Energy Information Administration.

Yet with 1.3 billion people, power-hungry industries and scant oil or natural gas, it has no immediate alternatives to coal for fueling its economy. China gets 70 percent of its energy from coal, three times the U.S. figure. It even converts coal into diesel fuel and ammonia that's used for making fertilizer.

After consuming as much coal as did the rest of the planet combined in 2010, China still can't muster enough electricity to avoid blackouts or accelerate the rise of its western provinces out of poverty, says Zhao Gang, director of a research institute at Beijing's Ministry of Science and Technology.

By 2025, with 250 million more Chinese projected to be living in cities, China's share of global carbon pollution will jump to 30.3 percent from 26.8 percent this year, the EIA says.

Meat, Fish, Air

China can't quit coal. But with efforts from entrepreneurs, mining enterprises and electricity giants, it's ready to tackle its addiction, says Zhou Fengqi, senior adviser to the Energy Research Institute of the government's National Development and Reform Commission.

"Now that people have meat and fish to eat every day, the environment has also become a big concern," Zhou says. "China is not like a developed country. We can't simply stop using coal. If we want to use it, we have to clean it up."

The cleanup is urgent because China's air is so polluted it causes 470,000 premature deaths a year, says Zhang Junfeng, an environmental health professor at the University of Southern California in Los Angeles.

Since 2009, the U.S. Embassy has issued air-quality readings on microscopic soot in Beijing on Twitter. People across the city check the tweets before exercising or taking their children outdoors. The smog was thick enough on Jan. 10 that Beijing's airport grounded 200 flights.

'Desperate Need'

Beijing Mayor Guo Jinlong pledged in February to slice his city's pollution by reducing its coal consumption by two-thirds by 2020, among other efforts. Shanghai is cracking down on vehicle emissions with inspections next year that will force older, polluting cars off the road.

"You have to have a desperate need," says Chuan, Yashentech's evangelizing chief executive officer, to explain why the couple's soot-scrubbing chemical is gaining traction in Shanghai. "In the U.S., the air is so clean there's no urgency. In China, the need is here. The sense of opportunity is very, very real."

The U.S. Environmental Protection Agency on Tuesday proposed the first limits on greenhouse-gas emissions from power plants. The rules permit less than half the average emissions currently released by U.S. coal-burning plants, effectively preventing the construction of new coal-fired facilities that can't capture and dispose of their own carbon.

‘Highly Disrupted’

Scientists say China must act now. The world has just two or three decades to avoid irreversible climate change, says Kelly Sims Gallagher, an energy professor at Tufts University in Medford, Massachusetts, and author of two books on pollution.

“If the Chinese don’t dramatically reduce carbon emissions from coal, there’s no way we can make a dent in climate change globally in the time period that matters,” Gallagher says.

David Fridley, at the U.S. Department of Energy’s Lawrence Berkeley National Laboratory, says it may already be too late to avert higher temperatures, rising seas and melting glaciers. He says China’s emissions won’t stop increasing until its population peaks at 1.45 billion in 2030 -- that’s 15 years after he predicts immutable global warming.

“If global emissions don’t start declining after 2015, all we can do is adapt to a world that will be highly disrupted,” he says.

Mindful of the brewing crisis, Chinese President Hu Jintao in 2005 began pressing 1,000 big steel mills, chemical factories, coal mines and power plants to use energy more efficiently. He ordered them to lower consumption by renovating boilers, trapping waste heat and other means.

Growing Faith

The government closed small polluters and toughened limits on vehicle, appliance and building emissions. It also accelerated solar, wind, hydro, natural gas and nuclear investments to cut coal as a percentage of electrical generation to 60 percent by 2020 from 80 percent in 2012, Zhao says.

At a United Nations meeting in Copenhagen three years ago, China pledged to cut by 2020 the ratio of greenhouse gas emissions per unit of economic output as much as 45 percent from the level in 2005.

China’s growing faith in its coal-cleaning technologies is one reason why the country agreed at a UN meeting in Durban, South Africa, in December -- after 15 years of resisting -- to seek legally binding international limits on carbon by 2015, Zhao says.

“We’ve achieved a foundation in terms of technical developments,” he says. “We can now solve some of these problems. We also have a great ability to invest.”

Inner Mongolia to Algae

Efforts to tackle carbon pollution extend from labs such as Yashentech’s, which is seeking such clean-energy breakthroughs as new uses for coal and antidotes to its pollution, to a windswept hill in the northern desert, where China’s biggest experiment in burying CO2 is under way.

Here, in Inner Mongolia, the world’s largest coal company, Shenhua Group Corp (SHGCLZ)., is turning coal into diesel via a form of gasification called direct liquefaction. Gasification heats coal with oxygen to release gas that makes not only electricity but also fuel, methanol and the building blocks of plastics.

