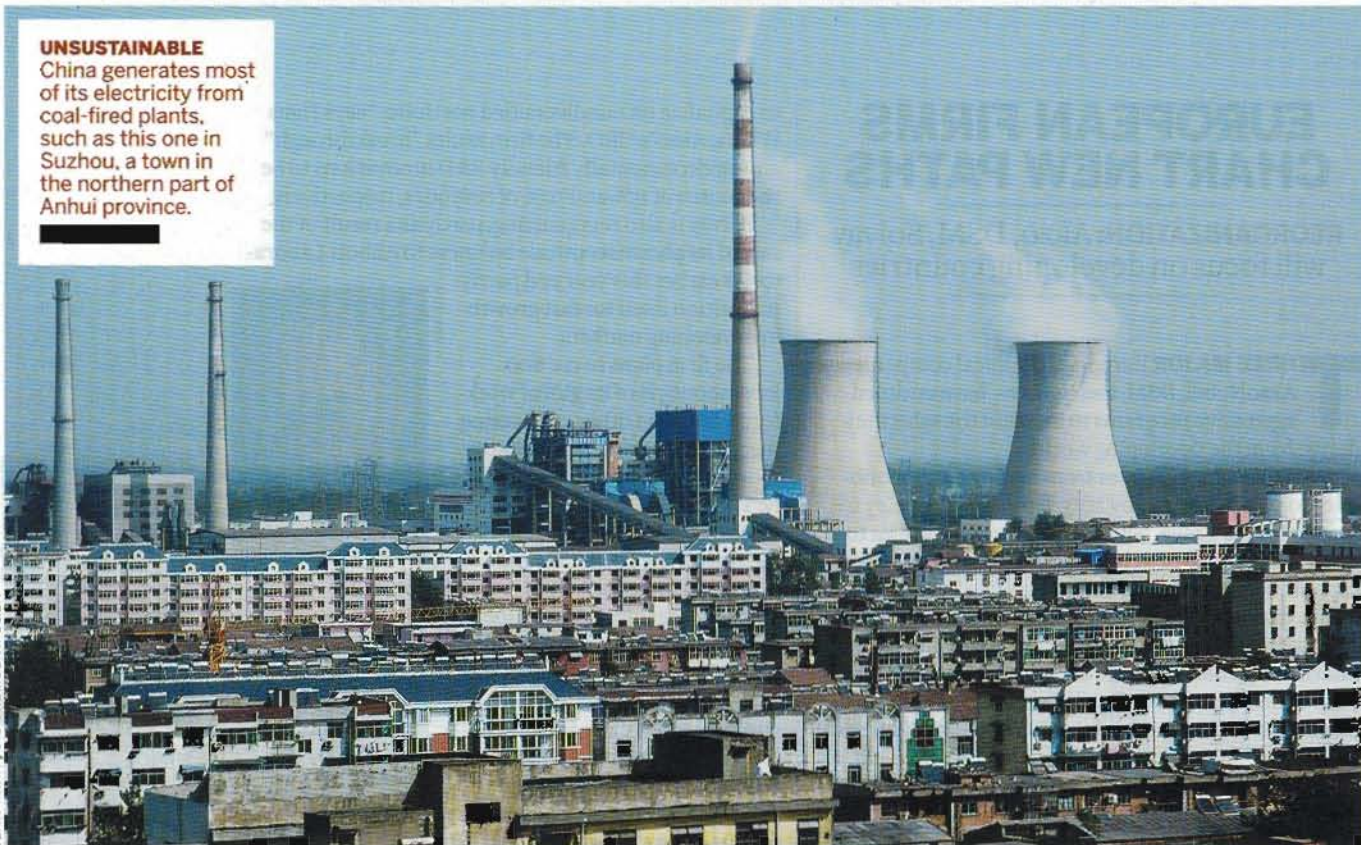


UNSUSTAINABLE

China generates most of its electricity from coal-fired plants, such as this one in Suzhou, a town in the northern part of Anhui province.

JEAN-FRANÇOIS TREMBLAY/C&EN



CHEMISTRY ENERGIZES CHINA

China's quest to develop **INNOVATIVE ENERGY SOLUTIONS** represents a huge opportunity for foreign chemical and materials makers

JEAN-FRANÇOIS TREMBLAY, C&EN HONG KONG

WHEN IT COMES TO energy generation, China welcomes new approaches. Philip Liu, an entrepreneur from Arizona, has raised \$60 million, largely from Chinese investors, for a large-scale demonstration plant he is building in southern China that will turn oil shale into fuel for the local chemical industry. The carbon-rich waste from the plant will feed into an adjacent facility that will produce a low-cost fuel for power and gasification plants.

