中国绿色科技
China Greentech Initiative
Strategic Insights, Industry and Government Collaboration, Market Acceleration

# THE CHINA GREENTECH REPORT™ 2014

## Greener, Smarter, More Productive

BY THE CHINA GREENTECH INITIATIVE

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**The China Greentech Initiative™** is the only collaboration platform that develops and connects strategic insights on China's greentech markets with an expert community of over 100 companies and governments. As a neutral third party, we accelerate the market by integrating expertise from different nations and municipalities, industries and ecosystems, as well as across stakeholder roles. China Greentech's trusted position enables us to produce the most reliable and holistic analysis to inform business decisions around the China opportunity and to facilitate collaboration. Our vision is to help companies increase their profitability while advancing China's cities and zones toward greener, smarter and more productive development.

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Researched and Produced by Greentech Networks Limited

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*Courtesy of Mike Hawkins*

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# PREFACE

Dear Reader,

It is with great pleasure that we bring you *The China Greentech Report 2014*. The Report highlights the rich insights developed by the annual China Greentech Program, through which leading industry executives, investors, policymakers and other experts collaborate on commercial solutions that address China's energy and environmental needs.

Of the many factors impacting China's development strategy, tackling pollution has quickly become a top priority. A growing sense of urgency to reduce pollution and improve quality of life in cities is compelling China to adopt a greener, smarter and more productive approach to development. The 2014 Report provides insight on the regulatory, financing and technology changes across China's diverse greentech markets in response to the government's shifting priorities, and discusses how companies can best capture opportunities while supporting China in its battle against smog.

As China begins to adopt a more integrated approach to development, companies have the opportunity to form partnerships that position their businesses for success. The 2014 Report assesses eight of the newest and most relevant opportunities in China today in the areas of (1) Energy Value Chains; (2) Built Environment; (3) Sustainable Industry; and (4) Cleaner Vehicles.

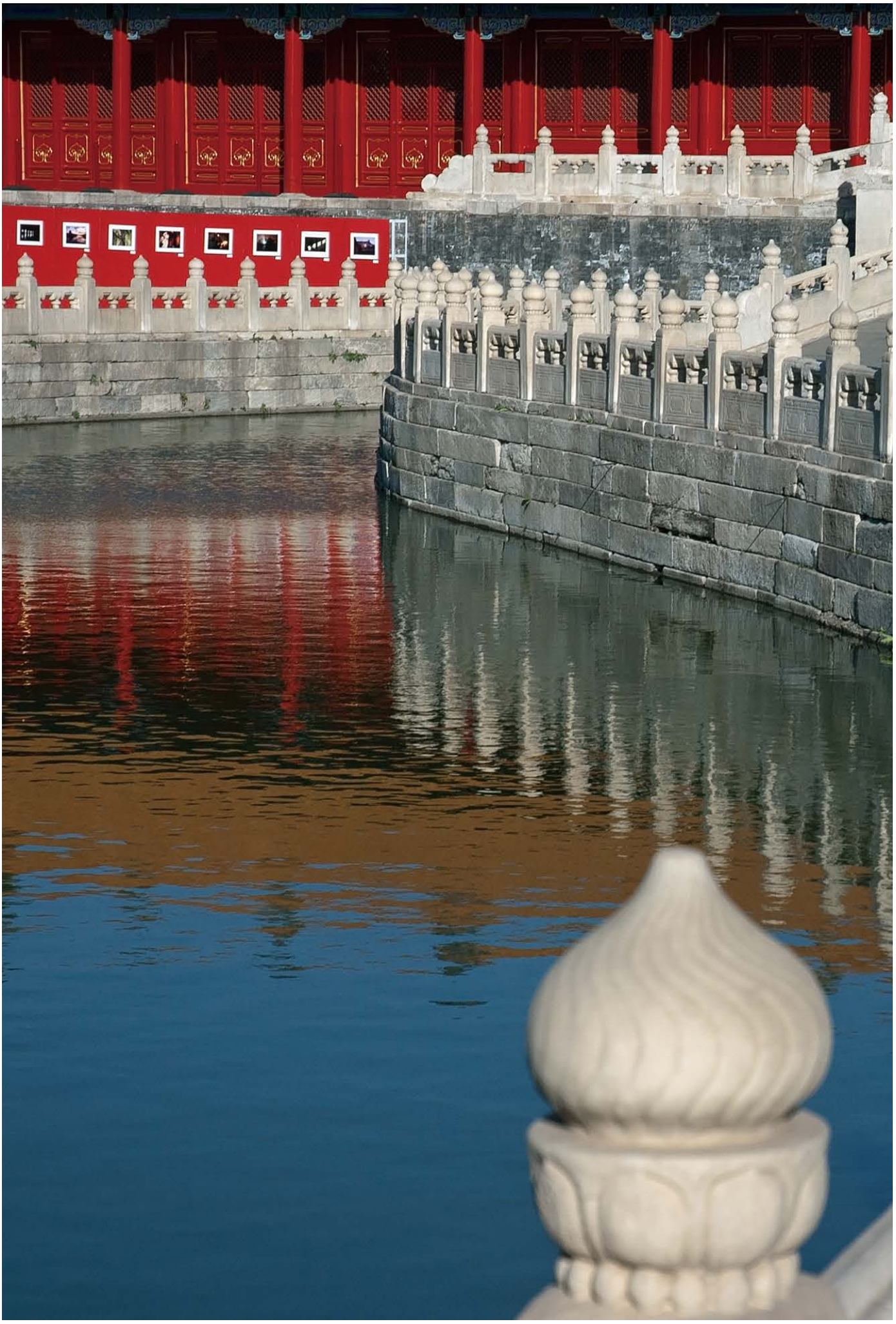
*The China Greentech Report* is a collective view that has been informed by over 1,000 experts from more than 100 organizations that make up the China Greentech community. Please refer to the Acknowledgments section of this Report where we recognize contributing Partner companies, organizations and individuals for their dedication to this effort.

*The China Greentech Report* has many uses—as context for corporate decision-making, a resource for educating the market, and a basis for shaping policies. The Report is a freely distributed publication designed to raise awareness and highlight actions we can take together to accelerate China's green growth. We hope you find it valuable.

Yours truly,

Ellen G. Carberry and Randall S. Hancock

***Managing Directors***
***The China Greentech Initiative***
***August 2014***



Courtesy of Les Whittle

Courtesy of Les Whittle

# EXECUTIVE SUMMARY

***The China Greentech Report 2014* is the culmination of an open-source, commercial collaboration of more than one hundred leading technology companies, service providers, investors, policy makers, NGOs and advisors who participated in The China Greentech Initiative's 2013 Program. These organizations collaborated by ecosystem and committed their expertise, time and funding to address the developing opportunities and challenges in China's evolving greentech markets.**

*The China Greentech Report* series—beginning with the 2009 edition released at the World Economic Forum in Dalian, China and followed by the 2011, 2012 and 2013 editions—has established China Greentech as the authority on China's greentech markets. This latest edition in the series builds upon the foundational perspectives from earlier Reports to offer new insights and recommendations, as well as takes an in-depth look at emerging market opportunities. *The China Greentech Report 2014* focuses on the following:

- New central and local government plans for pollution reduction
- China's path towards greener, smarter and more productive development
- How forward-thinking companies are using innovative technologies, leveraging knowledge of best practices and employing global collaboration models to accelerate China's sustainable growth

Following these chapters, the Report summarizes Opportunity Assessments for four greentech ecosystems (Energy Value Chains; Built Environment, Sustainable Industry; and Cleaner Vehicles) that were developed in collaboration with China Greentech Partner companies and organizations that participated in the 2013 Program. The Opportunity Assessments focus on the following topics:

- Capitalizing on China's Potential Distributed Energy Boom
- Achieving Energy Savings through Demand-Side Management
- Green Building Solutions by Climate Zone
- Capturing Energy Efficiency Opportunities in New and Retrofitted Buildings
- Future Urban Transportation Systems to Help Solve China's Traffic, Emissions and Energy Challenges

- Developing Successful Regional Electric Vehicle Ecosystems
- Addressing China's Industrial Air Pollution Challenges
- Applying Circular Economy Concepts in China's Industrial Parks

While our findings do not reflect China's greentech development in its entirety, they do shed light on sectors that the China Greentech community has considered most relevant for promoting resource efficiency and pollution reduction in 2014 and beyond.

**Defining Greentech**

***Greentech*** refers to technologies, products and services that deliver benefits to users of equal or greater value than those of conventional alternatives, while limiting the impact on the natural environment as well as maximizing the efficient and sustainable use of energy, water and other resources.

## Greener, Smarter and More Productive

**As momentum builds around the importance of cleaner growth, China has the opportunity to leave behind former approaches to development that have resulted in soaring global emissions and resource scarcity, and instead carve out a new standard for development. Sustainable development, formerly considered an optional approach for local governments seeking to distinguish themselves as environmental stewards, is increasingly the prerequisite for meeting national pollution reduction requirements and attracting high-quality, long-term business partners and investment. As businesses and governments adopt a greener, smarter and more productive approach to urban and industrial development, China's cities and industrial zones will reap the benefits.**

### China's Pollution Debate Enters a New Era

**Recent history is a disturbing reminder of China's need to act immediately on pollution. Northern China's air pollution in the winters of 2013 and 2014 triggered a chain of trend-setting events: a surge in hospital admissions related to respiratory illness, a storm of public opinion on social media platforms, and a hike in demand for transparent air quality data. The severity and duration of the 2013 and 2014 air crises have inspired several facets of change—controversial government initiatives, candid media attention, and a surge in private investment in greentech solutions.**

All eyes will be on China over the next few decades as the country redefines and refines its approach to development. This is exactly the moment that calls for the government and private sector to partner and lead the way in implementing a more sustainable growth model across sectors. If this opportunity is missed, resource constraints, choked cities and public health costs will become major bottlenecks for development and, in some cases, negate the progress that China has made as a developing nation emerging into a global leader. China has the opportunity to set an example for the rest of the world, to innovate and approach development differently than in the past.

China's 2013 Action Plan for Air Pollution Prevention and Control (Action Plan) is the nation's most recent and visible campaign towards sustainable development. Released in September 2013, the Action Plan includes a targeted list of ten measures to reduce air pollution in major regions across China by 2017. High-level goals include capping the share of coal in China's energy mix at 65% and reducing $PM_{2.5}$ emissions by 25% in the Beijing, Hebei and Tianjin region, 20% in the Yangtze River Delta, and 15% in the Pearl River Delta, based on 2012 levels.[1]

Heightened concern about pollution has also been accompanied by growth in greentech investments. China's solar industry, in particular, is enjoying a fair share of this investment after a four-year downturn. In 2013, investments in newly installed utility and distributed solar capacity amounted to RMB 130 billion. Based on the market price of RMB 10 per watt, 2014 investments will likely meet the RMB 140 billion mark. In 2013 alone, an additional 12.9 GW (or twice the existing capacity at the end of 2012) of solar capacity was added to the grid, bringing total capacity to 19 GW by year-end, thus helping to absorb the industry's manufacturing overcapacity.

Development and installation of wind, natural gas, and nuclear offer a mixed progress report. Installed wind power capacity grew by about 25% in 2013, and grid connectivity for wind farms has improved. Only 11% of wind-generated power was not transferred to the grid in 2013, down from 17% in 2012 and 25% in 2011.[2] With installed capacity for natural gas growing by about 14% in 2013, both wind and natural gas power generation capacity seem to be on track based on 12th Five-Year Plan targets. In contrast, nuclear power has remained relatively stagnant since March 2011.

