IN PARTNERSHIP WITH:

SUSTAINABLE ENERGY FOR A GROWING CHINA

HOW ADVANCED SCIENCE CAN HELP SECURE THE COUNTRY'S ENERGY FUTURE

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This white paper was created by *Fortune* Industry Perspectives and DuPont. It is the second of a series showcasing sustainable development thought leadership, which will help inform the discussions at the 2013 *Fortune* Global Forum, June 6-8, 2013, in Chengdu, China. For more information on sustainable development in China, please visit www.DuPont.com/FortuneGlobalForum.

Introduction

SCIENTIFIC AND technical innovation will be key to helping China meet its soaring demand for energy, while protecting its fragile environment and meeting its international obligations to help mitigate global climate change. This will be a journey, not a step change. China will continue to consume large quantities of fossil fuels while it works to create an economy based on clean, renewable energy. As a result, China will be the world's energy laboratory for decades to come.

China's GDP is expected to quintuple between now and 2050, according to the IMF, driving extraordinary growth in energy consumption. This rapid growth will profoundly reshape international energy markets in coming years. Chinese energy demand will likely boost energy prices and stimulate scientific innovation across the global energy sector, from fossil fuels to renewables. "As new industries such as photovoltaic manufacturing develop in China, they also impact the rest of the world," says DuPont chair and CEO Ellen Kullman.

China's increasing dependence on foreign oil and gas is a significant factor driving government efforts to diversify the country's energy portfolio. Around 50% of total Chinese energy production comes from imported fossil fuels, according to the Economist Intelligence Unit. Although China was a net oil exporter until the early 1990s, the country is currently the world's second biggest oil importer after the United States. China has been a net coal importer since 2007, and Chinese imports of liquified natural gas (LNG) have also risen sharply in recent years, according to research by Lawrence Berkeley National Laboratory.

China is committed to finding market-based solutions to its energy needs. Under President Xi Jinping, China recently announced plans to end its system of controlled pricing for domestic coal, effectively marketizing an important sector of the Chinese economy and signaling openness to market-based approaches in other areas of energy policy. According to the government's official energy policy white paper, released in October 2012: "China is actively promoting market-oriented reform in the energy sector

CHINA RECOGNIZES THAT SUSTAINABLE DEVELOPMENT IS NOT POSSIBLE WITHOUT CLEAN, RENEWABLE ENERGY.

by giving full play to the fundamental role of the market in the allocation of resources. All projects listed in the national energy program, unless forbidden by laws or regulations, are open to private capital."

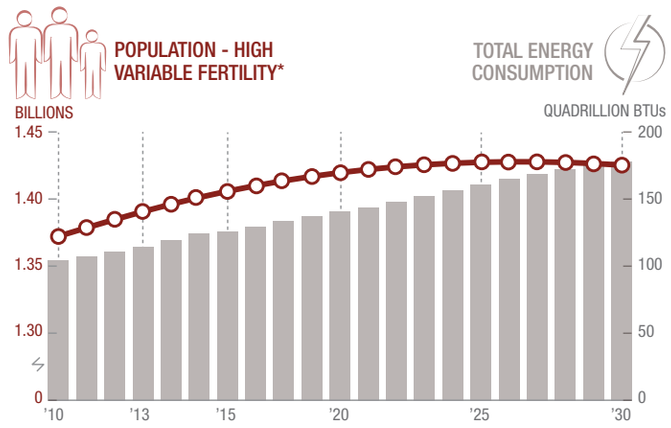
The world's most populous nation is also the biggest energy consumer on the planet. In 1982, China consumed around 500 million tons of coal-equivalent energy, according to Li Junfeng, head of the National Climate Change Strategy Research Center. Today annual consumption is close to 3.7 billion tons of standard coal. Back then China had only 50 gigawatts of installed power generation capacity. Installed capacity is close to 1.16 terawatts now, and national energy consumption has increased more than sevenfold, surpassing the United States.

China's energy consumption is driven mainly by its vast population and by its rapidly growing economy. China has a low rate of population increase by international standards due to the one-child policy and other efforts to control population growth. With an annual growth rate of 0.481%, China's total population is currently increasing by about 6.5 million people every year, according to the CIA World Factbook. Meanwhile, GDP per capita has grown more than 20-fold in the last three decades, from less than $300 in the early 1980s to nearly $6,000 today. "Population growth and economic development are the two things that have led to unstoppable growth in energy consumption," says Li.

Today, China accounts for 12% of global energy demand, and Chinese energy consumption is growing four times faster than that of the rest of the world. China is already the world's largest producer and consumer of electricity, the third-largest global oil consumer, and the fifth-largest consumer of natural gas, according to the Berkeley Energy & Resources Collaborative. No surprise, then, that China is also the largest sovereign contributor to greenhouse gases.

China recognizes that sustainable development is not possible without clean, renewable energy. Renewables, including hydroelectric and nuclear power, currently account for about 9% of the country's total energy portfolio, according to Worldwatch Institute. The remaining 91%

CHINA POPULATION AND ENERGY CONSUMPTION



*High Variant Fertility projects .5 children above medium variant, i.e instead of 2.1 children per woman, it would be 2.6 children. Sources: UN World Population Prospects: The 2010 Revision United Nations Population Division and FAOStat and EIA; Long term series estimates and projections from 1980 to 2020; Economically active population from the ILO and the data refers to the 5th edition, revision 2008. 2008: Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database. Projections: EIA, World Energy Projection System Plus (2011).

ALTHOUGH CHINA IS THE WORLD'S LEADING HYDROPOWER PRODUCER, THE COUNTRY CURRENTLY USES ONLY 30% OF ITS TOTAL HYDRO CAPACITY.

comes from fossil fuels. However, the government recently committed itself to achieving 15% of total energy consumption from non–fossil fuels by 2020. (More than half of that 15% is expected to come from new hydro capacity.) China led the world with $52 billion in clean-energy investment in 2011, according to the United Nations. It is already one of the world's largest wind-power producers and a leader in solar technology. China has ambitious plans to build out its already impressive hydroelectric sector and is also increasing its nuclear capacity, with a renewed emphasis on safety.