Shenhua is trying to find the best and cheapest way to dispose of the resulting waste carbon. It captures and buries some of it and is studying whether to pump it into oil wells to boost output.

Meanwhile, in a fishy-smelling lab in Langfang, a city just south of Beijing, ENN Energy Holdings Ltd. (2668) feeds carbon dioxide to microalgae. The company is eventually planning to get the organisms’ CO2 breakfast from its Inner Mongolia coal-to- methanol plant. In return, the algae yield oil for biofuels and omega-3 fatty acids that people can take to guard against heart disease.

‘Envy of the World’

“The Chinese are deploying some of these decarbonizing technologies more aggressively than anyone,” says Chris Hartshorn, vice president of Boston-based Lux Research Inc., which on March 1 released a 40-page report on China’s technology priorities. “They have the money, and their system for investing simultaneously in research, technology and market adoption should be the envy of the world.”

China is underpinning its cleanup by boosting the efficiency of coal-burning plants. Turbines from Shanghai Electric Group Co. (601727), the world’s largest provider of coal-fired electricity-generating equipment, require less carbon-spewing rock to begin with.

China Huaneng Group Corp. (902) is designing its GreenGen plant in Tianjin to wring more power from coal while capturing more than 98 percent of its sulfur emissions, which can then be sold to industrial users. By 2016, Huaneng plans to trap 80 percent of GreenGen's carbon emissions and use them to boost production in oil wells in nearby Bohai Bay.

'Keep It Underground'

Environmentalists say efforts to improve coal power are shortsighted because they divert attention and money from renewable energy.

"Electricity from coal plants that are designed to avoid filthy and uncontrolled pollution is two to three times more expensive than alternatives like wind and solar," says Bruce Nilles, deputy conservation director of environmental advocacy group Sierra Club. "Coal is the biggest part of our carbon problem, and we're fighting to keep it underground."

A visit to a pollution-enveloped open-pit mine in Shizuishan on the banks of the Yellow River, which is swollen with ice on a January afternoon, shows the ground China must cover in its race to tame coal's poisons.

Grime-Streaked Miners

North of town, the cooling towers of a China Guodian Corp. (CNEPGZ) power plant are barely visible through gray smog. Inside the mine, coal buyer Wang Peng watches closely to make sure Guodian gets the right quality. Wang says the air is so foul in this city 515 miles (829 kilometers) west of Beijing that he and 80 percent of his co-workers have sent their parents to live in nearby Yinchuan. His 16-year-old daughter is studying in New York for the same reason.

"When we were kids, we used to drink from the rivers," he says, gesturing toward the bleak landscape. "Now, we can't."

Shizuishan's miners brave conditions that would be unimaginable in the West.

Two dozen men, none of whom wear masks, steer front-end loaders and steam shovels to pile coal into a parade of red trucks that back into spaces just inches apart. The trucks never stop for more than a few minutes, adding diesel fumes to

coal dust. The miners, their exposed faces streaked with grime, balance on the trucks to direct the loaders as the hot coal sends up steam in the winter chill. After a few minutes, visitors' handkerchiefs turn black when they blow their noses.

Coal Binge

China's coal binge killed more than five miners every day last year, according to the State Administration of Coal Mine Safety. While China treasures its booming economy and newly minted billionaires, Wang worries about the price it pays.

"When we look into the sky, all we see is gray because of pollution the industries have caused," he says.

A thousand miles southeast of Shizuishan, researcher Wang Hao explains how Shanghai Electric is producing turbines that require less coal from China's 15,000 mines.

In a spotless work area with polished green floors, as 1,000-ton yellow cranes work overhead, he shows off turbine blades 12 feet (3.7 meters) in diameter. Some of the blades are twisted left and some are twisted right to capture every bit of energy from rushing steam. These turbines need 270 grams (10 ounces) of coal for each kilowatt-hour of electricity, down from 400 grams a decade ago.

Topping the U.S.

Shanghai Electric built this complex at Lingang in 2007 in a joint venture with Siemens AG (SIE), gaining access to technology from the Munich-based company. A decade ago, Shanghai Electric produced 15 steam turbines a year. Now, it makes 60 that can each produce up to three times as much energy. And after thousands of job cuts, it builds them for 30 percent less than Siemens does in Europe.

Efficient turbines have helped China top the U.S. in wringing power from coal. In 1949, the Chinese converted an average of 21 percent of coal's energy to usable power, compared with 24 percent for the U.S., says Li Zheng, dean of the thermal engineering faculty at Beijing's Tsinghua University. By 2011, China stood at 37 percent and the U.S. at 30 percent.