China's plan to maintain a national GDP growth target of 7.5% through 2014 must be accompanied by an equally resolute vision for cleaner growth. To achieve this, China must invest in energy efficiency, reduce emissions from heavy industry, and boost renewable energy's share in the national energy mix; furthermore, clear economic incentives must form the core of these initiatives. By adopting a greener, smarter and more productive approach to development, China has the opportunity to improve resource efficiency as well as the quality of life for its citizens.

1. 《大气污染防治行动计划》*[Air Pollution Prevention and Control Action Plan], September 12, 2013, www.gov.cn*
2. *"能源局发布 2013 年风电发展情况" [NEA Publishes 2013 Figures for Wind Power Development], China Industrial Economy Information Network, March 10, 2014, www.cinic.org.cn*


## Building a Greener, Smarter and More Productive China

**China must move beyond its current approach to address its energy and environmental challenges by integrating intelligent greentech solutions to improve efficiency across value chains. The adoption of cleaner technologies enhanced with information systems and optimized processes will not only reduce pollution but also save resources across sectors. China Greentech proposes that China adopt a greener, smarter and more productive approach to development and apply these concepts on all levels and scales, ranging from small-scale initiatives to large-scale industrial restructuring, to maximize the benefits of sustainable growth.**

If China is to achieve greener, smarter and more productive development, collaboration across sectors must improve. To that end, in early 2014 China Greentech formed a partnership of international and Chinese companies to identify and overcome the hurdles that often hinder collaboration—whether that be divisions across countries, sectors, companies or expertise areas—to pursue commercial opportunities together. The companies will combine their collective resources with China Greentech's analysis, project intelligence, and network to integrate their products and services to customize solutions for China's project owners and governments.

The China Greentech Strategic Partnership was formed to define the models through which local and international firms can work together to collaborate around specific market opportunities, dismantle market misconceptions, address obstacles to greentech solution adoption, and build lasting relationships among governments and the private sector to drive cleaner development. The group believes in building insight around how China can best apply 'greener, smarter and more productive' concepts in projects pertaining to industrial efficiency, distributed energy, greener buildings and cleaner mobility.

As momentum builds around the importance of cleaner growth, China has the opportunity to carve out a new standard for development, leaving the old one, which has resulted in soaring global emissions and resource scarcity, behind. The factors and players needed to drive this transformation are in place—public awareness is at its height, city officials feel pressure to build cleaner urban centers, and more readily available user-friendly tools are allowing wide-scale participation in resource conservation across industries and value chains like never before. Dependence on these factors alone, however, is not enough to ensure sustainable growth. Instead, businesses and governments must adopt an entirely new mindset—an integrated greener, smarter and more productive approach.

# Energy Value Chains

## Capitalizing on China's Potential Distributed Energy Boom

### Opportunity Assessment Summary

A means of diversifying China's coal-dominated electricity mix and stimulating demand for an oversupply of solar PV modules, distributed energy has an outlook that is increasingly promising, with 8 GW of installed distributed capacity by 2013.[3] Growing support for distributed energy systems by government, grid companies, developers and end-users promises to accelerate distributed energy adoption through 2015.

**Definition and Scope—Distributed Energy**

Distributed energy (DE) refers to energy generated onsite or near energy end-users—typically on a small-scale—that can be connected to the grid or off-grid (stand alone). DE power generation includes rooftop solar photovoltaics (PV) and building integrated PV (BIPV); gas-fired combined cooling, heating, and power (CCHP); small-scale hydropower; waste-to-energy; small wind turbines; small-scale biomass; and any hybrid of these solutions.

Key insights from China Greentech's distributed energy opportunity assessment include the following:

**New policies indicate a tipping point for distributed energy.** The Chinese government is showing increasing support for distributed energy development by providing energy production subsidies and backing utility-provided procedures to streamline grid connectivity.

**Distributed solar shows signs of promise, while gas-fired CCHP develops at a slower pace.** Distributed solar development has benefitted from subsidies and falling module prices, but the industry still relies on government support to remain competitive. Gas-fired CCHP is making progress under State Grid's new policies but grid connection difficulties, complex project development processes, and an expected increase in gas prices will likely constrain its competitiveness.

**Industrial parks show potential for integrating distributed energy and information and communications technology solutions.** Integrating hybrid DE solutions and information and communications technology (ICT) offers higher energy efficiency than standalone rooftop PV or gas-fired CCHP systems. Industrial parks are an ideal test bed for implementing these solutions.

3. "分布式能源破茧而出 "*[Rising of Distributed Energy], March 25, 2013, www.nea.gov.cn*

## Achieving Energy Savings through Demand-Side Management

### Opportunity Assessment Summary

Demand-side management (DSM) will play an increasingly important role in China's efforts to curb energy consumption and improve grid reliability. If implemented to its full potential, DSM would enable China to overachieve NDRC's annual 0.3% power consumption reduction target—potentially by as much as a factor of 20.[4] DSM's potential to help China manage its energy and environmental needs through electricity savings, peak load reduction, reduced power consumption, and improved grid stability is vast.

**Definition and Scope—Demand-Side Management**

Demand-side management (DSM) describes grid-company and end-user efforts to reduce electricity peak load and overall power consumption. DSM encompasses a range of stakeholders, including government, utilities, end-users, energy service companies (ESCOs) and solution providers. To maximize benefits, DSM measures are customized to the electricity requirements and consumption patterns of the end-user, through various combinations of technologies and incentives.

Key insights from China Greentech's demand-side management opportunity assessment include the following:

**China's power supply shortages are driving stronger government focus on DSM.** Growing energy demand has outpaced energy production in the past decade, leading the government to prioritize end-user energy efficiency.

**Potential gains exceed China's targets.** National targets and a pilot city program launched in 2011 and 2012 demonstrate the government's commitment to capture savings through DSM. However, while mandatory reductions could save nearly 50 billion kilowatt-hours (kWh) between 2013 and 2015, recent DSM projects and related studies indicate a much higher savings potential of 1 trillion kWh by 2020—exceeding China's targets by a factor of 20.

**Challenges must be addressed for DSM to live up to its potential.** Low financial incentives, limited information on power consumption patterns, and cumbersome access to funding constrain further development of DSM projects. Large-scale success will require more effective strategies and incentives, innovative financing models and greater awareness of the many benefits of DSM. State Grid's push to update grid technologies can also boost DSM development.

*4. "Commitment to a Little Bit Could Go a Long Way," China Sustainable Energy Program, Johnson Controls, April 2011.*

# Built Environment

## Green Building Solutions by Climate Zone

### Opportunity Assessment Summary

There is a unique opportunity to capture energy savings across regions by adopting climate-specific solutions for buildings, which account for about 20% of China's energy consumption. Designing buildings based on climate conditions and replicating proven solutions is essential to achieving energy savings.

**Definition and Scope—Green Building Solutions by Climate Zone**

Green building solutions by climate zone refers to energy-saving building solutions including the building envelope and HVAC, as well as related policies and incentives that are customized based on surrounding climate conditions. This opportunity assessment focuses on building solutions for the "Cold" and "Hot Summer, Cold Winter" climate zones as defined in the "1993 Standard of Climatic Regionalization for Architecture."

Key insights from China Greentech's opportunity assessment on green building solutions by climate zone include the following:

**Climate matters.** Buildings should be designed based on local climate conditions to maximize energy and other resource savings. The building sector accounts for about 20% of China's energy consumption—and with its rapidly expanding building floor area, China has a huge opportunity to improve energy efficiency through the adoption and replication of solutions tailored to climate conditions.

**Regional solutions are essential.** Design choices and operational practices based on regional climate differences are essential to maximizing energy savings in buildings. Reducing heat energy consumption is critical in northern China and improving air conditioning efficiency should be of highest priority in the south.

**Replicate solutions.** Proven energy efficient solutions can be replicated to increase savings nationwide. Envelope insulation or external shading can be replicated across climate zones with minor adaptations.

**Policy and operational challenges hinder solution adoption.** Policy, design and operational challenges continue to impede green building solution adoption. China must adopt policies to: 1) encourage incorporation of green building solutions from the early design stage, 2) streamline subsidy allocation and 3) build the capacity of building-operating personnel.

## Capturing Energy Efficiency Opportunities in New and Retrofitted Buildings

### Opportunity Assessment Summary

Both new and retrofit green building projects offer opportunities for building developers, operators, owners and solution providers. Stakeholders that engage in these opportunities can be more competitive in China's emerging green building market and earn reputations as innovative market leaders.

### Definition and Scope—Energy Efficiency in Buildings

Energy efficiency in buildings refers to the opportunities for developers, owners and operators to use less energy in the construction, operation and maintenance of buildings. Energy efficiency opportunities can be applied to both new and retrofit buildings. We focus on opportunities for solution providers to drive overall market development through innovative technology, marketing and financing solutions.

Key insights from China Greentech's opportunity assessment on building energy efficiency include the following:

**Governments should work to improve access to subsidies and raise awareness on the benefits of building efficiency.** Various subsidies for green buildings are in place, but access is often challenging due to low awareness of their availability.

**Building developers and operators should explore new and retrofit green building projects sooner, rather than later.** Rather than waiting for market conditions to improve, companies can boost their brands and capture long-term energy savings by leading the market to adopt these solutions.

**Solution providers can offer integrated technologies and market directly to end customers, including consumers.** Combining and promoting the solutions of multiple partners highlights the value to end customers. Energy savings solutions can even be promoted to consumers who are direct and indirect beneficiaries.

**Financiers can support smaller-scale projects.** Smaller projects are often neglected by traditional commercial lenders even though they are easier to develop due to lower complexity and variables. They are often also in a better position to take advantage of alternative financing sources such as energy service companies (ESCO). Using financiers to develop business cases raises the confidence level of commercial lenders who, combined with ESCOs, can make smaller projects feasible.

# Sustainable Industry

## Addressing China's Industrial Air Pollution Challenges

### Opportunity Assessment Summary

Six industries account for more than 80% of total sulfur oxides (SOx), nitrogen oxides (NOx) and soot emissions in China. Of those emissions, power and heat generation account for 47.5% and 66.7% of SOx and NOx, respectively. Reduced reliance on fossil fuels, adoption and operation of air pollution technologies and investment in energy efficiency, such as through demand-side management, will be critical to reduce air pollution from industrial processes.

### Definition and Scope—Industrial Air Pollution

China Greentech defines industrial air pollution as the introduction of gases, chemicals, particulates or other materials into the atmosphere from industrial activity. Our scope focuses on the non-greenhouse gas air pollutants $PM_{2.5}$, NOx and SOx.

Key insights from China Greentech's opportunity assessment on building energy efficiency include the following:

**Growing public awareness of the adverse health effects of $PM_{2.5}$ is compelling the Chinese government to increase its pollution reduction efforts.** With pollution data more readily available to the public, a growing number of Chinese citizens are becoming aware of the adverse health effects of $PM_{2.5}$, and in turn have taken to social media to express their concerns.

**The sources of $PM_{2.5}$ are diverse and complex.** Secondary aerosols are the largest contributor to $PM_{2.5}$; six industries account for 80% of total sulfur dioxide (SOx), nitrogen oxide (NOx) and soot emissions. While some $PM_{2.5}$ particles are emitted directly, others are formed when pollutants such SOx and NOx react in the atmosphere. Combustion is the main source of $PM_{2.5}$ emissions, whether for electricity, heating, transportation or other energy services.

**Opportunities in technology and professional services grow as the government invests in air pollution reduction.** Investments in renewable distributed energy, energy efficiency, pollution control technologies and capacity building for professional staff will grow as China attempts to curb air pollution, especially particulate matter.