"I don't think I could have implemented this project in the U.S.," says the Chinese-born Arizonan. "But in China, when they trust the management team, the investors will put the money down—and quickly." AuraSource, the U.S.-based company that Liu founded, developed the oil shale tech-

nology at R&D facilities in Shanghai after licensing the basic processes from Chinese research centers.

AuraSource's experience is just one illustration of the opportunities that exist in China in the alternative energy field. China has become a magnet for all sorts of entrepreneurs who have creative ideas about how to generate or conserve energy, Liu says.

From producing biofuels to improving the efficiency of its power grid, China has

embarked on an all-out drive to change the way it generates, transports, and consumes power. The national effort is opening up myriad opportunities for chemical and materials companies around the world for which, in many ways, China is a more appealing market than the U.S.

"I think it's safe to say that China is sometimes bolder in its initiatives, and China is faster," says Weiguang Yao, Dow Chemical's Shanghai-based chief technol-

"In China, when they trust the management team, the investors will put the money down—and quickly."

ogy officer for the Asia-Pacific region. "The decisionmakers are supporting alternative energy, and this is the key in China."

One good reason for China to become a world-class innovator in energy generation is that it has to change the way it powers itself. A nine-day traffic jam in August on a highway between Inner Mongolia and Beijing would not have been nearly as bad if the Chinese capital were less dependent on coal to power itself. Roadwork was mostly to blame for the gridlock, but trucks ferrying coal to Beijing's power plants represented a large proportion of the vehicles caught in the monster jam. China's glitzy capital relies on a steady stream of coal trucks to keep the lights on.

But the epic traffic jam actually ranks as one of the more trivial reasons why China is urgently seeking to develop alternative sources of power. For most of its energy needs, China depends on coal and imported oil, and that's clearly an undesirable state of affairs.

OTHER THAN HAVING to be transported over long distances, coal generates air pollution and CO₂ emissions for which China attracts stern international criticism. And finding alternatives to imported oil is a national security imperative, given that China has less secure access to Middle Eastern oil than do the U.S. and European countries.

Although coal and petroleum will still be a major part of China's energy mix for decades to come, the country's achievements in the development of alternative energy are impressive. Last month, Ernst & Young ranked China first in the world in its latest Renewable Energy Country Attractiveness Index.

In 2009, "China led the world in clean technology investments," states a report released earlier this year by the Pew Charitable Trusts. The report adds that China has some of the world's most ambitious renewable energy targets: 30 gigawatts of new energy generation capacity each from wind and biomass by 2020.

For many major chemical and materials makers, the Chinese alternative energy market is an important one. "We're most active in solar, but also in wind and in energy infrastructure; Chinese energy generation is a big deal for us," says Jeremy Burks, president of Dow Corning Greater China.

Some companies in the energy materials field even find China to be

a more developed market than the U.S. "We see the U.S. as an emerging market and China as the established market," says Edward Frindt, chief executive officer of Ohio-based Novolyte Technologies, a supplier of electrolytes to the lithium-ion battery industry.

Whereas many major companies produce sophisticated batteries in China, he says, the industry in the U.S. is still government supported. The outlook for electric vehicles is also brighter in China than in the U.S., Frindt notes. "There's a long history of internal combustion engines in the U.S., but in China, they're developing an infrastructure that may be more supportive of electric ones."

Because biofuels could reduce China's dependence on imported oil, enzymes producer Novozymes sees vast opportunities in the country for its second-generation biofuels technology. These fuels, which are still not commercially mature, are made from corn and wheat waste materials rather than from the grain itself. Novozymes has teamed up with oil refiner Sinopec and the Chinese agricultural products supplier Cofco to build a cellulosic ethanol plant that Novozymes will supply with enzymes.

"This technology reduces pollution and

HIGH PERFORMANCE
Liquid silicon rubber from Dow Corning helps provide stable electric power to the Qinghai-Tibet railway, located in extremely inhospitable conditions.



water use, which fits with the Chinese agenda," says Michael Christiansen, president of Novozymes China. "Moreover, it helps the agricultural economy by upgrading the value chain for farmers producing corn who would otherwise not use the waste." The large-scale adoption of cellulosic biofuels in China could create 6 million jobs, Christiansen says, while reducing the country's dependence on petroleum by 10%.