Huaneng says it will beat the average with 42 percent at GreenGen when the plant is completed in mid-2012.

The science ministry's Zhao says that in addition to looking for efficiency, China is hunting breakthroughs in capturing coal's pollutants -- and using them in new ways.

"Carbon capture is an important direction we want to take," Zhao says. "A lot of companies are preparing for huge investments."

Carbonated Drinks

Huaneng's technique for trapping pollution from its Shidongkou plant on the Yangtze River shows how capturing has already gained a foothold.

Scientist Liu Lianbo of Huaneng's Clean Energy Research Institute says Huaneng traps the carbon from the plant's smokestack and sends it through ammonia-derived chemicals called amines. The process isolates and concentrates the waste, removes heat and recycles the amines. Huaneng sells the carbon to makers of carbonated drinks and dry ice.

The cost to capture the carbon in 2011: $39 per ton. That's about a third of the cost for most capture experiments in the U.S., Duke Energy Corp. (DUK) Chief Technology Officer David Mohler says.

U.S.-China Cooperation

In one measure of China's emerging technological leadership, the U.S. government is studying Huaneng's approach with help from its Chinese counterpart in Beijing. The DOE's Lawrence Livermore National Laboratory is monitoring the effort. Livermore engineers traveled to Duke's facility in Gibson County, Indiana, in January to investigate how the U.S. company could adopt Shidongkou's methods.

In a reversal of traditional roles, Huaneng isn't sure how much proprietary data to reveal or how much to charge Duke for licensing, Livermore scientist Julio Friedmann says.

Companies may adopt carbon trapping because governments are likely to limit CO2 through taxes or emission caps, according to the 2011 annual energy outlook published by Exxon Mobil Corp. (XOM), the world's largest energy company by

market value. By 2040, carbon costs may reach $80 a ton in the U.S. and $30 a ton in China, the report says.

China's government is pressing to capture a million tons of carbon a year in a demonstration that will begin by 2015. That's sparking a race for funding. Huaneng is competing with coal giant Shenhua, says Sung Ming, chief representative in Asia for Clean Air Task Force, a Boston-based nonprofit that advises the U.S. and China. PetroChina Co. (857) and other oil companies are interested, too, because blasting CO2 into oil wells can boost production.

In the U.S., each ton of $30 carbon can squeeze out two or three barrels of $125 crude.

Omega-3 Fatty Acids

In his lab outside Beijing, ENN Energy Vice President Zhu Zhenqi is betting on carbon for a different kind of oil: omega-3 fatty acids.

Zhu, who looks like a college professor in his brown tweed sport coat, feeds CO2 that ENN produces in its lab to microalgae to harvest them for biofuel and food supplements. The green, single-cell organisms are so voracious they double in size every 24 hours.

Scientists have long known algae feed themselves by consuming CO2 during photosynthesis. ENN thinks it can turn carbon-gorging algae into a business. A company can grow 20 times more algae per acre than soybeans, Zhu says, while eliminating coal's waste as the organisms gobble up CO2.

Spirulina

Zhu leads visitors through a greenhouse-like laboratory where horizontally stacked water tubes run lengthwise. The hundreds of tubes all look about the same, even though they're being used to test different kinds of algae, growing conditions and CO2 from several coal varieties. For now, ENN gets the CO2 from a nearby lab where the company, in another experiment, is simulating what it's like to burn coal underground to reduce pollutants that reach the surface.

After feeding algae 110 tons of CO2 a year, ENN gets 20 tons of biodiesel fuel and 5 tons of protein. Zhu plans to expand to 20,000 tons of CO2 annually by 2013, using the waste carbon from ENN's Inner Mongolia plant. ENN will turn the protein from the algae into fatty acids and spirulina, a protein-rich supplement Zhu says is so popular it sells for a higher price for its weight than crude oil.

"If we deliver to the energy market alone, we're not going to make money," he says.

Burying Carbon

Shenhua is exploring the possibility of ridding the planet of carbon pollution by burying coal's poisons underground.

Along a stretch of desert in Erdos, Inner Mongolia, some 1,800 workers navigate a mile-long, $2.4 billion plant. They're turning coal into 1 million tons of diesel, naphtha and liquefied petroleum gas for Shenhua's truck fleet, PetroChina and other customers each year. Before Shenhua opened the plant in 2008, nobody had ever built a complex this big to make fuel from coal using direct liquefaction, chief engineer Shu Geping proudly says.

Workers heat and pressurize coal and capture the escaping chemicals in liquid form in a sealed vat. Then they blast them with hydrogen to make the fuel they seek, leaving liquid CO2 as a byproduct.

Trucks deliver 100,000 tons of the liquid each year to a hillside 10 miles west of the plant. Shenhua stores the CO2 in silver tanks, each decorated with a red star, until it's ready to inject it through a wellhead to as deep as 8,000 feet.