## Applying Circular Economy Concepts in China's Industrial Parks

### Opportunity Assessment Summary

China has set national targets for energy and water intensity, industrial water recycling and solid waste reuse. 50% of national industrial parks and 30% of provincial industrial parks are targeted to achieve circular economy transformation by 2015, as measured by rising output of recycled resources and declining waste discharge.[5]

### Definition and Scope—Circular Economy Concepts in Industrial Parks

China Greentech defines a circular economy as one that reduces waste by reducing, reusing and recycling energy and resources. This can refer to individual enterprises recycling their own waste, nearby companies sharing and reusing waste products, or an entire economic system operating on the philosophy of circular design principles.[6] This opportunity assessment focuses on circular economy concepts within industrial parks. The main waste streams considered include energy, solid waste and water.

Key insights from China Greentech's opportunity assessment on applying circular economy concepts in industrial parks include the following:

**Strengthen enabling environments for circular economy projects, especially wastewater sharing.** Industrial parks are natural catalysts for a circular economy, but still face economic and policy barriers. In particular, low water prices fail to reward efficiency, requiring governments to instead offer predictable public investments and incentives for wastewater projects.

**Design new industrial parks with energy and waste recycling in mind.** Resource reuse is economically attractive but introduces new challenges. Planners, industry and solution providers should collaborate on tailored recycling systems for each new park, such as water pipe infrastructure for recycling and reuse.

**Use Corporate Social Responsibility (CSR) initiatives to catalyze change.** Large multinationals can use their CSR budgets for China to fund demonstration projects with unattractive economics—then work toward policy reforms and a sustainable business model to improve the project's economics over time.

*5. Wang Xuejun,《循环经济与可持续发展：中国工业园区案例介绍》, "Circular Economy and Clean Production: China Case Study," 2012*
*6. Report on Circular Economy, CCICED, 2005, www.cciced.net*

# Cleaner Vehicles

## Future Urban Transportation Systems to Help Solve China's Traffic, Emissions and Energy Challenges

### Opportunity Assessment Summary

China's economic growth and rapid urbanization over the past two decades have intensified urban mobility demands. Vehicle ownership ballooned from only 5.3 million in 1990 to 136 million by 2013.[7] This exponential growth has led to severe traffic congestion, higher energy demands, and worsening air pollution from vehicle emissions.

**Definition and Scope—Cleaner Urban Transportation**

Urban transportation systems encompass several elements including: public transport, non-motorized transport (such as pedestrians and cyclists), private motorized traffic, and commercial traffic. The major objective of cleaner urban transport is to meet the demands for both accessible and efficient transportation services while promoting sustainable transportation networks suited for high-density urban populations, as well as minimizing congestion and vehicle emissions like carbon dioxide, nitrous oxides and particulates.

Key insights from China Greentech's opportunity assessment on urban transportation include the following:

**Near and long-term planning.** There are measures that can be adopted both immediately and in the long-term to minimize the environmental impact of urbanization and growing demand for vehicles. Short-term economic measures include congestion pricing and price reductions for public transportation. Long-term measures include the development of accessible public transit options, bicycle-friendly communities and mixed-use zones that minimize travel time between home, work and shopping areas.

**Next-generation transportation options.** Long-term planning should also consider the development of next-generation transportation systems. While there may be higher upfront costs associated with such systems, they have the potential to accelerate cleaner urban transportation development.

*7. "* 中国车用能源展望 *2012" [China Automotive Energy Outlook 2012], China Automotive Energy Research Centre and Tsinghua University, 2012;* 截至 *2012* 年底，中国汽车驾驶人首超 *2* 亿机动车保有量已达 *2.4* 亿辆 *[China's Private Vehicle Ownership Reached 240 Million in 2012], Xinhua News, January 13, 2013; 2014* 中国汽车市场展望 *[2014 Outlook for Automotive Development in China], wjshw.com, April 21, 2014, www.wjshw.com*


## Developing Successful Regional Electric Vehicle Ecosystems

### Opportunity Assessment Summary

China's 2015 targets for EVs and charging infrastructure are aggressive and challenging. They demand an accelerated approach with strong cooperation between government and the private sector. Regional EV ecosystems, designed around current technology and concentrated market opportunities, could accelerate EV adoption.

**Definition and Scope—Regional Electric Vehicle Ecosystems**

Regional electric vehicle (EV) ecosystems use available technologies and viable business models to introduce EVs within a contained physical environment. Vehicles and charging infrastructure are clustered at densely populated locations to serve customers with common and predictable driving needs. Commercially viable business models and value propositions for all stakeholders are essential requirements for regional EV ecosystems.

Key insights from China Greentech's opportunity assessment on regional EV ecosystems include the following:

**A regional EV ecosystem approach can help China meet ambitious EV targets.** National targets announced in 2012 aim for an 18-fold increase of EV sales in just three years. The government is already subsidizing vehicle purchases to encourage this growth, but many experts suggest regional EV ecosystems will be essential for success.

**Concentrating EV infrastructure and services in suitable locations with sufficient demand is already commercially viable with existing EV technologies.** Despite underdeveloped infrastructure and technological limitations, there are niche markets in which EV vehicles can operate cost-effectively if the right incentives are in place.

**The most promising locations for regional EV projects in Beijing are business campuses dominated by high-tech companies and white-collar workers.** Zhonguangcun Haidian Science Park and the Guomao office complex, for example, have the population, socioeconomics and market drivers to support their own EV ecosystems.

# VIEWPOINT

*Courtesy of Mike Hawkins*

Courtesy of Mike Hawkins

# China's Pollution Debate Enters a New Era

**Recent history is a disturbing reminder of China's need to act immediately on pollution. Northern China's air pollution in the winters of 2013 and 2014 triggered a chain of trend-setting events: a surge in hospital admissions related to respiratory illness, a storm of public opinion on social media platforms, and a hike in demand for transparent air quality data. The severity and duration of the 2013 and 2014 air crises have inspired several facets of change—controversial government initiatives, candid media attention, and a surge in private investment in greentech solutions.**

While national priorities like economic growth and energy security continue to shape China's development model, pollution reduction has become an equally important item on the government's agenda. Within the broader pollution debate, air quality, and more specifically $PM_{2.5}$ (particulate matter of 2.5 micrometers in diameter or less), is now the focal point of citizen complaints, evolving from an industry-specific challenge to a much broader public concern that is compelling the government to adopt a new approach to development.[1]

Resource constraints, choked cities and public health costs will become major bottlenecks for development and, in some cases, negate the progress that China has made.

All eyes will be on China over the next few years as the country redefines and refines its approach to development. This is exactly the moment that calls for the government and private sector to partner across sectors and lead the way in implementing a more sustainable growth model. If this opportunity is missed, resource constraints, choked cities and public health costs will become major bottlenecks for development and, in some cases, negate the progress that China has made as a developing nation emerging into a global leader. China has the opportunity to set an example for the rest of the world, to innovate and approach development differently than in the past.

China's 2013 Action Plan for Air Pollution Prevention and Control (Action Plan) is the nation's most recent and visible move toward a sustainable development approach. Released in September 2013, the Action Plan includes a targeted list of ten measures to reduce air pollution in major regions across China by 2017. Announced by the State Council (the nation's highest ranking government body), the Action Plan has significantly more authority than if issued by a ministry-level agency such as the Ministry of Environmental Protection (MEP). The Plan is also progressive in several ways: it delegates pollution reduction responsibility to local governments, calls for regional cooperation in air quality improvement,[2] and incorporates $PM_{2.5}$ reduction

*1. Response to a City's Smog Points to a Change in Chinese Attitude, New York Times, October 24, 2013, www.nytimes.com*

*2.《大气污染防治行动计划》 [Air Pollution Prevention and Control Action Plan], September 13, 2013, www.gov.cn*

targets into key performance indicators (KPIs), making it difficult for officials to shirk responsibility. Based on a State Council announcement released in April 2014, city and provincial officials will be evaluated based not only on their achievement of $PM_{2.5}$ targets, but also on key indicators related to areas including but not limited to cleaner production, industrial air pollution control and data disclosure.[3]



Targets detailed in the Action Plan are more ambitious than earlier pollution control efforts, such as those outlined in the October 2012 Five-Year Plan for Air Pollution Prevention and Control in Key Regions.[4] High-level goals include capping the share of coal in China's energy mix at 65% and reducing $PM_{2.5}$ emissions by 25% in the Beijing, Hebei and Tianjin region, 20% in the Yangtze River Delta, and 15% in the Pearl River Delta, based on 2012 levels.[5] In addition to unveiling stricter $PM_{2.5}$ reduction targets, subsequent industry-specific plans have been released to complement the Action Plan. The Work Plan for Strengthening Air Pollution Prevention Efforts for the Energy Sector (released in May 2014), which sets specific targets for the energy sector as they relate to air pollution reduction through 2017, is one such example.[6]

Nevertheless, the Action Plan also presents some ironies—and the tradeoff cannot be ignored. In an effort to reduce pollution in China's urban centers, the government has accelerated development of coal-to-gas plants that convert low-quality coal to cleaner-burning gas for electricity; thus far, at least 18 plants are planned with a total annual production capacity of 75.1 billion cubic meters (bcm).[7] However, according to studies, synthetic natural gas plants emit as much as 82% more $CO_2$ than plants that burn coal directly for electricity when factoring in production, transportation and combustion stages. These plants are also far more water-intensive and are being built in some of China's most water-stressed regions, including Xinjiang and Inner Mongolia.[8] World Resources Institute (WRI) estimates that annual water consumption for the 18 plants will account for nearly 20% of the region's total water use in 2011.[9]

Clearly, there is a need for China to fully assess the benefits and drawbacks of its pollution reduction campaigns. Businesses and non-governmental organizations (NGOs) can help inform decisions by identifying and directing investment toward the solutions needed to execute low-carbon, low-pollution projects.

*3.* 国务院办公厅关于印发大气污染防治行动计划实施情况考核办法（试行）的通知 *[State Council Notice on Assessing Performance Related to Implementation of the Action Plan on Air Pollution Prevention and Control] April 30, 2014,www.gov.cn;* 国务院发布《大气污染防治行动计划》专家解读 *[An Opinion Piece on the State Council's Announcement of the Action Plan for Air Pollution Prevention and Control], September 13, 2013, www.scopsr.gov.cn*

*4.*《重点区域大气污染防治‘十二五’规划》 *[12th Five-Year Plan for Pollution Prevention and Control in Key Regions], October 2012, www.gov.cn*

*5.*《大气污染防治行动计划》[*Air Pollution Prevention and Control Action Plan], September 12, 2013, www.gov.cn*

*6.*《能源行业加强大气污染防治工作方案》 *[Strengthening Air Pollution Prevention Efforts for the Energy Sector], National Energy Administration, May, 27, 2014, www.nea.gov*

*7. Combating Air Pollution May Hurt Water Supplies, China Daily, October 26, 2013, www.chinadaily.com*

*8. Ding, Yanjun et al., Coal-based Synthetic Natural Gas (SNG): A Solution to China's Energy Security and $CO_2$ Reduction? Energy Policy, 2013; China's Coal Solution Has Carbon Downside Across Globe, The Seattle Times, May 6, 2014, www.seattletimes.com*

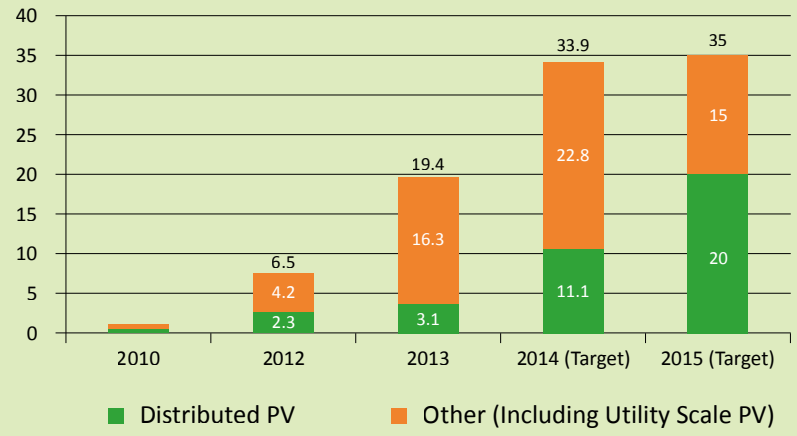
*9. China's Response to Air Pollution Poses Threat to Water, World Resources Institute, October 23, 2013, www.wri.org*

**China continues to see growth in greentech solution adoption**

Heightened concern about pollution has also been accompanied by growth in greentech investments. China's solar industry, in particular, is enjoying a fair share of this investment after a four-year downturn. In 2013, investments in newly installed utility and distributed solar capacity amounted to RMB 130 billion. Based on the market price of RMB 10 per watt, 2014 investments will likely meet the RMB 140 billion mark. In 2013 alone, an additional 12.9 GW (or twice the existing capacity at the end of 2012) of solar capacity was added to the grid, bringing total capacity to 19 GW by year-end, thus helping to absorb the industry's manufacturing overcapacity.