China's clean energy market has come under criticism abroad for being closed to foreign manufacturers. The European Union Chamber of Commerce in China complained last year that foreign suppliers are locked out of the Chinese wind turbine market even though they've built plants in the country to comply with local-content requirements. Last month, the United Steelworkers union filed a trade case against China's predatory practices in the clean energy sector.

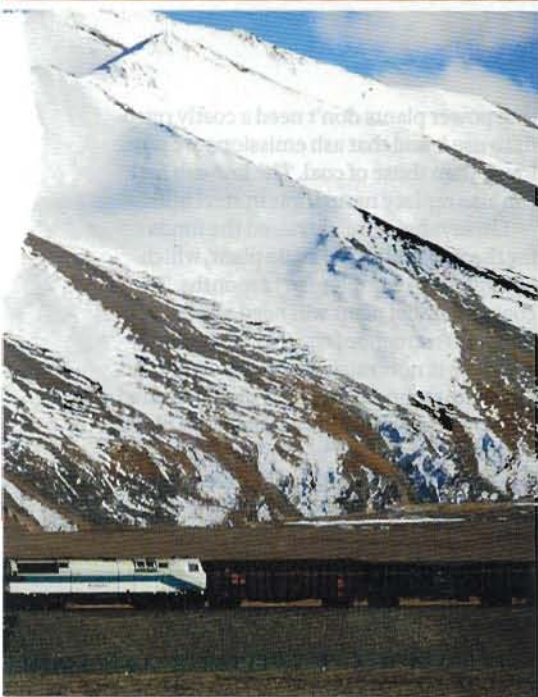
IN CONTRAST, producers of chemicals and materials with energy applications find China to be a land of opportunity. Frindt, who lived in the country for three years, says Novolyte's sales of battery materials in China will grow by as much as 50% this year. The company operates a plant in Suzhou, is opening a second plant as a joint venture, and also runs a 12-chemist R&D center in the country. "The Chinese market is several times bigger than the U.S. one," Frindt observes.

UPSTART

China is ramping up alternative energy in addition to coal

ELECTRICITY GENERATION CAPACITY, GIGAWATTS				
	2007	2015	2020	2035
U.S.				
All types	995	1,069	1,082	1,216
Coal-fired	313	325	326	337
Wind	16	64	64	69
Solar	1	1	1	1
CHINA				
All types	716	1,021	1,242	1,924
Coal-fired	496	625	750	1,233
Wind	6	39	63	130
Solar	0	4	6	6
WORLD				
All types	4,428	5,005	5,470	7,009
Coal-fired	1,425	1,545	1,671	2,366
Wind	93	277	347	486
Solar	8	45	53	64

SOURCE: DOE, International Energy Outlook 2010



DOW CORNING

grated into customers' production lines. "Especially for the paste, there's a lot of customization to meet customers' unique processing conditions," Doyle says. DuPont finds the potential of the Chinese solar market so vast that it also formed DuPont Apollo, a panel-manufacturing venture in southern China that's specifically for the Chinese market.

Ferro Corp. also is increasing its ability to serve solar-cell manufacturers in China. The U.S. firm is expanding an existing R&D center in Suzhou, where it manufactures metallization pastes, and it is building an applied technology center in Taipei that will open in a few months. Both labs will offer a range of characterization instruments and have the capability to build prototype solar cells.

The top end of the Chinese market is where foreign producers of chemicals and materials usually find the best opportunities. "Typically, we work with the medium-to large-scale producers," says Paul H. Liu, who heads Solutia's Asia-Pacific operations. He explains that Solutia supplies solar-cell encapsulants suitable for both thin-film cells and cells based on polysilicon.

China has about 40 producers of either polyvinyl butyral (PVB) encapsulants for thin-film solar cells or ethyl vinyl acetate (EVA) encapsulants for polysilicon-based cells, Liu notes. Because their facilities are too small or their product performance is inferior, many of these producers can supply only marginal solar cell firms, Liu claims. "The smaller producers of PVB or EVA work with the smaller producers of solar cells," he says.

For Marc Doyle, global business director of DuPont Photovoltaic Solutions, any protectionism that might exist in China's clean energy sector is a nonissue. China is the biggest buyer of DuPont's solar materials, including Solamet solar metallization pastes, encapsulants, and Kevlar films used as solar-panel backsheets. The country is the world's largest solar-cell producer, accounting for about 40% of world output.