Although China is the world's leading hydropower producer, the country currently uses only 30% of its total hydro capacity. Like many other countries, China faces huge challenges balancing the benefits of hydropower against its significant environmental and social costs. Going forward, the country must figure out how to increase hydropower production without putting excessive stress on the environment, particularly water resources that are also needed for agriculture to feed a huge and growing population.

Nuclear energy is also an important part of China's overall energy strategy. China recently completed a comprehensive review of nuclear safety procedures, prompted by the 2011 Fukushima disaster in Japan. With assistance from Westinghouse and other multinationals, China plans to build numerous new nuclear facilities nationwide over the next few years, with the goal of increasing the country's total nuclear power generation to 80 gigawatts by 2020. The government has announced that it will favor remote coastal locations for new reactors and will scale back on plans to build reactors near major electricity demand centers inland.

A global network of public and private stakeholders are working to reshape China's energy economy. Key players include Chinese government agencies such as the National Energy Administration under the National Development and Reform Commission; scientists and engineers at institutions ranging from Tsinghua University in Beijing to Berkeley's Lawrence Livermore Lab, state-owned energy producers and distributors such as CNPC, Sinopec, CNOOC, State Grid, and China Southern Power Grid; and multinational corporations, including integrated energy companies such as BP and Exxon, major engineering firms like GE and Westinghouse, and applied science companies like DuPont.

TPG / GETTY IMAGES

This paper examines the current state of play in the world's energy laboratory. It presents three key challenges for the Chinese energy sector, including the shift from an industrial economy to one increasingly driven by consumer spending, China's continued dependence on fossil fuels, and environmental pressures resulting from the country's rapid growth.

Next, it describes the Chinese government's "all of the above" energy strategy, which includes conservation; restructuring the energy production system; and smart, sustainable exploitation of all energy sources, including fossil fuels, hydro, nuclear, and renewables.

Finally, it explains how DuPont and other international companies are working in concert with government and private-sector partners in China to help develop sustainable energy solutions that can power the country's growth and maintain the health and prosperity of its citizens going forward.

China's 3 Energy Challenges

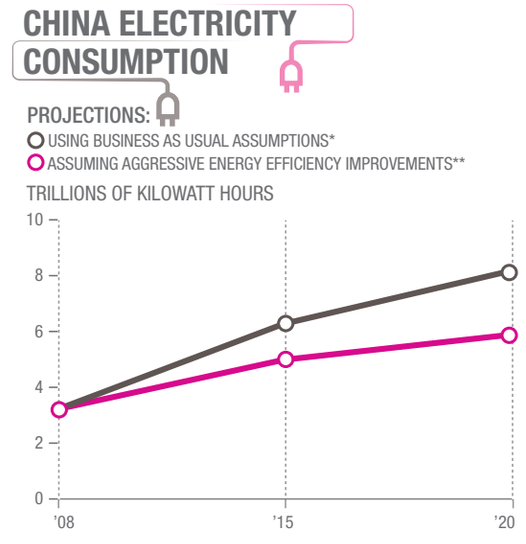
No. 1

THE "WORLD'S FACTORY FLOOR" IS BECOMING THE "WORLD'S SHOPPING MALL."

Nobody knows the exact day or the precise place, but at some point in 2011, a Chinese citizen migrated from a rural district to one of the country's fast-growing cities, and China's urbanization rate hit 50% for the first time in history. Urbanization rates have continued to rise since then: Every year, around 20 million Chinese move to the cities, seeking jobs and the amenities of urban life. Today China has more than 170 cities with populations of more than a million, and at least eight megacities with populations that exceed 10 million.

Urbanization has major implications for China's energy sector. In 2012, Chinese consumers, most of whom live in cities, generated half the country's GDP growth. "Urban consumers don't just want food and a place to live," explains Shaun Rein, managing director of the China Market Research Group, a consulting firm based in Shanghai. "They want to drive cars, not bicycles. They want to live comfortably in houses with hot water and air-conditioning."

Today, China's economic growth and energy consumption have been driven mainly by industrial production. "The industrial sector accounted for 74% of China's total delivered energy consumption in 2008, and its share remains above two-thirds through 2035," according to projections by the U.S. Energy Information Administration. But as millions of Chinese enter the middle class, they are living longer, buying more cars, moving into bigger houses that need more heat and air-conditioning, and purchasing more energy-hungry appliances. In 2010, China overtook the U.S. to become the world's biggest automotive market, according to the China Association of Automobile Manufacturers. As a result of all these shifts, China's 1.3 billion consumers are increasingly driving the country's soaring demand for energy.



Sources: *China Electricity Council;
**China Energy Group (Lawrence Berkeley National Laboratory).

No. 2

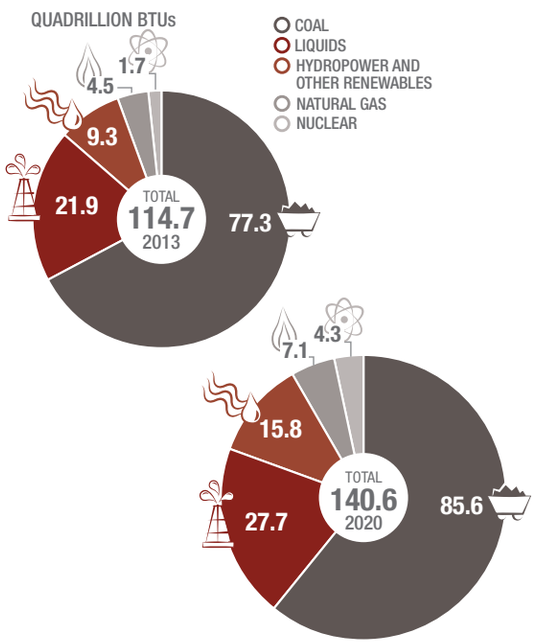
CHINA WILL BE DEPENDENT ON FOSSIL FUELS FOR THE FORESEEABLE FUTURE.