In January 2014, the National Energy Administration (NEA) announced that China would install an additional 14 GW of solar power in 2014.[10] Four months later, the National Development and Reform Commission (NDRC) issued a joint statement with MEP and NEA announcing that China would reach 70 GW of installed solar capacity by 2017.[11] If China maintains its current pace of installation, it will exceed these targets; however, as additional projects are developed, more emphasis must be placed on connectivity and long-distance transmission infrastructure to ensure capacity is fully utilized.

**Figure 1: Cumulative Installed Solar PV Capacity (GW*)**




*GW = Gigawatt

*Source: "能源发展'十二五'规划" [The 12th FYP for Energy Development], January 1, 2013, www.gov.cn, "2013 年光伏发电统计数据" [2013 Statistics for Photovoltaics in China], National Energy Administration, April 14, 2014, www.nea.gov.cn*

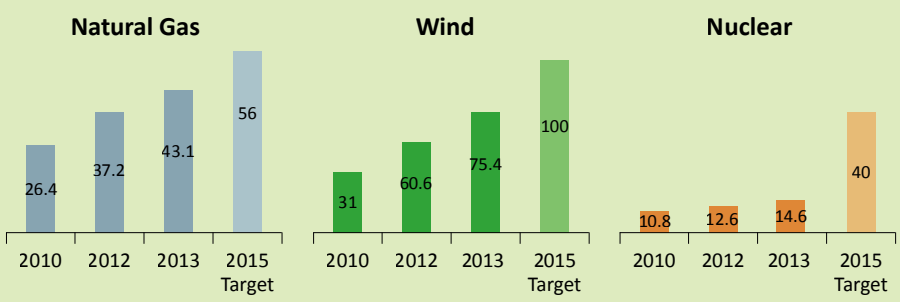
Distributed energy, defined as energy generated onsite or near energy end-users that can either be connected to the grid or stand alone off the grid, will play an increasingly important role in supporting China to achieve its sustainable growth objectives. Typically small-scale, distributed energy projects are built close to the demand, which eliminates the need for extensive distribution. While only 3.1 GW (16.3%) of the 19 GW of solar capacity existing today are distributed photovoltaic (PV) projects,

*10.《国家能源局关于下达 2014 年光伏发电年度新增建设规模的通知》[NEA Notice on Achieving New 2014 Installation Targets for PV], National Energy Administration, January 17, 2014, www.nea.gov*
*11.《能源行业加强大气污染防治工作方案》[Strengthening Air Pollution Prevention Efforts for the Energy Sector], National Energy Administration, May, 27, 2014, www.nea.gov*

emerging investment opportunities will facilitate growth in this segment.[12] Government targets suggest this as well: of the 14 GW of solar capacity installments planned for 2014, 8 GW will be distributed energy, or 10 times the capacity installed in 2013; distributed energy projects, particularly industrial rooftop solar, will proliferate as cleaner energy becomes more cost-competitive. Zhejiang, Guangdong and Hebei provinces currently lead this market, accounting for 40% of newly added distributed solar in 2013.[13]

Wind, natural gas, and nuclear development offer a mixed progress report, with wind and natural gas clearly outperforming nuclear. Installed wind power capacity grew by about 25% in 2013, and grid connectivity for wind farms has improved: only 11% of wind-generated power was not transferred to the grid in 2013, down from 17% in 2012 and 25% in 2011.[14] With installed natural gas capacity growing by about 14% in 2013, both wind and natural gas power generation capacity seem to be on track based on 12th Five-Year Plan targets. In contrast, nuclear power has remained relatively stagnant since March 2011; following the disaster in Fukushima, Japan, only two gigawatts of capacity were added, putting China at just over a third of its nuclear capacity target for 2015 (Figure 2).

**Figure 2: 12th Five-Year Plan Targets and Progress for Installed Power Generation (GW*)**




*GW = Gigawatt

*Sources: "能源发展'十二五'规划" [The 12th Five-Year Plan for Energy Development], January 1, 2013, Central People's Government, www.gov.cn; "2013 年发电装机达 12.47 亿 新能源和可再生能源占比 31%" [2013 Power Production Capacity Reaches 124.7 TW; New Energy and Renewables Represent 31% of Growth], Bjx.com.cn, February 10, 2014; "2013 年全国电力工业运行简况" [2013 National Power industry Briefing], China Coal Resources, February 20, 2014, www.sxcoal.com*

Smarter solutions for energy efficiency improvements in industrial and commercial establishments are also developing quickly. Tianjin's Automatic Demand Response System Pilot Project, the first of its kind, has helped reduce peak power load by up to 15% for commercial and government buildings included in the project. Participating industrial users have enjoyed a 7.7% reduction in electricity usage during peak hours and a 30% reduction during off-peak hours.[15]

*12.《年光伏发电统计数据》[2013 PV Installation Statistics], National Energy Administration, April 28, 2014*
*13. Ibid.*
*14. "能源局发布 2013 年风电发展情况" [NEA Publishes 2013 Figures for Wind Power Development], China Industrial Economy Information Network, March 10, 2014, www.cinic.org.cn*
*15. Honeywell and Tianjin Economic–Technological Development Area Launch China's First Demand Response Project Under United States-China Smart Grid Cooperative, January 5, 2012, www. honeywell.com*

Residential energy efficiency solutions have not developed as quickly. Nevertheless, the idea is gaining traction with Chinese startups in Zhongguancun, an area in Beijing known as the Silicon Valley of China. The company iKair is one example of a startup that designs household devices that measure indoor temperature, air quality, lighting and other indicators to provide residents with the data needed to make informed decisions on energy use as well as filtration needs.[16]



**Financial innovation and information technology will play pivotal roles in driving greentech solution adoption**

Innovative financing models are emerging to support the development of greentech projects, allowing commercial and individual investors the opportunity to finance greentech projects directly. New financing models employed by companies like MOSAIC, a crowd-funding startup company that makes solar and other clean technologies more affordable and easier to access, are becoming popular in the U.S. market. Similar platforms have the potential to become a funding source for greentech projects in China as their benefits are recognized. In the near term, however, funding from the state and small-to medium private Chinese firms will remain the main source of financing for projects. In April 2014, the government announced that it would allow more private investment in the energy and infrastructure sectors, with private investments already planned for solar, wind and hydro projects.[17]

As financing models evolve, investment in greentech projects will become more accessible to the general public, spurring growth in the industry, promoting public participation, and empowering citizens around environmental issues.[18] The International Finance Corporation's (IFC) risk-sharing model for textile and dyeing factories illustrates how innovative financing models are supporting the development of energy and water efficiency solutions in China's industrial sector.

### Project Financing for Greentech Projects: IFC's Risk-Sharing Model for Textile and Dyeing Plants

Access to reliable financing options is often the determining factor in a company's ability to pursue greentech project opportunities. In many cases, even the most promising project ideas are not implemented due to financing barriers such as lending restrictions, investor uncertainty about financial return, or limited awareness of financing options.

A World Bank Group-supported program provides one example of how innovative financing models can help capture resource savings in China's most energy-and water-intensive sector: industry. The program demonstrates how flexible financing models can help manufacturers not only invest in energy and water efficient equipment, but also increase profitability.

Since 2006, the International Finance Corporation (IFC), the private sector arm of the World Bank Group, has engaged in multiple industrial efficiency projects under their China Utility-Based Energy Efficiency Finance (CHUEE) Program and China Water Program to demonstrate the business case for energy efficiency, renewable energy, and water efficiency projects.

*16. iKair, www.ikair.com*
*17. China to Allow Private Investment in 80 Projects, Reuters, April 23, 2014, www.reuters.com*
*18. MOSAIC, www.joinmosaic.com*

To improve access to funding for industrial enterprises, IFC partners with local banks to provide loans for energy and water efficiency investments made by industrial enterprises. In addition to monetary support, IFC provides industrial enterprises with auditing and technical consulting services to help identify energy-and water-saving solutions that promise bankable payback periods under five years. Recognized as "green loans" by the government, IFC's services support resource efficiency investments by reducing the risk for potential creditors and qualifying the investment decisions of lenders.[19]

Since 2012, IFC's China Water Program has supported more than 20 textile dyeing facilities improve energy and water efficiency through more than 50 cost-effective projects. And between mid-2006 and December 2013, IFC-facilitated loans for energy efficiency and renewable energy projects through CHUEE's risk-sharing facility totaled USD 790 million, enabling a total investment of USD 1.88 billion in energy efficiency upgrades; this reduced annual greenhouse gas emissions by 19 million tons.[20] The cost and energy savings achieved in these projects demonstrate the importance of informed decision-making and institutionalizing financing options for energy and water efficiency projects.

As the IFC case study demonstrates, upfront costs do not need to hinder greentech solution adoption. Strategic partnerships between local banks, project owners and third-party lending institutions can provide transparent, low-risk project development options. Resulting projects can then serve as demonstrations for future investment, increasing investor confidence and propelling the market forward.

Furthermore, upfront costs are minor when compared to the economic losses associated with environmental degradation: according to a joint study by the World Bank and Development Research Center of the State Council, air pollution costs (including costs associated with healthcare and loss of workforce) in China amount to an average of RMB 600 billion to 1.8 trillion every year. In comparison, the central government pledged an average of RMB 340 billion per year to combat pollution under the 2013 Action Plan period, for a total of RMB 1.7 trillion. Rather than planning for remediation, China would be better served if it invested in pollution reduction upfront to optimize current assets, boost efficiency, and scale renewable energy adoption to achieve meaningful environmental improvements and reduce the costs associated with pollution.