Self-Sufficient

Shu, who wears his jacket inside on this January day because he keeps his office cold, says Shenhua's goal is to use coal -- the only resource China has in abundance -- for energy security. "In times of conflict, China must be self- sufficient," he says.

Nonetheless, Shu is calculating how to cut the cost of capturing the carbon. Right now, trapping and burying CO2 costs $50 a ton, he says. That may drop to $14 a ton if he gets government approval to bury more. Costs are lower than for traditional plants because a coal-to-liquids facility like his can isolate pure carbon exhaust. In

typical power plants, the carbon concentration in the exhaust is 10 to 12 percent, making it harder to catch.

Even after Shenhua captures 100,000 tons of CO2 a year, another 3.5 million tons escape at Erdos. Li Yan, head of climate campaigns for Greenpeace in East Asia, says that's unacceptable.

'Green Transition'

Pollution from plants that use coal to make fuel and chemicals is one reason why China fell short last year in progress toward its pledge to cut greenhouse gases, she says. Such plants, built in the desert, also strain water supplies, she says.

China needs more renewable energy for generating electricity, not more coal, Li says.

"A green transition is something every country will face," Li says. "Letting it happen faster will benefit China in every possible way."

China's biggest effort to reduce the impact of using coal to make electricity is taking shape in Tianjin, 70 miles southeast of downtown Beijing. The final touches are being put on the $1 billion GreenGen plant for its planned midyear opening.

GreenGen uses a process called integrated gasification combined cycle, or IGCC. It heats coal to form a chemical mix called syngas and sends that to a gas turbine to make electricity. Leftover heat goes to a steam turbine in a second step.

Keeping Coal Viable

Electricity from early IGCC plants is expensive, at $175 per megawatt-hour, says Kieron Stopforth, a Bloomberg New Energy Finance analyst in London. That compares with $139 at traditional coal-fired plants that capture carbon and $72 at conventional plants that release carbon. Costs will drop as IGCC technology matures, Stopforth says.

Shanghai Electric, which built GreenGen's steam turbines, plans to make gas turbines for 24 new IGCC facilities each year. That would create more gasification plants generating power from coal in one year than the total number that existed or were planned globally in 2010.

GreenGen may set off a wave of government approvals for the plants across China, Clean Air Task Force's Sung says.

Duke Energy is keeping tabs on GreenGen as the U.S. struggles to maintain coal as a viable electricity source.

'Harder to Use Coal'

Duke has almost completed a 618-megawatt IGCC plant in Edwardsport, Indiana, using gasifiers designed by General Electric Co. and built in China by Hangzhou Boiler Group (002534). At $3.3 billion, it's about $1 billion more than the original estimate. Duke altered the design, including making gasifiers taller for better maintenance. In some cases, engineers underestimated how much piping they'd need, raising costs. Even so, plant manager Jack Stultz says IGCC technology will shape coal's future.

"Most regulations that are current or pending make it harder to use coal," he says. "If we can't do it here, coal's life expectancy gets pretty short."

Yashentech's Chuan and Wang say China will need to burn coal far into the future, creating opportunities for their company and others focused on cleaning it up.

During the 2008 financial crisis, the couple took pay cuts and pledged their California home as collateral for loans to keep the company afloat. Today, there's more interest. San Francisco-based Nth Power LLC is providing startup investments, following an original backer, Palo Alto, California-based Firelake Capital Management LLC. Yashentech is also trying to land Chinese government grants.

Pollution-Weary Chinese

"In China, we get lots of support from the people, politicians and moneymakers," Chuan says.

Wang, explaining the science behind his soot-reducing discovery, says the dimethyl carbonate his catalyst extracts from a derivative of coal is important because it's rich in oxygen. That makes combustion more efficient, reducing carbon when diesel buses belch pollution.

Yashentech produces dimethyl carbonate for $730 a ton, or 36 percent less than rivals, he says.

Wang hopes that in 10 years, vehicles across China will run on sootless diesel, trimming carbon emissions 3 percent. That alone won't stop global warming. But Wang says it will lift the hearts of pollution-weary Chinese whenever they step behind a bus and don't get blasted by foul air.

China's paucity of oil and natural gas and the slow commercialization of renewable energy mean the country may never kick its coal habit.

But with entrepreneurs such as Chuan and Wang, companies that are focused on curbing pollution and government making it imperative to do so, China is stepping forward in the race to tame a dirty fuel the world still can't live without.

--John Lippert and Chua Baizhen, with assistance from Richard Weiss in Frankfurt, William Mellor in Sydney and Mark Drajem in Washington. Editors: Gail Roche, Jonathan Neumann

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