Given China's significant coal reserves, it is likely that fossil fuels will continue to dominate the country's energy portfolio. Coal supplied 70% of the energy that China consumed in 2009, followed by oil with 19%, hydro with 6%, and natural gas with 4%. Chinese coal consumption is expected to rise 35% by 2020. China depends on coal for about 80% of its electricity generation. Starting in late 2002, China began to experience coal shortages as a result of the country's dizzying economic growth. "As brownouts and blackouts hit most of the provinces, a sense of crisis gripped the country," energy historian Daniel Yergin writes in his 2011 book *The Quest*. "Factories were working half-days or even shutting down because of shortages of energy, while sales of diesel generators soared as desperate industrial enterprises resorted to making their own electricity."

Concerns about energy shortages have encouraged China's state-owned oil giants to step up their domestic oil exploration efforts and to tap international sources as well, often via joint ventures with international oil companies in Africa, Asia, North America, and elsewhere. Yergin predicts that by 2020, China will pull ahead of the United States and become the world's biggest oil consumer.

CHINA DEPENDS ON COAL FOR ABOUT 80% OF ITS ELECTRICITY GENERATION.

TOTAL ENERGY CONSUMPTION BY FUEL



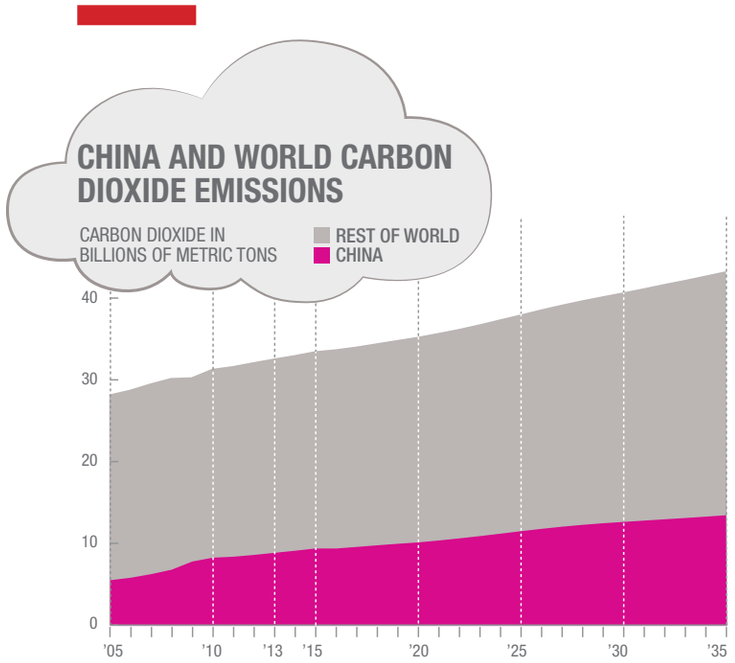
Sources: 2008: Derived from U.S. Energy Information Administration (EIA); International Energy Statistics database (as of March 2011). Projections: EIA, World Energy Projection System Plus (2011).

No. 3

CHINA'S FOSSIL FUEL DEPENDENCE CARRIES HEAVY ENVIRONMENTAL COSTS.

China's heavy reliance on fossil fuels is putting significant pressure on public health and the natural environment. Environmental degradation, pollution, and associated health problems cost an estimated 11% of China's annual GDP, according to research by Lawrence Livermore National Laboratory. China has six of the 10 most polluted cities in the world. Acid rain affects a third of the country's territory. More than three-quarters of the river water flowing through urban areas is unsuitable for drinking or fishing, according to research by Council on Foreign Relations scholar Elizabeth Economy, an expert on Chinese environmental issues.

China's main environmental challenges include flooding, desertification, water scarcity, dwindling forest resources, and population growth. Deserts cover 25% of China's territory, and the deserts continue to spread. For China, making progress on the energy conservation and clean energy production fronts is quite literally a matter of life and death.



Sources: History: U.S. Energy Information Administration (EIA); International Energy Statistics database (as of March 2011). Projections: EIA; Annual Energy Outlook 2011; National Energy Modelling System; World Energy Projection System Plus (2011).

What China Is Doing

China recognizes that its energy needs can only be met by an "all of the above" energy strategy. It must include conservation, restructuring the energy production system, and smart, sustainable exploitation of all energy sources, including fossil fuels, hydro, nuclear, and renewables. According to the government's recent energy policy white paper: "China will continue to take the Scientific Outlook on Development as its guiding principle, and work hard to transform its development pattern, giving prominence to building a resource-conserving and environment-friendly society. It relies on scientific, technological and system innovation to raise efficiency in all aspects of energy utilization, further develops new and renewable energy resources, and promotes the clean and efficient development and utilization of fossil energy resources."

SHEN XIANGHUI / IMAGINECHINA

FOCUS ON CONSERVATION

China is making significant progress on the conservation front. The country's energy consumption grew by 5.82% a year from 1980 to 2011, according to government data, underpinning average annual GDP growth of 10%. From 2006 to 2011, energy consumption dropped by 20.7%, saving the energy equivalent of 710 million tons of standard coal.

A number of state initiatives have helped move the needle on energy efficiency, including phasing out inefficient industrial programs, raising minimum efficiency standards for building materials and construction methods, mandating better automobile fuel economy, and more. "Starting in 2005 the government really began paying attention to efficiency," says Bo Shen, a Beijing-based researcher in the China Energy Group at Lawrence Berkeley National Laboratory. "Energy efficiency is the most important resource we have at the current stage when renewable energies can't meet demand by themselves because of cost and availability issues."

As the saying goes, what gets measured gets managed. To that end, Bo has been working on policy recommendations designed to help the Chinese government develop a consistent program of energy audits for businesses across the country. Consistent auditing helps the government understand how energy is being used in different sectors. It also helps enterprises track how much energy they procure, how they

WIND IS THE THIRD-LARGEST SOURCE OF POWER IN CHINA, SECOND ONLY TO THERMAL POWER AND HYDROPOWER, AND SURPASSING NUCLEAR POWER.