A 2014 World Wildlife Fund (WWF) study further suggests that cleaner development could result in significant monetary savings for China. With support from the State Electricity Regulatory Commission, the study factors in key assumptions about the cost and performance of renewable electricity technologies, economic restructuring, and the application of energy efficiency technologies. The report concludes that it would be far less costly for China to build an electricity system powered by 80% renewable energy ('high renewables' scenario)* by 2050 than to continue to rely on coal for electricity production. WWF estimates that the total cost of such an electricity system would amount to USD 57.7 trillion (RMB 350 trillion) between 2011 and 2050—about four trillion less RMB than a 'business-as-usual' scenario.[21]

*19. China Greentech research and analysis*
*20. International Finance Corporation, www.ifc.com*
*21. China's Future Generation: Assessing the Maximum Potential for Renewable Power Sources in China to 2050, World Wildlife Fund, February 18, 2014, www.worldwildlife.org*

**China's central government takes a clear stand against pollution and public participation grows**

Despite some of the controversial initiatives outlined in the Action Plan for Air Pollution Prevention and Control, several developments in late 2013 and early 2014 suggest that the government is increasingly committed to pollution reduction. For example, lower sulfur fuel standards are finally being implemented after a two-year delay in refinery upgrades,[22] renewable energy installation targets have been ramped up, and beginning in January 2015 local environmental protection bureaus (EPBs) will have the authority to impose daily fines on polluters until violations cease.[23]

Premier Li reiterated the government's commitment to air pollution reduction at the annual meeting of the National People's Congress (NPC) and the Chinese People's Political Consultative Conference (CPPCC) in March 2014, when he declared a national "war on pollution". The Premier announced several action items to help China become cleaner and more livable: tightening fuel standards, retiring nearly 27 million tons of iron and steel capacity, and initiating pricing reforms for coal and natural gas. Premier Li emphasized that special focus would be placed on energy-intensive industries, and that a regional approach would be necessary.

Premier Li reiterated the government's commitment to air pollution reduction at the annual meeting of the National People's Congress (NPC) in March 2014, when he declared a national "war on pollution"

Revision of the national Environmental Protection Law in April 2014, the first revision since 1989, is one of the most significant updates in the history of environmental governance in China. Adopted by the Standing Committee of the NPC in April, and officially in effect beginning January 2015, the most recent revision of the law entitles NGOs that are registered with civil affairs agencies at the municipal level and above to file environmental public interest lawsuits. The final revision followed ongoing discontent around previous drafts that restricted the right to file public interest lawsuits to the All-China Environmental Federation and national level organizations. The revised environmental law also grants MEP greater authority to punish polluters and strengthens protections for citizens that disclose environmental offenses.[24]

While national law still does not extend the right for individuals to file public-interest lawsuits, the revision represents a step forward for environmental governance.[25] In the meantime, local courts will continue to pioneer efforts to broaden public participation in environmental litigation; the Qingzhen Environment Court in Guizhou Province, for example, granted individuals the right to bring public-interest lawsuits as early as 2010 and continues to serve as an example for courts being established today.[26]

*22. China to Raise Fuel Standards to Combat Pollution, Wall Street Journal, February 7, 2013, www.wsj.com; China Announces Breakthrough Timeline for Implementation of Ultra-Low Sulfur Fuel Standards, International Council on Clean Transportation, March 2013, www.theicct.org*

*23. After Declaring War on Smog, China Gets Around to Updating its Environmental Laws, April 22, 2014, www.businessweek.com*

** A few key assumptions for the 'high renewables' scenario include: the service sector contributes 75% of GDP by 2050; the capacity factor for wind and solar units increase by 20-29% and 15-20% by 2050, respectively; capital costs for installation and operations and maintenance (O&M) of on-shore 30 MW wind units decrease by 0.7% annually; and the capital cost for installation of 3MW solar units decrease by 3.1% annually (3.3% for O&M)*

*24. China's Legislature Adopts Revised Environmental Protection Law, Xinhua Net, April 14, 2014, www.xinhuanet.com*

*25. China's New Environmental Law Looks Good on Paper, April 24, 2014, China Dialogue, www.chinadialogue.com*

*26. China Greentech analysis*

China's "war on pollution" comes at an opportune time as the Intergovernmental Panel on Climate Change (IPCC) confirms that climate change will further increase threats to water, health, and worker productivity in China.[27] The World Health Organization (WHO)'s March 2014 report on the public health implications of air pollution created additional impetus for action. The report stated that an estimated seven million premature deaths occurred globally as a result of exposure to air pollution in 2012 and labeled air pollution as the world's largest single environmental health risk today. According to the WHO report, heart disease and strokes account for 80% of those deaths.[28] The threat to China's sustainable development is clear.



**Local governments follow the central government's lead on air pollution reduction**

Beijing was among the first to draft a municipal plan for air pollution reduction to carry out the September 2013 Action Plan. The city will strive to cap annual average $PM_{2.5}$ concentrations at 60μg/$m^3$ by 2017 through measures including vehicle restrictions, gas-fired winter heating, and the phasing out of coal-fired power plants. The capital has also pledged to cut coal consumption by 30 million tons by 2017.[29] Penalties for polluters have also been ramped up, especially for those that refuse to suspend production during times of severe air pollution. Effective as of March 1, 2014, Beijing's Air Pollution Prevention Regulation allows the Beijing Environmental Protection Bureau to fine polluting enterprises that refuse to suspend their operations during periods of severe smog as much as RMB 500,000, up from RMB 100,000.[30]

Beijing's plan is unique in that it details district targets for each of the measures outlined, as well as the city or district government department and individual responsible for achieving those targets.[31] But capping emissions is not entirely within Beijing's control: an estimated 10-30% of pollution originates from surrounding regions, including Hebei. Under certain atmospheric conditions, surrounding areas can account for an even higher percentage of the pollution in Beijing.[32]

In response to the 2013 Action Plan and growing scrutiny from its neighbors, the Hebei provincial government has drafted a 50-point plan for air quality improvement.[33] Goals include a 40-million ton net reduction of annual coal consumption from 2012 levels, an elimination of vehicles classified as "high-pollution emitters," and a 60-million ton cut in steel production capacity. Since releasing its plan, Hebei has shut down more than 8,000 high-polluting firms[34] and the provincial governor, Zhang Qingwei, has warned that any official responsible for an additional ton of steel or cement capacity would be fired.[35]

*27. Climate Change Worsening all Aspects of Life in China, Says Leaked IPCC Report, China Dialogue, March 19, 2014, www.chinadialogue.net*
*28. Seven Million Deaths Linked to Air Pollution Annually, March 25, 2014, World Health Organization, www.who.int*
*29.《北京市 2013-2017 年清洁空气行动计划》[Beijing 2013-2017 Clean Air Action Plan], October 13, 2013, www.beijing.gov.cn*
*30. Polluters to Face Harsher Penalties, China Daily, February 28, 2014, www.chinadaily.com*
*31.《北京市 2013-2017 年清洁空气行动计划》[Beijing 2013-2017 Clean Air Action Plan], October 13, 2013*
*32. Beijing is Trapped in its Polluted Neighborhood, China Dialogue, June 25, 2013, www.chinadialogue.net*
*33.《河北省大气污染防治行动计划实施方案》[Implementation Plan for Hebei Air Pollution Action Plan], September 12, 2013, www.gov.cn*
*34. Hebei Closes 8,300 Small High-Polluting Firms, Xinhua, January 16, 2014, www.xinhuanet.com*
*35. China's Hebei Province to Shut More Steel Capacity if Conditions Allow, Reuters, March 7, 2014, www.reuters.com*

Home to seven of China's ten most polluted cities in 2013, Hebei faces a sizable challenge and has reason to act quickly. In addition to growing scrutiny from its neighbors, local citizen complaints are on the rise. Between 2012 and 2013, figures from Weibo (the Chinese version of Twitter) indicate that local citizen posts by Hebei residents containing the word "air pollution" increased nearly ninefold.[36] On February 25th, 2014, a resident of Shijiazhuang, the capital of Hebei Province, filed the first known lawsuit against the government for the health and economic damages related to air pollution.[37] While the outcome of this lawsuit remains to be determined, it is yet another indicator that public sentiment on air quality has reached a boiling point.[38]

On February 25th, 2014, a resident of Shijiazhuang, the capital of Hebei Province, filed the first known lawsuit against the government for the health and economic damages related to air pollution

Transforming Hebei's economy will require a willingness to take risk and a change in mindset at all levels of government. But the shift in the province's development mechanism does not have to be revolutionary. Simple technological upgrades, operational efficiency improvements, and consumer awareness are the first steps in transforming to a high-value economy without threatening jobs and improving quality of life.

While we have focused our discussion on Beijing and Hebei, China's "war on pollution" extends far beyond the northeast to southern municipalities and the autonomous regions of the west. In fact, there are only three provinces (Tibet, Yunnan and Hainan) that have not set specific $PM_{2.5}$ reduction targets for 2017.[39]

**Improved public access to data will help accelerate government initiatives for air pollution reduction**

Public participation is becoming an increasingly important driver for environmental protection, with access to data playing a decisive role in driving forward pollution reduction efforts. In the past six years, improved access to pollution data has provided the public with the tools needed to compel the government to reassess the nation's development model and follow through on pollution reduction promises.

*36. 微博高级探索 [Weibo Advanced Search Tool], Hebei Province, accessed on May 12, 2014*
*37. Chinese Man Becomes First to Sue Government Over Severe Smog, Reuters, February 25, 2014, www.reuters.com*
*38. Xingtai Leads List of China's Cities with the Worst Air Pollution in 2013, Forbes, January 13, 2014, www.forbes.com*
*39. China Greentech research and analysis*

## Data Availability Informs the Pollution Debate

The air pollution debate in China has entered a new era. Heightened levels of public concern and distress about poor air quality have fueled debate across academic circles and social media platforms alike. But the impact goes beyond health—dense smog in China's urban centers is even impacting the performance of renewable energy systems. According to one source, energy output for a residential solar power distributed energy project in Beijing was reduced by 87% during a week-long haze that obscured the sun in February of 2014.[40] The increasingly apparent social and economic implications of air pollution have pressured decision makers to improve data transparency.

$PM_{2.5}$ data became publicly available in Beijing in 2008 when the U.S. Embassy began releasing hourly pollution levels on its Twitter feed. Despite the MEP's public demand to discontinue the service, the Embassy continued reporting air quality data on the grounds that it provided American diplomats and the larger U.S. community with the information needed to make informed decisions about outdoor activities. This became a turning point for the pollution debate in China.

Between 2012 and 2013, nationwide Weibo posts containing the word "air pollution" increased tenfold, indicating a growth in awareness and public concern about pollution.[41] In response to growing public demand for data transparency, the MEP accelerated its timeline for data publication and began releasing hourly pollution data from 35 monitoring sites across Beijing in October 2012. Several cities followed suit and by January 2013, at least 74 municipalities across China were publishing real-time data for six pollutants including sulfur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), ozone ($O_3$), carbon monoxide (CO), $PM_{10}$ and $PM_{2.5}$.[42]

By January 2014, 161 Chinese cities were publishing real-time air quality data on the MEP's real-time air quality disclosure platform, easily accessible to the public by computer or smart phone.[43] According to the Institute of Public and Environmental Affairs (IPE), Beijing, Dongguan, Nanjing, Suzhou, and Chongqing rank highest for the timeliness, comprehensiveness, and user-friendliness of disclosed air quality data. Chengde, Karamay and Luoyang are among the lowest ranked. The rankings do not factor in the accuracy of data.[44]

*40. 雾霾突袭光伏电站 [Smog Attacks Solar Power Stations], Southern Weekly, March 13, 2014, www.infzm.com*
*41. 微博高级探索 [Weibo Advanced Search Tool], Hebei Province, accessed on May 12, 2014*
*42. Seventy-Four Chinese Cities Release Real-Time $PM_{2.5}$ Data, Xinhua News, January 1, 2013, www.xinhuanet.com*
*43. Institute of Public and Environmental Affairs (IPE), Blue Sky Roadmap Report II, Real-time Disclosure Begins, January 14, 2014.*
*44.. Ibid*

**Laying the foundation for sustainable growth**

China's environmental situation is unlikely to improve in the short term, regardless of the government's verbal commitment to sustainable growth. Historical data of $PM_{2.5}$ levels in Beijing indicate no sign of progress: data from the U.S. Embassy show that annual $PM_{2.5}$ levels averaged between 90µg/m$^3$ and 105µg/m$^3$ from 2009 to 2013, as much as ten times the average annual concentration recommended by the World Health Organization of 10µg/m$^3$.[45] While the national Action Plan is more ambitious than previous plans with similar air pollution reduction objectives, the government's overall approach remains nearly entirely the same—focused primarily on achieving quantitative targets, as opposed to addressing underlying inefficiencies.