Because China is such a big market for alternative energy, it makes sense for companies supplying related chemicals and materials to build manufacturing and R&D capabilities in the country. Both DuPont and Dow Corning operate prototyping lines at their R&D centers in Shanghai, where they test how their solar materials can be inte-

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AuraSource, a much younger and less established company, will not customize its products for China, but rather will develop the technology there. If customization is needed, the company will do that work in the U.S. when it transfers the technology back to its home base.

To feed its plant in Qinzhou, in the southern province of Guangxi, the firm will

import low-cost oil shale from Indonesia and transform it into lightweight fuel oil, dry gas, and various hydrocarbon feedstocks that will supply nearby petrochemical plants. The carbon-rich waste will serve as feedstock for an adjacent facility that will produce a low-ash coal-water fuel that can replace heavy oil in power plants. The main advantages of this mixture, Liu says, are

that power plants don't need a costly retrofit to use it and that ash emissions are much lower than those of coal. The low-ash fuel can also replace natural gas in steel mills.

Liu says he's already raised the funds for the \$60 million oil shale plant, which he expects to complete in 12 months. The coal-water fuel plant will need an additional investment of roughly \$20 million, which he is now raising from investors. Once the technology is fully demonstrated, Liu hopes to build commercial-scale plants in the U.S.

Even though the U.S. contains the world's largest deposits of oil shale, Liu developed his business in China because he found it easier to do so there. In China, he managed to gain access to the basic technologies for extracting fuel from oil shale at low temperature and for producing a coal-water mix with low-ash emissions. AuraSource refined the technologies at the company's R&D center in Shanghai at a much lower cost than in a lab in the U.S.

THE DEVELOPMENT of a commercially viable way to turn oil shale into fuel has been the object of so much research that a newcomer such as AuraSource would not have been taken seriously in the U.S., Liu says. AuraSource received no money from the Chinese government, he notes, but was able to meet with wealthy investors in China.

The commercialization of oil-shale-based fuel would be a huge achievement. Yet, China appears to be capable of delivering equally significant breakthroughs in the solar energy field.

In August, when China's National Development & Reform Commission organized a tender for 13 solar energy farms with a combined generation capacity of 280 MW, some of the 50 companies vying for the projects submitted bids as low as 10 cents per KW of electricity delivered to the grid, DuPont's Doyle says.

"The bids have not been finalized, but if that's the actual price, that would mean that China is already coming lower than anywhere else in the world, even before creating a domestic gigawatt-scale market," he observes. The bids were made by Chinese power companies that will presumably generate power from Chinese-made solar cells.

At 10 cents per KW, Doyle says, solar energy is competitive with both nuclear and wind energy. As a result, he anticipates that solar cells, a marginal domestic energy source today, could take off dramatically in China. "Look at the size of the country, the

spectrum
chemicals & laboratory products

trans·par·en·cy:
see right
through us.
trust your ingredients.

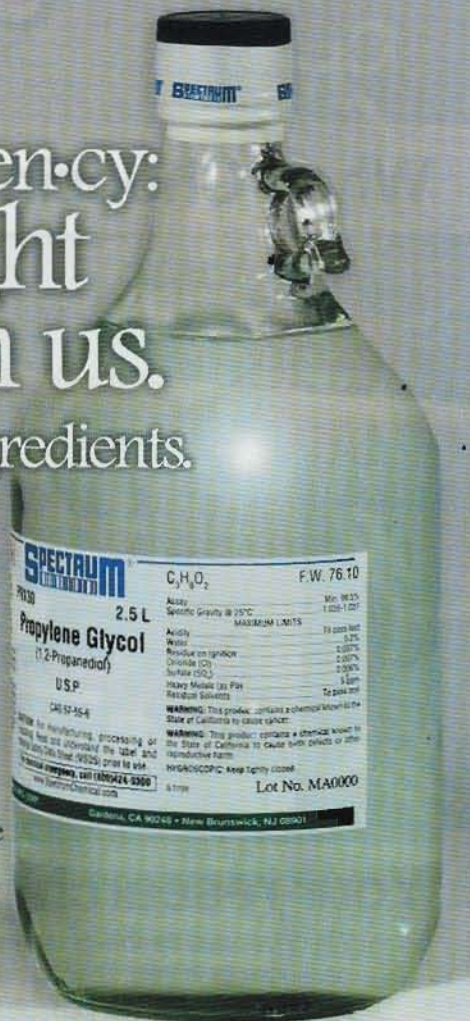
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total demand for power, the environmental issues, the need to clean up the Chinese power industry," Doyle says. "China is already the world's largest producer of solar cells, but the growth of the solar industry will only accelerate here as the domestic market develops."