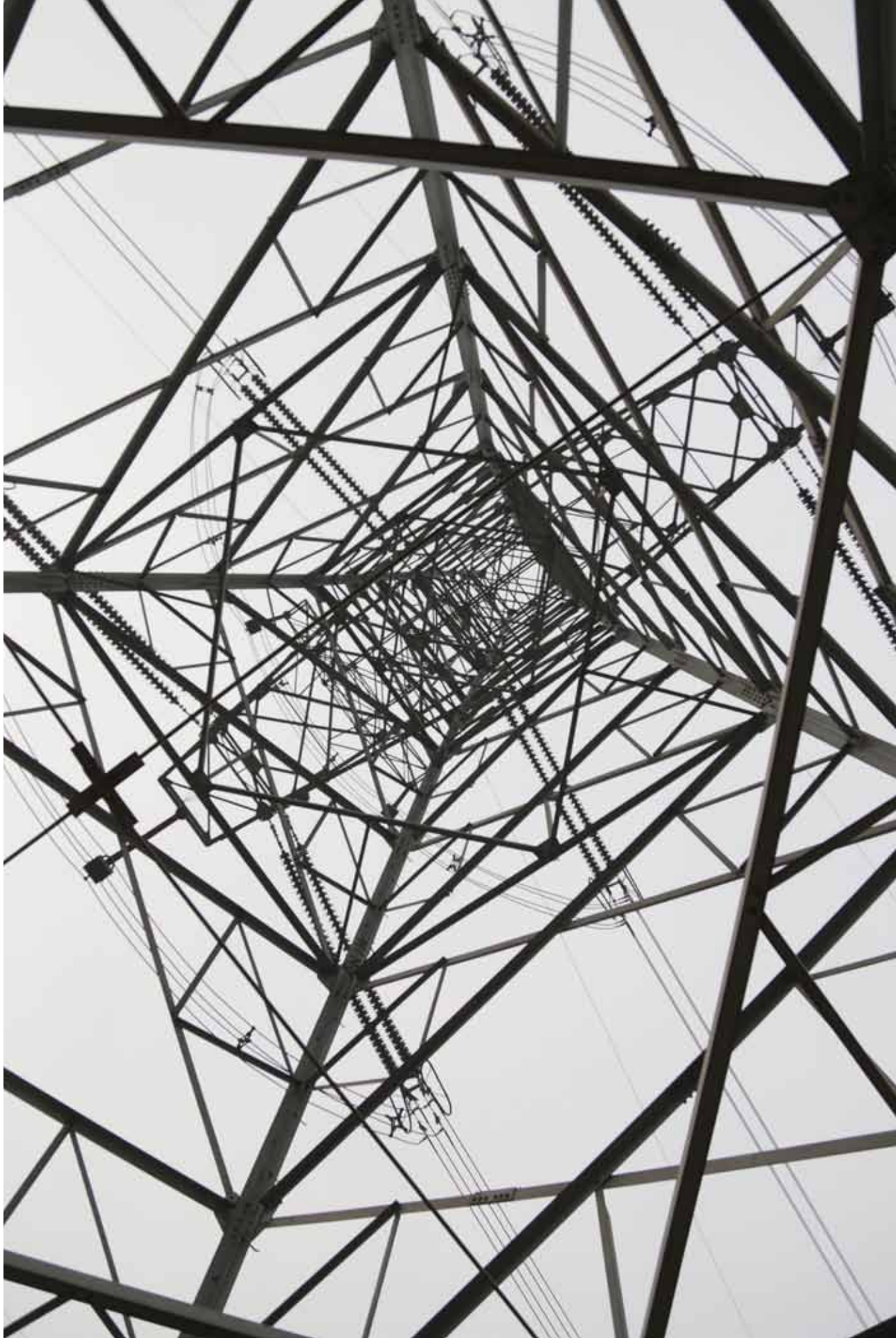
use energy, and where energy is leaking.

In the past, however, authorities conducted energy audits sporadically, usually in order to comply with various short-term government mandates. Auditing tended to stop when the program ended, making it difficult to track energy consumption trends over time. Going forward, Bo argues, the government needs long-term, concerted policy mechanisms to manage energy audits. "We need more organization at the national government level," he says.

China is aggressively implementing energy-saving initiatives such as efficient boilers, building construction, and lighting equipment, along with smart grid technology for the country's massive power generation and transmission network. The government has strengthened building codes, and as a result buildings have become more efficient in terms of both their design and their energy performance. As in the United States and other Western countries, green labeling initiatives provide standardized criteria that determine whether a new building can be labeled energy efficient.

For its part, DuPont currently provides technology that helps Chinese manufacturing plants operate more efficiently. DuPont uses the same technology in its own manufacturing facilities in China and around the world. Each plant sets energy conservation goals and tracks energy project data in a centralized database. Through this process of simple goal setting and planning, DuPont has been able to achieve continuous improvement in energy efficiency.

Starting in 2008, DuPont launched an internal energy conservation program called the Bold Energy Plan (BEP) in response to soaring global energy prices that were seriously impacting production costs. At that time, the company's goal was to reduce its total energy bill by US$202 million (23%) by 2012. DuPont surpassed that goal, recording cumulative energy savings of US$230 million (26.5%) by the end of 2012. In China, 18 large-scale DuPont factories joined BEP, according to Carl Chen, Energy Center of Competency Leader for DuPont Asia Pacific. In 2011 and 2012, two DuPont operations in South China received energy conservation



awards from local governments. "At the beginning of every year, factories joining the energy program set up their energy-saving goal and enter the value into DuPont's energy-saving system," says Chen. "This system automatically collects data that reflects the performance of each factory, each region, and even DuPont in saving energy."