China's plan to maintain a national GDP growth target of 7.5% through 2014 must be accompanied by an equally resolute vision for cleaner growth.

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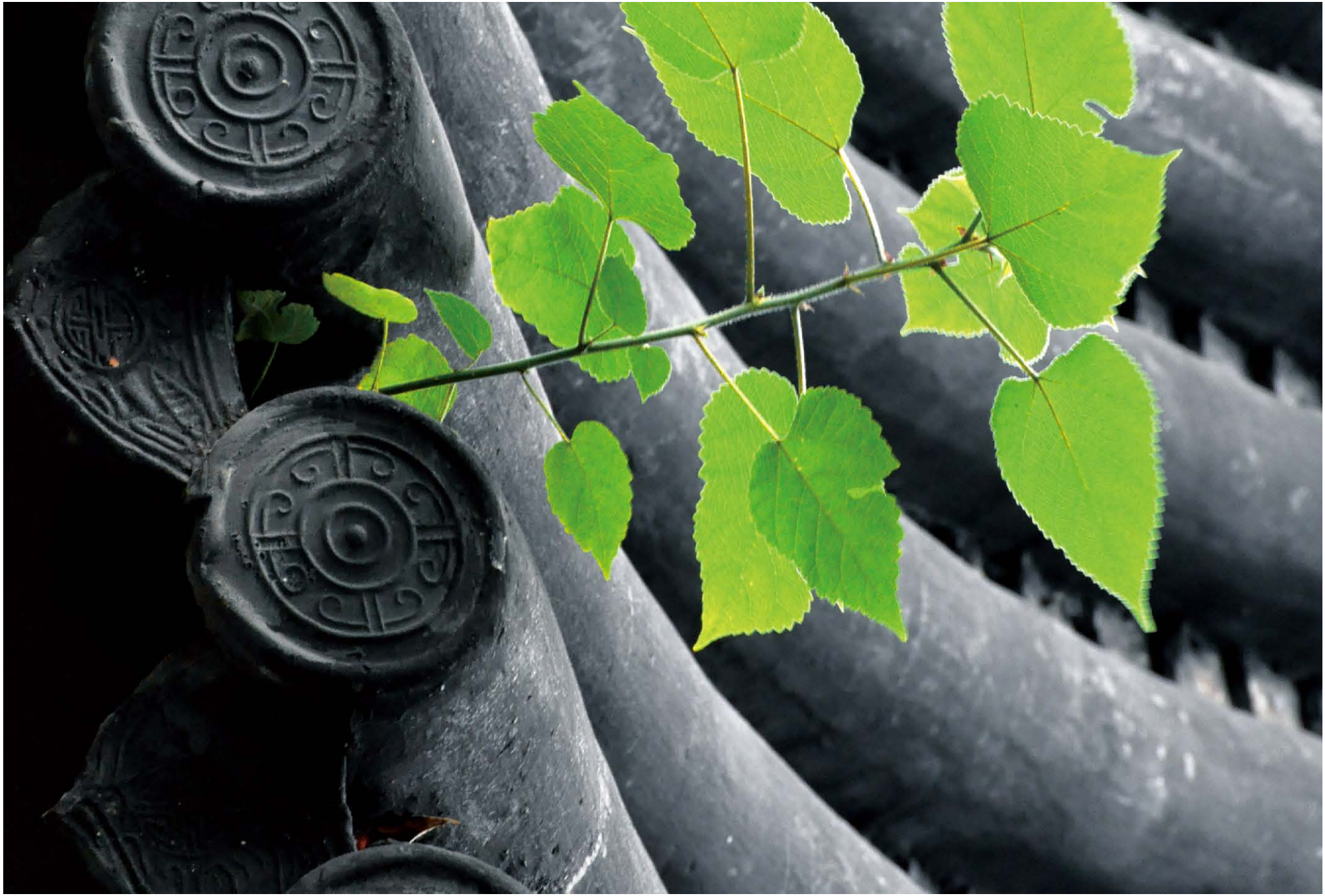
China's plan to maintain a national GDP growth target of 7.5% through 2014 must be accompanied by an equally resolute vision for cleaner growth. High emissions and inefficiencies throughout value chains are preventing China from achieving its full potential. According to China Greentech analysis, China's industrial sector as a whole (including both heavy and light industries) consumed eight times more energy per unit GDP than that of the EU in 2011.[46] To achieve cleaner growth, China must invest in energy efficiency, reduce emissions from heavy industry, and boost renewable energy's share in the national energy mix; furthermore, clear economic incentives must form the core of these initiatives. By adopting a greener, smarter and more productive approach to development, China has the opportunity to improve resource efficiency as well as the quality of life for its citizens.

*45. "U.S. Embassy Beijing Air Quality Monitor; WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide," World Health Organization, 2005*
*46. China Greentech analysis*

*Courtesy of Greg Kaeuper*



Courtesy of Greg Koeuper

# Building a Greener, Smarter and More Productive China

**China must move beyond its current approach to address its energy and environmental challenges by integrating intelligent greentech solutions to improve efficiency across value chains. The adoption of cleaner technologies enhanced with information systems and optimized processes will not only reduce pollution but also save resources across sectors. China Greentech proposes that China adopt a greener, smarter and more productive approach to development and apply these concepts on all levels and scales, ranging from small-scale initiatives to large-scale industrial restructuring, to benefit from sustainable growth.**

## Definition—Greener, smarter and more productive

China Greentech defines greener as adopting cleaner energy sources and technologies to reduce emissions; smarter as leveraging information systems and Big Data analytics to make informed decisions about resource use and management; and more productive as streamlining processes to use resources more efficiently and improve economic performance.

If China integrates available technologies, makes better use of advanced analytics and applies experience gained from projects to inform decision-making, the cross-sector impact would be significant: urban planners would be better equipped to predict changes in population density, the impact of climate change, and constraints in a city's mobility system; manufacturers would have the insight needed to further reduce emissions from industrial processes; and building developers would have the tools needed to more effectively engage tenants in energy, water and waste reduction.

If China is to achieve greener, smarter and more productive development, collaboration across sectors must improve. To that end, in early 2014 China Greentech formed a partnership of international and Chinese companies to identify and overcome the hurdles that often hinder collaboration—whether that be divisions across countries, sectors, companies or expertise areas—to pursue commercial opportunities together. Built on the foundation of China Greentech's research and analysis, the companies will combine their collective resources to integrate their products and services to customize solutions for China's project owners and governments.

The China Greentech Strategic Partnership was formed to define the models through which local and international firms can work together to collaborate around specific market opportunities, dismantle market misconceptions, address obstacles to greentech solution adoption, and build lasting relationships among governments and the private sector to drive cleaner development. The group believes in building insight around how China can best apply 'greener, smarter and more productive' concepts in projects pertaining to industrial efficiency, distributed energy, greener buildings and cleaner mobility.

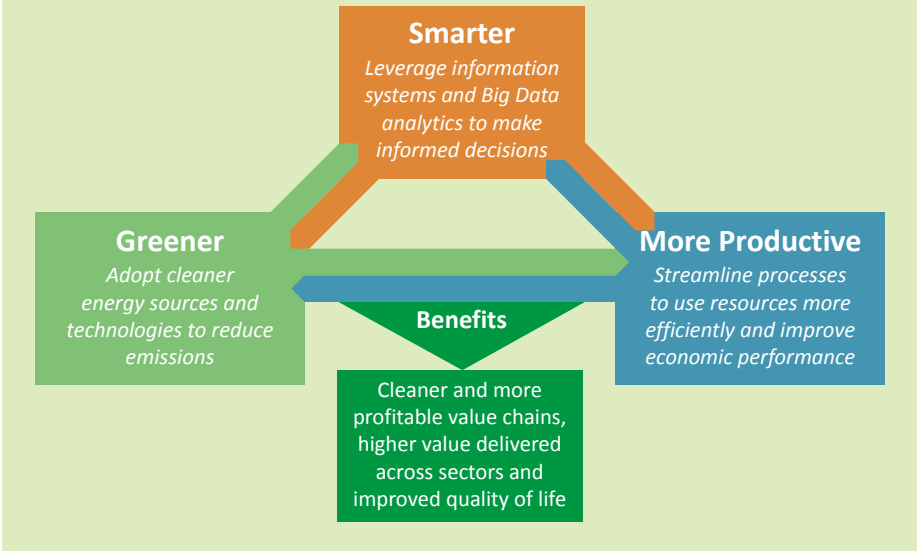
The China Greentech Strategic Partnership will work to define the models through which local and international firms can work together to collaborate around specific market opportunities, dismantle market misconceptions, and address obstacles to greentech solution adoption

**Ecosystems of companies develop solutions to build low-emission, resource-efficient cities and industries**

China's cities and industrial zones are hotspots for the adoption and scaling of greentech solutions. Formerly an optional development approach, sustainable urban development is increasingly the prerequisite for meeting national pollution reduction requirements and attracting high-quality, long-term business partners and investment.

The advantages of smarter and cleaner development in cities and industrial zones are increasingly obvious—increased efficiency across production and operations, as well as a better quality of life for residents. The following figure captures China Greentech's vision for a greener, smarter and more productive China. The graphic shows that the full benefits of this approach to development are only achievable if applied together, as opposed to considered as stand-alone concepts. A holistic, integrated approach is essential.

**Figure 3: Rethinking China's Development: Greener, Smarter, and More Productive**




China's national energy and environmental goals will create commercial opportunities for companies to partner with local governments to develop and implement customized solutions across sectors. Improved economic performance, an expanded network of like-minded business partners, and recognition as a leader in accelerating China's sustainable development are just a few of the long-term benefits for forward-thinking firms. The case studies that follow demonstrate how companies are working together with governments and other stakeholders to drive cleaner development.

**Jingfeng: A gas-fired power plant retrofit reduces pollution in Beijing**

Retrofitting existing power plants represents a huge opportunity for emissions reduction in China given the country's near-term dependence on highly-polluting fossil fuels—within the next few years, and perhaps even decades, coal will remain China's major source of energy, representing at least 60% of the national energy portfolio in 2020.[47]

Increasingly strict emissions standards and pollution fines have pressured plant operators to adopt and operate pollution control technologies in recent years, particularly since new national standards for NOx emissions of 100mg/m$^3$ went into effect for power plants on January 1, 2012. These standards became effective for existing power plants as of June 2014, following a two and a half year grace period to allow the plants to plan for compliance.[48] In response, privately-owned small-to-medium sized plants, which have historically opted to pay pollution fines rather than invest in retrofits, are pursuing upgrades more than ever before. Reducing emissions from these plants is important, as they typically emit more pollutants on a per kilowatt basis than larger plants due to design limitations, and since privately-owned plants are less closely monitored by the government.

*47. The Unimaginable: Peak Coal in China, September 4, 2013*
*48. 火电厂大气污染物排放标准 [Emissions Standards for Air Pollutants for Thermal Power Plants], Ministry of Environmental Protection, January 1, 2012, www.mep.gov*

LP Amina, a US-based energy and environmental company with a focus on sustainable power generation, has applied its solutions to achieve an average of 70% NOx reduction across more than 25 small-to-medium sized existing coal-fired plants (in total over 8 GW of capacity) since 2009. By partnering with local universities and equipment suppliers, LP Amina has developed solutions that not only reduce emissions, but increase efficiency and improve fuel switching flexibility. Following six years of refinement and market penetration in China, LP Amina is now applying these solutions developed in China to the United States, Europe and other markets in Asia.