Although China's domestic solar energy market is still small, the country is the world's largest consumer of wind energy turbines. It is building wind farms both on- and offshore, presenting opportunities for material makers. For instance, Dow Corning makes Molykote, a specialty lubricant that works especially well under the high load factor that is typical of wind turbines.

The lubricant is also durable. "When turbines are offshore, they're inaccessible, so you want the equipment to be long-lasting," Burks says. He notes that some Dow Corning products are also used to help reinforce the blades' composite materials.

At Dow, Chief Technology Officer Yao refers to the Chinese wind energy market as "an exciting business." In April, he notes, the company started producing its Airstone epoxy materials at a plant in Tianjin. The material makes windmill blades stronger, lighter, and easier to manufacture, Yao says.

Beyond energy generation, China is a hospitable market for companies offering materials that help reduce energy consumption or improve energy efficiency. Dow Corning's Burks notes that the company's silicone-based pylon insulators are being ad-

SILENT LOCOMOTION

Many scooters in Chinese cities are electric and use lead-acid batteries instead of more efficient lithium-ion ones.

opted in China as a replacement for heavier and less efficient ones made from porcelain or glass. Resistant to extreme temperature changes and high radiation, the company's liquid silicone rubber is used to provide stable electric power to Chinese railways, in particular along the Qinghai-Tibet route, where the environment is famously inhospitable.

A prosaic but potentially lucrative Chinese market is window film that cuts down on solar heat. "People talk a lot about new technologies and green buildings but generally not about a readily available solution like this one," says Solutia's Liu. The company's line of window films can reject up to 81% of solar heat, considerably reducing a building's air-conditioning bill.

The products can be installed on existing buildings for far less than the cost of a top-to-bottom energy-efficiency retrofit, Liu says. The films, he adds, have attracted the attention of Chinese government officials who are required to reduce energy consumption. "There's a lot of activity sponsored by the government in China," he points out.

THERE'S ALSO A LOT of competition for window films in China, Liu says, and it's hard for a company such as Solutia to get the message across about its superior technology. "Everyone can make claims, and in the end, it's up to whoever has the best sales talk," Liu laments. Solutia is lobbying for construction standards in China that would specify minimum performance requirements for solar films. Some of the films now promoted in China peel off, fail

to reduce solar heat, or significantly reduce window transparency, Liu claims. The predatory competition from these low-performing products "actually hurts the reputation of the industry," he adds.

As incomes continue to rise in China, demand will gradually shift toward high-quality products, Novolyte's Frindt predicts. Lithium-ion batteries, for which Novolyte supplies electrolytes, present numerous advantages over other types of batteries, be it in small- or large-scale applications.

When used to power China's ubiquitous electric scooters, lithium-ion batteries provide a longer range than lead-acid types, and they also have a longer useful life. Lithium-ion batteries are easier to carry, which is an advantage for riders who have to lug their batteries into their apartment for charging. Electric bikes offer the advantages of low noise and environmental emissions.

In large-scale applications such as storing the electricity generated by solar farms or wind turbines, lithium-ion batteries cost less over time because they don't need to be replaced as often. The main problem in China, Frindt says, is that buyers have a propensity to consider only their upfront costs. "The thinking is progressively changing, but for now buyers would rather replace every year if the initial cost is low." He's encouraged that purchasing managers for the largest government programs are starting to look at the long-term cost implications of their decisions.

Asked to describe the main difference between doing business in the U.S. and China, Frindt responds that competition is fiercer in China. "Competition in energy storage is less in the U.S., whereas China forces us as a business to be competing at the highest level. It's very intense," he says.

The fierce competition in the power storage field reflects China's emergence as a hotbed of activity for anything that has to do with creating or conserving energy in an innovative manner. Reducing China's reliance on coal will take years. In the meantime, the country's adoption of a wide range of alternative energy sources is translating into opportunity for chemical and materials makers from around the world. ■

"China is already the world's largest producer of solar cells, but the growth of the solar industry will only accelerate here as the domestic market develops."