FOCUS ON INNOVATION

Chinese companies are innovating in many areas of energy production and distribution. The Chinese Ministry of Science & Technology operates more than 100 academies that conduct clean tech research, according to a recent article in *Foreign Affairs*. Major Chinese energy companies such as Huaneng, the XinAo Group, Shenhua, State Grid, and CNOOC have used state funding and their own resources to develop thin-film solar technology, biofuels, batteries, wind technologies, efficient vehicles, coal gasification and carbon capture technologies, shale gas extraction, and smart grid technologies, among others.

Much of this technology has scaled very rapidly with help from the Chinese government. In 2006, for example, the government established a price support policy for on-grid wind power in accordance with the Renewable Energy Law, according to Shi Dinghuan, a State Council member who also chairs the China Renewable Energy Society. By the end of 2012, on-grid wind power capacity had grown to more than 60 gigawatts, making China the world's leading wind power producer. Today wind is the third-largest source of power in China, second only to thermal power and hydropower, and surpassing nuclear power.

BIOFUELS

China's vast agricultural sector has spawned an important biomass energy sector. For the generation of electricity, more than 20 million farmers rely on biogas and shared biogas digesters to meet their daily energy needs across the country. China is currently developing large-scale biogas digesters in collaboration with poultry and dairy farms. Shi Dinghuan points to the Deqing Ranch, a major producer of chicken eggs on the outskirts of Beijing that has built a biomass system that converts its trash into electricity. China also uses various kinds of straw to produce ethanol, and trash to produce biodiesel.

CHINA LED THE WORLD WITH $52 BILLION IN CLEAN-ENERGY INVESTMENT IN 2011.

DuPont is an active player in the global transportation biofuels sector via its offerings in starch-or grain-based biofuel-processing aids as well as in the development of novel biomass-based biofuel production technologies. DuPont produces starch processing enzymes and fermentation control additives that allow grain-based ethanol producers worldwide, and of course in China, to optimize the efficacy of their process. The company's Accellerase® enzyme product line converts treated biomass into sugars, a key step in the production of cellulosic biofuel, thus increasing the ethanol yield per unit of feedstock. In China, DuPont is in discussions with strategic partners about the commercialization of the technology.

SOLAR GROWTH

Because solar energy is inexhaustible, photovoltaic (PV) power is the most important renewable energy sector. China has been the world's leading solar panel manufacturer since 2005. Today, annual production of solar panels in China accounts for more than half of global production. In 2011, China established a price support policy for on-grid PV power, which greatly stimulated the growth of installed solar capacity. In January, the government announced that installed PV capacity would more than double this year over 2012, to 10 gigawatts, according to a Reuters report.

The government has already built major solar installations in areas of western China that have abundant land and plentiful sunshine. This technology has huge potential in rural China because solar pumps become feasible once electricity is available. "Building PV plants in the desert not only can generate power but also may improve its ecosystem," says Shi Dinghuan. "Once electricity is available, solar pumps become feasible. They can pump underground water for irrigation and planting grass. Solar panels can also provide shade for the ground, stopping moisture evaporation."

PHOTOVOLTAIC CAPACITY IS EXPECTED TO MORE THAN DOUBLE IN 2013, TO ***10GW.***

On the more densely populated eastern coast, the policy has been to encourage distributed solar energy production via rooftop PV panel systems. In 2009 the Chinese government launched its Golden Sun program, which offered subsidies amounting to 50% of the initial investment for any solar device installed on a roof, according to Zheng Xiaoqiang, vice president and COO at Yingli Green Energy, a solar technology company based in Baoding, a city in the northern province of Hebei. “The government has become aware of the role renewable energy plays in future economic growth,” he says.

GD Solar has achieved significant success in the distributed solar energy production sector. Last year the Jiangsu-based company launched a major pilot project in Shanghai called the Jinqiao Smart PV Power project. GD Solar sources many of its PV materials from DuPont. “As a PV expert, DuPont is well versed in all kinds of materials,” says GD Solar chairman Li Hongyuan. “DuPont has collected a lot of data about on-site practical applications to provide us with a sound theoretical basis when it comes to selecting the most suitable materials.”

Solar thermal energy is also developing rapidly nationwide. “In both cities and rural villages, solar water heaters are everywhere to meet people’s daily need for hot water,” says Shi Dinghuan. “They have replaced coal power as far as hot water is concerned.”

DuPont has major efforts under way to reduce the electricity generation costs of China’s PV sector (see below). The company’s PV materials include conductive silver pastes, encapsulant materials, and backsheet materials. On the PV research front, DuPont focuses on enhancing efficiency and longevity, and reducing installation costs. Effective reduction in electricity-generation costs per watt will enable PV power to achieve grid parity soon, which will make solar power competitive with fossil fuels and other forms of electricity.

In Golmud, a city in the northwestern province of Qinghai, China Power Investment Corporation (CPI) recently built the Golmud Solar Farm, a 320-megawatt solar plant that is currently the world’s largest solar power project. The farm uses a number of DuPont products, including silver metallization pastes for increased power output and backsheet materials for long-term solar panel protection. “We believe that DuPont’s products are reliable,” says CPI executive Xie Xiaoping. “Ultraviolet rays are stronger on the Qinghai-Tibetan Plateau because of its high elevation. In this environment, we have to guarantee the life

span of our components, so we use DuPont products."

RENEWABLE PARTNERSHIPS

Hot water notwithstanding, coal still dominates China's energy portfolio. Coal-fired power plants generate much of the country's air pollution. For these reasons, any sensible energy strategy must focus on implementing cleaner coal technology. Since 2006, China has shut down thousands of small, inefficient coal generation plants, according to a recent speech by Liu Zhan of the China Power Investment Corporation. China is also building new super-critical coal plants based on carbon capture and sequestration that generate far less particulate and greenhouse gas emissions than traditional plants.

The U.S. and China have collaborated extensively to develop clean coal technology. Peabody Energy is part of the consortium that is building GreenGen, a $1 billion, 650 megawatt coal plant near Tianjin. Projected to produce near-zero emissions, the integrated gasification combined cycle plant will also serve as a carbon management research center. And that's just one example. Nowadays there are creative partnerships between international and Chinese partners across many renewable sectors. For example, Sinopec Group, China's largest oil refiner, is in partnership with Icelandic geothermal developer Orka Energy to expand China's geothermal heating capacity. The goal is to expand geothermal heating to at least 100 million square meters of house floor by 2020.