One of LP Amina's more recent projects, a gas-fired power plant retrofit in Jingfeng, Beijing, was a direct result of China's stricter NOx emissions standards. The 410 MW plant, located in the southwest corner of Beijing, is operated by government-owned Beijing Energy Investment Holding Co. Ltd. and supplies over 100,000 residents with heating and electricity. LP Amina used its direct ammonia injection denitration technology to reduce NOx emissions by 80% at the Jingfeng plant.[49] Compared to other retrofit options on the market, LP Amina's direct ammonia injection system also uses significantly less energy and occupies less space, a critical benefit for inner-city plants where land is limited. The Jingfeng project demonstrates how a combination of stricter emissions standards and customized solutions can accelerate the adoption and impact of pollution reduction equipment.

In the future, LP Amina's retrofits will also provide additional value streams using polygeneration technologies. These technologies capture $CO_2$, which can be used for future commercial use, and produce byproducts like liquid hydrocarbons, which have an estimated market size of RMB 6 billion globally. The creation of additional value streams for operators will build even greater incentives for future upgrades and set an example for others looking to enter this unique niche market.[50]

*49. SCR systems are catalysts that separate $NO_2$ into non-polluting components.*
*50. LP Amina*

**Zhangbei: Weather forecasting and data analytics maximize the benefits of integrated renewable energy**

China's resource constraints are increasingly visible, threatening the country's energy security and clean water supply. Inefficient resource use exacerbates this problem—China's energy consumption per unit of GDP output remains two to three times higher than that of most European countries.[51]

Applying data analytics to renewable energy technologies is one of the most valuable yet underutilized methods of addressing China's growing energy constraints. According to a 2013 Ernst & Young study, companies that make use of data analytics continue to outperform their competitors.[52] This is because Big Data analytics can provide companies with improved visibility of trends impacting their businesses—operational performance, market developments, and competitor behavior—to help optimize decisions. Nevertheless, few Chinese power generators use advanced analytics to optimize their energy portfolios during electricity production. The Zhangbei power plant in Hebei Province is a rare example of how one group of companies couples analytics with existing operational knowledge to boost the economic viability and integration of renewable energy sources.

**Zhangbei power plant.** Fully operational since December 2013 (with a total investment of RMB 10 billion), the Zhangbei power plant is the world's largest integrated renewable energy demonstration pilot, and China's first. With a planned capacity of 700 MW, 160 MW of capacity were in operation as of 2011, including 100 MW of wind generation, 40 MW of solar power, and 20 MW of battery storage.[53]

At the Zhangbei power plant, the State Grid Corporation of China in collaboration with IBM, Goldwind, Jinko Solar and other solution providers demonstrates how weather forecasting analytics and storage technology can help improve integration of renewable power sources. Specifically, weather forecasting analytics—the use of data to better predict how weather patterns impact power generation from individual wind and solar units—allows plant operators to allocate energy between storage systems and the grid based on power demand. The forecasting system's short-term accuracy (defined as within four hours) is 94%, far exceeding the State Grid requirement of 75%, which allows operators to optimize wind and solar resources without impacting grid stability. The system also increases renewable energy availability at Zhangbei by 10%—equivalent to RMB 18 million in annual electricity sales.[54]

The collaboration among State Grid and the partnering companies is one of the key success factors for the Zhangbei power plant. Taken together, the integrated solution offered by IBM, Jinko Solar and Goldwind in partnership with State Grid allows these companies to maximize the environmental and economic benefits of their offerings that could not have been delivered independently.

*51. International Energy Agency, (see The China Greentech Report 2013, page 46)*
*52. Big Data and Enterprise Mobility, Ernst and Young, 2013, www.ey.com*
*53. China Market Focus: North China Grid Co. (NCGC) $1.6 Billion Zhangbei Renewables Demonstration Project, US-China Market Review, Summer 2012*
*54. Integrated Wind and Solar Power Forecasting in China, IBM Research China, 2013*

**Holistic thinking, collaboration and information-sharing help accelerate biomass solution adoption and industry growth**

In response to growing public concern and international scrutiny on the public health implications of pollution, China is boosting investment in cleaner energy sources, including biomass. China's annual agricultural and forestry biomass fuel resources are equivalent to 460 million tons of standard coal (TCE)—if fully exploited, this could represent 12% of China's primary energy production capacity for 2015. To fully spur biomass adoption, however, government plans for development will not suffice; market education and demonstrated successes are necessary.

DP CleanTech, a biomass technology company originating in Europe, emphasizes end-to-end integration of operations and equipment; this approach has proved a fundamental success factor for National Bio Energy, its largest client in China, over the last 10 years. Through a holistic framework, DP CleanTech has been able to collaborate with customers to localize its international experience to optimize boiler designs, refine knowledge of fuel performance, and promote the economic benefits of high-performance solutions both in China and abroad.

DP CleanTech's approach to solution refinement and subsequent impact on the market exhibits the benefits of stakeholder education and collaboration across the value chain in accelerating biomass solution deployment. The company has collaborated with local universities to conduct sophisticated analyses on combustion performance for over 60 fuel types, which they make readily available to plant operators.

Additionally, the implementation of a value chain approach has empowered operators to make more informed decisions on the biomass fuel and equipment that best meet their needs, as well as fuel collection logistics and long-term operational maintenance training. This in turn improves the operational efficiency of their biomass plants and increases their profit margins. In leading by example and by sharing data with the very stakeholders who need to apply these solutions, DP CleanTech has helped build the case for high-performance boiler adoption and contributed to the development of the biomass market as a whole.

DP CleanTech's business model has positioned the company to play an influential role in shaping biomass development both in China and globally. Beginning in 2014, the company will participate in a national review of underperforming biomass power plants to help promote best practices for operational efficiency. By demonstrating its expertise and willingness to share valuable information with the market, DP CleanTech is prepared to capitalize on this high-growth opportunity. The firm will continue to use the experience gained in China to refine and develop solutions that cater to global needs as it expands into South East Asia, Australia, Asia, Latin America and Africa.

## Conclusion

As momentum builds around the importance of cleaner growth, China has the opportunity to carve out a new standard for development, leaving the old one, which has resulted in soaring global emissions and resource scarcity, behind. The factors and players needed to drive this transformation are in place—public awareness is at its height, city officials feel pressure to build cleaner urban centers, and more readily available user-friendly tools are allowing wide-scale participation in resource conservation across industries and value chains like never before. However, this is not enough to ensure sustainable growth. Instead, businesses and governments must adopt an entirely new mindset—an integrated greener, smarter and more productive approach.

A growing number of companies have already recognized the need for cross-sector collaboration to effectively contribute to China's greener, smarter and more productive development and are profiting in the process. As the cases above show, there are opportunities for companies to employ proven technologies, collaborative business models, and cost-effective solutions to accelerate pollution reduction from power generation. In one case, technologies demonstrate the economic viability of renewable energy. In another, cost-competitive retrofits are married with government goals to reduce emissions from existing power plants. And in the third case, open collaboration and information-sharing drive adoption of biomass solutions. Once more companies offer solutions that adopt this integrated approach, China will experience the benefits on a much larger scale, and be well positioned to make a real shift towards a greener, smarter and more productive economy.

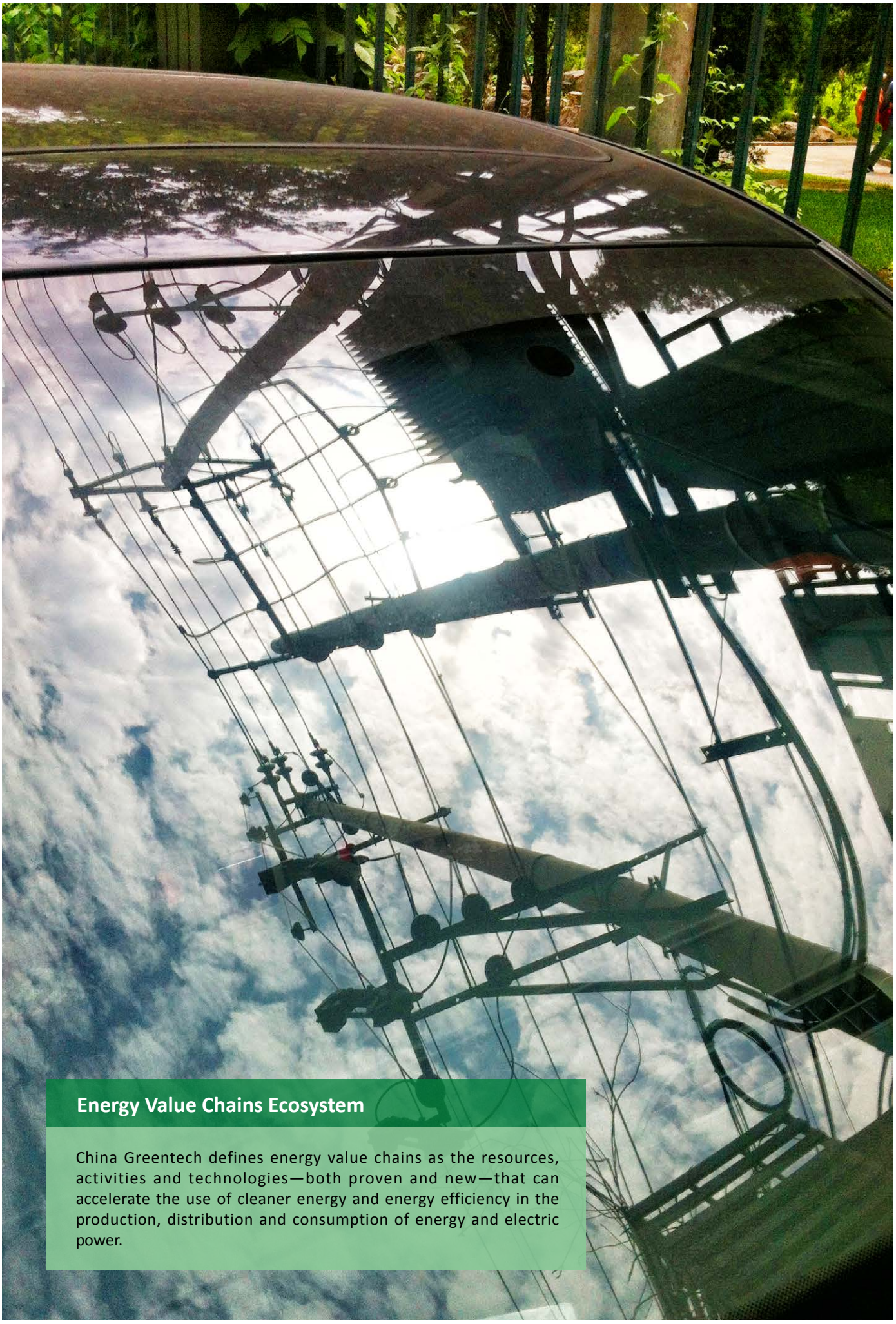
However, these efforts will reach their full potential only if closely aligned with government ambitions. Rather than operating in silos, the private and public sectors must collaborate on project efforts to make full and efficient use of the resources that each can provide. For example, the private sector can provide innovative solutions and advisory services while governments help ensure access to infrastructure and institutional support for greentech project implementation, and draft policies that accelerate greentech solution adoption. Promising signs of privatization in the energy and infrastructure sectors, historically dominated by state-owned companies, suggest that China is already making progress towards more cohesive public-private collaboration on sustainable development initiatives.