China currently leads the world in the rapid adoption of renewable energy technologies. One example is wave power, a power generation technology that harnesses the energy of ocean waves. Israeli wave power company SDE has completed its first commercial-scale wave power generation plant in Guangdong, on the South China Sea coast, and has three more plants in the works near Guangzhou. SDE's technology uses buoys that bob up and down with the waves. Energy from this motion and from the ebb and flow of tides gets transferred to a series of pistons that transmit power to a generator, thus producing electricity. In this

WEI TA / IMAGINECHINA

sector China is outpacing developed countries such as the United States, which currently has zero functioning wave power plants.

Smart grid technology is another major growth area. GE Energy Services and State Grid, China's leading utility, are partnering in several projects designed to support Chinese energy demand by developing standardized technologies for electric vehicle charging, the integration of large-volume energy storage systems, transducers, distributed electric resources, and micro-grids. Meanwhile, U.S. energy storage company ZBB Energy and its Chinese joint venture company, Meineng Energy, have secured contracts to provide advanced energy storage and control technologies for installation at an energy storage test center and a government building demonstration site. The goal here is to demonstrate how advanced technology can deliver consistent power to buildings from an inconsistent grid.

DEVELOPING GLOBAL ENERGY SUPPLIES

China has enlisted a number of international joint venture partners, including Hess, GE Oil & Gas, Devon Energy, and others, to help build out its onshore and offshore production capacity. In recent years, China has also invested some $65 billion in energy projects worldwide, ranging

AP PHOTO/ MEAD GRUVER

from oil-sands production in Alberta to energy equipment manufacturing in Brazil. In 2012, for example, Sinopec and Oklahoma-based Devon Energy signed a $2.5 billion deal to explore for oil and gas in emerging shale fields in North America. Last summer, CNOOC agreed to pay $2.1 billion for OPTI Canada, a producer that held a minority stake in a large oil-sands project.

The list goes on: In October 2012, Sinopec acquired Royal Dutch Shell's 80% stake in Pecten Cameroon Co., an African oil producer. That same month, Baoji Oilfield Machinery Co. (BOMCO, a subsidiary of China National Petroleum Corp.) established a joint venture with two Brazilian companies, BRCP and Asperbras, to manufacture oil equipment in Brazil.

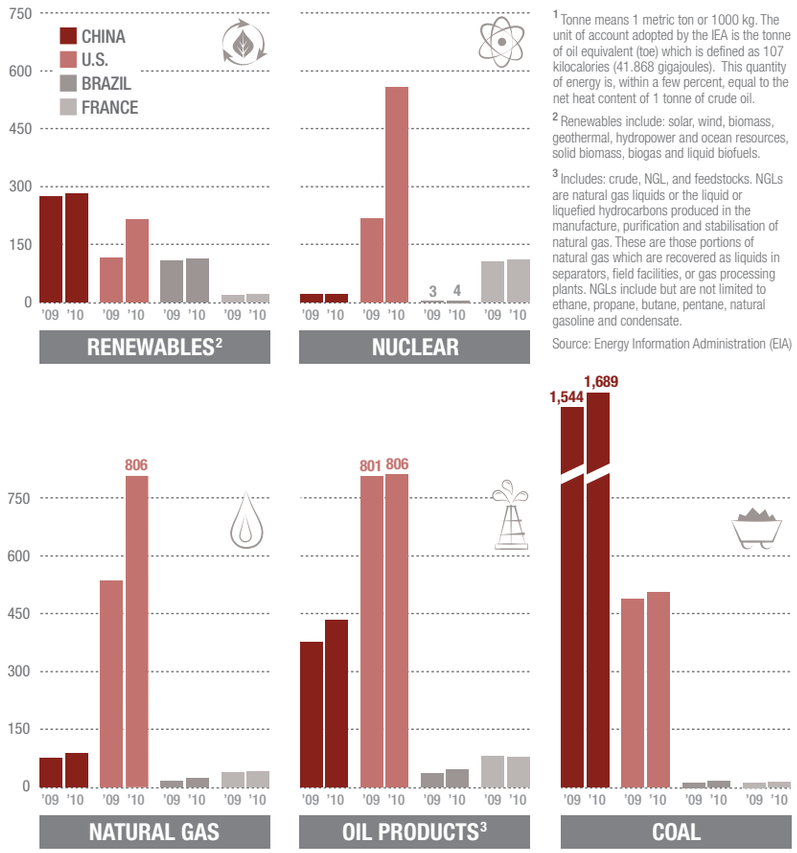
Now that most of the world's readily accessible oil supplies have already been tapped, the oil industry is increasingly focused on more technologically challenging extraction projects deep offshore and in areas such as the oil sands of western Canada. These wells tend to produce heavier crude with high concentrations of asphaltene and paraffins that create fouling problems in the tubular piping through which the oil flows, increasing downtime and reducing productivity.

In the Middle East, on the other hand, oil companies are increasingly drilling "sour" crude that has high concentrations of hydrogen sulfide and other corrosive agents that quickly rust out standard steel piping. Historically the oil industry has sought metallurgical solutions to all these problems, typically by using expensive alloys such as nickel to produce thicker pipes that are more resistant to fouling and corrosion. Epoxy-based coatings have also been used successfully in some applications, although they don't work well in highly corrosive environments.

CHINA HAS INVESTED SOME $65 BILLION IN ENERGY PROJECTS WORLDWIDE, RANGING FROM OIL SANDS PRODUCTION IN ALBERTA TO ENERGY EQUIPMENT MANUFACTURING IN BRAZIL.

ENERGY SOURCES BY COUNTRY

THOUSAND TONNES[1] OF OIL EQUIVALENT



[1] Tonne means 1 metric ton or 1000 kg. The unit of account adopted by the IEA is the tonne of oil equivalent (toe) which is defined as 107 kilocalories (41.868 gigajoules). This quantity of energy is, within a few percent, equal to the net heat content of 1 tonne of crude oil.

[2] Renewables include: solar, wind, biomass, geothermal, hydropower and ocean resources, solid biomass, biogas and liquid biofuels.

[3] Includes: crude, NGL, and feedstocks. NGLs are natural gas liquids or the liquid or liquefied hydrocarbons produced in the manufacture, purification and stabilisation of natural gas. These are those portions of natural gas which are recovered as liquids in separators, field facilities, or gas processing plants. NGLs include but are not limited to ethane, propane, butane, pentane, natural gasoline and condensate.

Source: Energy Information Administration (EIA)

A Vision for the Future

A new science is needed to secure China's energy future. The country needs to conserve today's resources while developing the cleaner alternatives of tomorrow. Science-based innovations will help make China's consumption of valuable energy resources more efficient. China will need to consume all its energy resources—oil, coal, solar, wind, or biofuels—with greater efficiency. This not only conserves valuable supplies but also cuts costs. Science-based innovations allow China to use less energy to drive multiple systems that power the modern world.

The development of viable energy solutions requires collaboration between scientists and policymakers, communities, and private sectors. Those with the know-how, resources, and responsibility to address China's energy needs must work together to create the policy environment and funding mechanisms that can transform scientific innovations into viable new energy resources.

DuPont maintains that energy solutions are truly sustainable only when they are economically feasible as well as environmentally sound. In a market-driven society, cleaner, renewable energy sources will not succeed if the cost to produce and use them is higher than existing options. Applied science can help make renewable options economically viable, so that China is not forced to choose between sustainability and economic security.

GREENER CARS

DuPont has worked extensively with selected partners from China's automotive industry in developing electric insulation solutions with DuPont™ Nomex® that enable power electric vehicles to operate with higher reliability. Today, BYD, a leading electric vehicle manufacturer in China, uses EIS (Electrical Insulation System) featuring Nomex® in its production of Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV) traction motors. The company has also partnered with Chery Automobile Co. a Chinese auto manufacturer, to help create lighter, more fuel-efficient car engines.

At the DuPont China R&D Center in Shanghai, engineers use sophisticated computer-assisted engineering and design technologies (CAE/CAD) to model lightweight automotive parts. Fuel consumption goes down significantly as you subtract from the total weight of a vehicle. "We can usually save about 30% to 50% in weight," says Ryan Peng, automotive marketing manager, DuPont Performance Polymers, Greater China. "Roughly speaking, for every 50 kilograms that we save in weight, we can reduce carbon emissions by five grams, while also improving fuel economy by about 2%."

DuPont engineers save weight by replacing conventional metal parts with components that the company engineers using a short-fiber, reinforced nylon resin called DuPont™ Zytel®. "We want to improve fuel efficiency to allow people to continue driving the cars they want. The key is making the car frame lighter, but still safe and sturdy," says Tony Su, president of DuPont Greater China.

Each part has specific design constraints. For example, oil pans sit on the bottom of the engine, close to the road, so they need to withstand impact from stones and other projectiles that can cause leakage and failure. Before the oil pan ever gets manufactured, engineers use CAE/CAD software to calculate its structural stiffness. They model the deformation that would result from a stone hitting the pan at various speeds. DuPont engineers also simulate the manufacturing process to determine how the liquid plastic will flow into the mold that creates

ONLY BY INCREASING EFFICIENCY AND REDUCING INSTALLATION COSTS CAN THE PHOTOVOLTAIC INDUSTRY PROVIDE THE CHEAPEST ELECTRICITY.

the actual oil pan. All this computer modeling allows the engineers to predict failure points and adjust their designs to avoid failure.

Once the DuPont engineering team has molded a physical part, they subject it to even more testing in the real world. They test it in an anechoic chamber to determine how much noise and vibration it will produce when the vehicle is in motion. They also use impact test equipment that fires steel balls at the components. With the help of high-speed video capture equipment, DuPont engineers can figure out whether the component is tough enough to take a beating on Chinese roads.

COOLER, CLEANER GENERATORS

DuPont provides specialty fluids for the machinery that generates electricity from China's dams. DuPont Vertrel® XF fluid is a nonflammable hydrofluorocarbon with zero ozone depletion and low global warming potential. It is currently used to cool two of the hydraulic generators at the world's biggest hydro facility, the Three Gorges Dam hydroelectric power plant in Hubei province.

The Three Gorges plant currently houses 32 hydropower generators, each of which produces 700 megawatts of electricity. They operate between four to six months every year, depending on the water supply, and are the world's largest generators by output. Heat naturally rises with output, creating extreme cooling demands that are difficult to satisfy with traditional water- and air-based cooling systems.

That's why two of the newest generators use an innovative cooling system developed by the China National Electric Institute. Each generator contains three and a half metric tons of Vertrel® XF. When the generator produces heat, the Vertrel® XF changes from liquid to gas, absorbing a great deal of heat while maintaining a constant temperature. It then travels through a condenser and turns back into liquid that recycles through the generator, beginning the cooling cycle all over again.

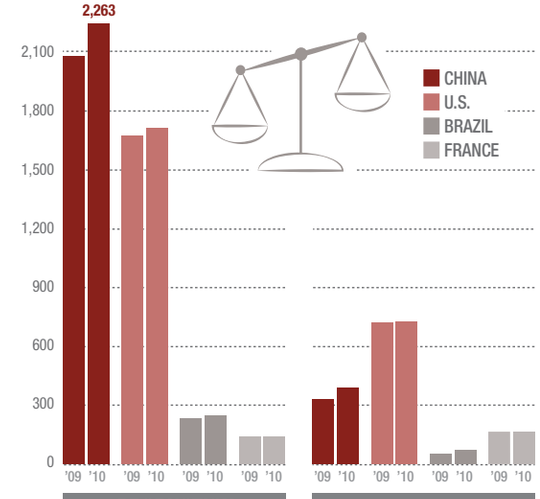
BETTER SOLAR PANELS

Only by increasing efficiency, extending lifetime, and reducing overall installation costs can the photovoltaic industry provide the cheapest electricity more effectively. For this reason, DuPont has made a major commitment to the Chinese PV sector. The company has established R&D centers in China and also built factories in Dongguan and Kunshan, according to Walt Cheng, managing director of DuPont Electronics and Communications for Greater China. The production equipment in DuPont PV R&D facilities simulates the production lines of its clients. So when PV manufacturing clients submit questions to DuPont researchers, they can provide solutions that meet client needs precisely. DuPont can thus help enhance their production efficiency, conformance rate, and quality. The company also develops solutions to reduce overall costs.

From R&D to production, an investment in the whole value chain enables DuPont to provide the best products in the market to help its clients quickly improve their production efficiency, while also increasing service life and reducing installation costs. DuPont is currently working with the Shenzhen–Hong Kong Innovation Circle to build the world's largest thin-film photovoltaic rooftop in China. The company is also partnering with Chinese photovoltaic panel manufacturer Yingli Green Energy, which uses DuPont™ Solamet® metallization paste and DuPont™ Tedlar® polyvinyl fluoride film for the protective backsheet layer in its PV modules. "We have a good relationship with DuPont, with a very large supply," says Yingli COO Zheng Xiaoqiang. Yingli PV panels are now at work in the

ENERGY BALANCE: IMPORTS VS. PRODUCTION

THOUSAND TONNES[1] OF OIL EQUIVALENT



[1] Tonne means 1 metric ton or 1000 kg. The unit of account adopted by the IEA is the tonne of oil equivalent (toe) which is defined as 107 kilocalories (41.868 gigajoules). This quantity of energy is, within a few percent, equal to the net heat content of 1 tonne of crude oil.

Source: Energy Information Administration (EIA)

THE GOVERNMENT IS ENCOURAGING THE USE OF BIO-RENEWABLE MATERIALS THROUGHOUT CHINA'S TEXTILE INDUSTRY.

world's largest solar-power plant, a solar farm in western China.

A major challenge facing the global photovoltaic industry is that materials and infrastructure for manufacturing PV components must remain at international standards, even while the market price of PV products continues to decline. In China, DuPont helps local manufacturers produce long-lasting PV panels using less material. "The efficiency of our electrical conductive pastes has increased by 0.4% to 0.5% every year since 2008," says Cheng. "This reduces our electricity-generation cost per watt. As a result, we have made huge strides in reducing costs for a kilowatt-hour."

RENEWABLE TEXTILES

Petroleum-based synthetic fiber makes up a growing share of textile production in China's vast textile and apparel industry. Faced with the reality of limited petroleum resources, the Chinese government has been encouraging local textile manufacturers to explore new bio-based materials made from renewable plants. "The promotion of such materials means investing in social responsibility," says Li Binhong, director of the China Textiles Product Development Center. "And that is the responsibility of the whole consumption chain, including developers, manufacturers, buyers, apparel brands, and consumers."

DuPont has also introduced an advanced bio-material to the Chinese market. In Zhuhai City, a town in Guangdong province, Yuhua Polyester Co. Ltd. is manufacturing DuPont™ Sorona® polymer, a renewably sourced, fiber-grade material used for carpeting and textile garments. Sorona® polymer allows mills and designers to reap the benefits of renewability from a versatile, high-performance material. Sorona® polymer contains 37% annually renewable plant-based ingredients. Even better is its environmental footprint. Producing Sorona® polymer uses 30% less energy and lowers greenhouse gas emissions by 63% compared with the production of a typical petroleum-based substitute such as nylon.

Sorona® renewably sourced fiber is used in residential and commercial carpets, apparel, and automotive mats and carpets. With the highest bio-based content in the synthetic carpet fiber market, Sorona® polymer offers durability and stain resistance. One of the first high-performance fibers derived from rapidly renewable material, Sorona® polymer continues DuPont's impressive record of textile innovation.

China's textile industry is no longer just a leading manufacturing center for the international market. It's becoming a huge domestic consumption market as well. As a strategic trend in China's 12th Five-Year Plan, the government is encouraging the use of bio-renewable materials throughout China's textile industry. K-Boxing, a domestic men's apparel brand that's especially popular in second-tier Chinese cities, has already adopted fabrics made with Sorona® polymer.

This co-marketing initiative has helped K-Boxing become a source of sustainable products in that marketplace, and has allowed it to differentiate its garments from those of competitors. The broad but still niche market for sustainable apparel is growing, and Sorona® polymer has helped K-Boxing gain a strategic foothold in that market. "I was attracted to the material," says Huang Lizhong, a K-Boxing designer. "One of the advantages of Sorona® is that it can be made into short fiber or long silk, and can be mixed with all types of fabric. So it can be used to make various tatted and knitted linings. It has a wide range of applications and sends out a very positive message of environmental protection."

Because of the significant role textiles play in the Chinese economy and manufacturing sector, it is vital for China to focus its textile manufacturers on renewable and efficient processes and products. Sorona® renewably sourced polymer is a good example of what is possible today, and what will come tomorrow.

Conclusion

China's economic growth depends on its ability to power that growth. The country faces huge challenges in building a sustainable, broad-based energy sector to fuel its growing economy and create a better life for its people. As China takes its rightful place as an economic superpower, it will consume a growing share of global energy supplies, driving up energy prices and putting stress on ecosystems worldwide. As a result, the international community has every incentive to help China develop innovative, sustainable solutions to its energy needs.

Finding these solutions will require creative thinking and investment from a global coalition of stakeholders, including the Chinese government, foreign governments, multilateral organizations, NGOs, scientists, Chinese corporations, and multinational corporations.

"The world's energy laboratory will be a busy place in coming years, and DuPont is ready to do its part," says CEO Ellen Kullman. "We've been using science and collaborative problem solving to improve the human condition for more than two centuries. We look forward to helping China deploy energy technologies that will underpin the health, safety, and prosperity of its citizens for decades to come." ●

View the video of DuPont's contribution to the future of energy in China.

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