But collaboration on stand-alone projects is not enough. At this critical juncture in China's development, stakeholders must consider how to make all aspects of development more sustainable—from emissions reductions in manufacturing to the use of advanced analytics to improve efficiency throughout a building's lifecycle, broader adoption of multimodal intelligent transportation options, and improved productivity in the workplace—to build and maintain a thriving and resilient economy. Above all, China has the opportunity to show the world how to integrate these cross-sector efforts—and enjoy the prosperity that results.

## Looking ahead

The next section of the Report will highlight eight Opportunity Assessments, which China Greentech developed over the course of 2013, analyzing market trends and providing insights on topics within four ecosystems: 1) Energy Value Chains; 2) Built Environment; 3) Sustainable Industry; and 4) Cleaner Vehicles.

These chapters highlight the technologies and business models that can be promoted across sectors to help China achieve its sustainability goals. While our findings do not reflect China's greentech development in its entirety, they do shed light on sectors that the China Greentech community has considered most relevant for China's efforts in promoting resource efficiency and pollution reduction in 2014 and beyond.



## Energy Value Chains Ecosystem

China Greentech defines energy value chains as the resources, activities and technologies—both proven and new—that can accelerate the use of cleaner energy and energy efficiency in the production, distribution and consumption of energy and electric power.

*Courtesy of Mike Hawkins*


## A Global Analysis of Energy and Water Conservation: The China Perspective

Together, global population growth and rising living standards make current and projected levels of energy and water consumption per capita unsustainable. In China, total net electricity generation is projected to approximately triple by 2040 and freshwater resources are some of the scarcest in the world. Although technologies and best practices exist to reduce consumption, market and nonmarket barriers limit their large-scale adoption. Some barriers are as simple as lack of information. Others are more complicated, relating to distorted financial incentives and established customs or perceptions.

RTI International provides independent, interdisciplinary research to help develop, implement, and evaluate energy and water conservation policies. Our engineers, economists, and policy analysts deliver robust, objective analyses of the technical and economic potential of initiatives to improve energy and water efficiency. For more than 20 years, we have conducted research to support decision making in every phase of program design and implementation, ensuring the success of demand-side management (DSM) strategies worldwide. For example, RTI helped establish a sustainable integrated water management system in Hebei Province through workshops with the Chinese Ministry of Water Resources and the State Environmental Protection Administration.

RTI is excited to use its more than 20 years of experience investigating and modeling energy and water consumption to help accelerate greener, smarter, and more productive development across China's residential, commercial, and industrial sectors. Our engineers are developing advanced energy technologies to save resources and reduce pollution; our economists are utilizing their expertise to assess the economic viability of efficiency options; our behavioral scientists are implementing cutting-edge survey and intervention techniques to assess and stimulate behavior change. An integrated, comprehensive approach is essential to identifying and implementing the most effective and efficient solutions in China and globally.


Courtesy of Wikipedia user Wing1990hk

# CAPITALIZING ON CHINA'S POTENTIAL DISTRIBUTED ENERGY BOOM

This opportunity assessment provides a summary of China Greentech's strategic research on distributed energy and identifies key factors that will drive development between now and 2020.

**Definition and Scope—Distributed Energy**

Distributed energy (DE) refers to energy generated onsite or near energy end-users—typically on a small-scale—that can be connected to the grid or off-grid (stand alone). DE power generation includes rooftop solar photovoltaics (PV) and building integrated PV (BIPV); gas-fired combined cooling, heating, and power (CCHP); small-scale hydropower; waste-to-energy; small wind turbines; small-scale biomass; and any hybrid of these solutions.

## Overview

Distributed energy (DE) is increasingly recognized for its potential to contribute to China's sustainable growth objectives. DE can help boost the proportion of cleaner energy in China's national energy mix, improve overall energy efficiency, and create a more flexible electricity grid. While still in the nascent stages of development, distributed solar systems are rapidly becoming commercially viable for industrial and commercial end-users, and natural gas systems are likely to see accelerated growth in the next three to five years. By the end of 2013, China had an installed distributed energy capacity of over 8 GW, of which solar accounted for 3.1 GW. As a result of improved grid connectivity, China experienced a marked increase in distributed energy solar projects equivalent to 801 MW in 2013.

In 2013, China Greentech conducted a detailed opportunity assessment analyzing the situation and trends for distributed energy in collaboration with our Partners, government organizations, and other stakeholders. China Greentech's Partner companies prioritized rooftop solar PV and natural gas-fired combining cooling, heat and power (CCHP) due to their strong growth prospects by 2015, and identified industrial parks as the ideal testing ground for integrating these solutions.

## Opportunity Assessment

**New policies indicate a tipping point for distributed energy in China**

***The Chinese government is showing increasing support for distributed energy development by providing energy production subsidies and backing utility-provided procedures to streamline grid connectivity.***

Distributed energy development in China is gaining momentum. Increasingly recognized as a means of diversifying China's coal-dominated electricity mix and stimulating demand for an oversupply of solar PV modules, distributed energy installed capacity increased to 8.1 GW by 2013.[1] Growing support for distributed energy systems by government, grid companies, developers and end-users promises to accelerate adoption of DE through 2015.

Beginning in November of 2012, State Grid began providing free grid connection services for distributed solar systems under 6 megawatts (MW) in installed capacity

From 2012 to 2014, State Grid Corporation of China (SGCC), China's largest grid operator and power distributor, issued several policies to support distributed energy development. Beginning in November of 2012, State Grid began providing free grid connection services for distributed solar systems under 6 megawatts (MW) in installed capacity.[2] The company also agreed to provide the following services: 1) connection of distributed solar PV projects to the grid within 45 working days (excluding construction), 2) electricity to customers in the event that DE alone does not meet user needs, 3) free measuring tools and backup capacity for solar and wind,[3] 4) the option to sell excess energy back to the grid at the local thermal power price. The significance of State Grid's announcements should not be underestimated. In an otherwise monopolized power transmission system, these policies represent a step forward for the sector, expanding development prospects for distributed energy.

**Distributed solar shows signs of promise, while gas-fired CCHP develops at a slower pace**

***Distributed solar development has benefitted from subsidies and falling module prices, but the industry still relies on government support to remain competitive. Although gas-fired CCHP is making progress under State Grid's new policies, grid connection difficulties, complex project development processes, and an expected increase in gas prices will likely constrain its competitiveness.***

State Grid's policies and incentives, along with falling PV module prices, have helped accelerate China's domestic solar market while infrastructure barriers have restricted gas growth. Distributed solar, including rooftop solar PV, is experiencing growth in project development, especially from solar manufacturers eager to expand their business portfolios and capture downstream project development opportunities. While little information on solar PV connections was publicly available before the new policies were announced in October 2012, by February 2013 State Grid had received 119 project applications, representing a total of 338 MW in power capacity.

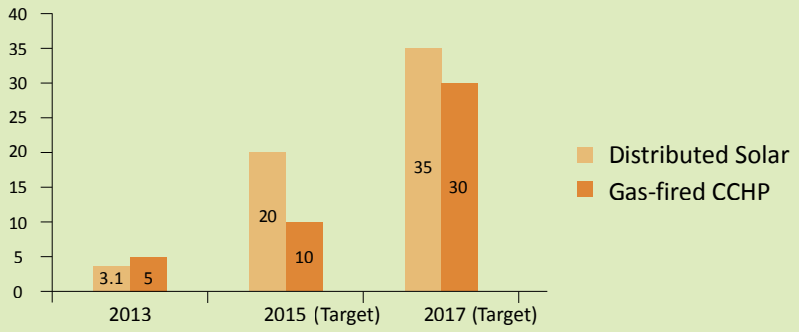
*1. "2013 年光伏发电统计数据 , "[2013 Solar PV Statistics], National Energy Administration (NEA), April 28, 2014, www.nea.gov; " 天然气分布式发电 扫除障碍 走向成熟 ", [Overcoming Obstacles in Distributed Gas Power Development], www.qianzhan.com, December 16, 2013*
*2. " 国网澄清 :6MW 以下光伏电站将免收接入费而非 10MW", [Free Grid Connection for Solar Power Stations Under 6MW], www.guangfu.bjx.com.cn, October 25, 2013*
*3. " 公司发布分布式光伏发电并网服务工作意见 ", [State Grid Announces Opinions on Grid Connection Services for Solar Power], www.sgcc.com, October 29, 2012*

Falling module prices is helping to spur overall adoption and reduce PV panel overcapacity, which led the central government to increase its 2015 solar capacity targets from 21 to 35 GW, with nearly 20 GW from distributed solar (Figure 1).[4] Since distributed solar is not yet competitive with electricity prices without subsidies in most cases, government policy will remain important for the development of these markets.

Distributed gas projects are progressing more slowly. Currently, there are just over 40 natural gas DE demonstration projects in operation across China (Figure 1), well behind the central government's target of 1,000.[5] While State Grid's new policies have partially eased grid connection procedures, the project development process is by nature complex and has numerous challenges. Attractive gas prices and stable supply are arguably the most important prerequisites to make CCHP commercially viable. However, they depend on the growth of gas imports and domestic unconventional gas development (such as shale) by state-owned enterprises. At the same time, Chinese developers still lack experience in gas-fired CCHP projects; they are most concerned with retail gas price trends and utilization of waste heat as they significantly impact project profitability. As a result of expected gas price increases and grid connection difficulties, CCHP has not been popular.



**Figure 1: 2013 Installed Capacity and 2015–2020 Targets for Distributed Power (GW)**




*Sources:* "关于发展天然气分布式能源的指导意见" [Opinion on Gas-fired Distributed Energy Development], October, 2011, http://www.ndrc.gov.cn; "2014 年分布式光伏发展趋势分析预测" [2014 Analysis and Estimate for Solar PV Development Trends], ChinaIRN, October 24, 2013, www.chinairn.com; "关于印发能源行业加强大气污染防治工作方案的通知" [Announcement on strengthening pollution control in the energy industry], National Development and Reform Commission, March 24, 2014, www.sdpc.gov.cn

*4. "能源局将推新能源并网新政" [The National Energy Administration to Release New Grid Connection Policy], February 4, 2013, Fujian Development and Reform Commission, www.fjdpc.gov.cn*
*5. "天然气分布式发电 扫除障碍 走向成熟", [Overcoming Obstacles in Distributed Gas Power Development], www.qianzhan.com, December 16, 2013*

**Industrial parks show potential for integrating distributed energy and information and communications technology solutions**

***Integrating hybrid DE solutions and information and communications technology (ICT) offers higher energy efficiency than standalone rooftop PV or gas-fired CCHP systems. Industrial parks are an ideal testing ground for implementing these solutions.***

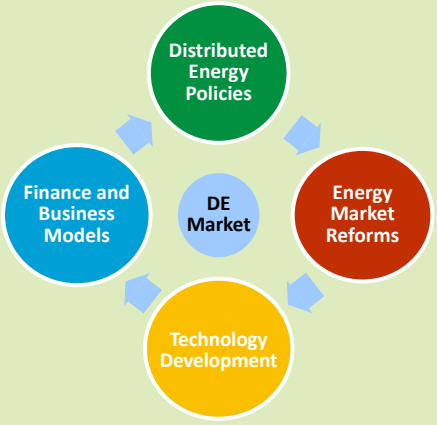
While gas-fired CCHP projects remain for the time being at the demonstration phase (with project growth to accelerate more quickly in coming years), hybrid DE solutions of gas and solar are a natural fit for industrial parks. Hybrid DE in industrial parks couples distributed energy and information and communications technology (ICT) to achieve optimized energy usage. Energy demand can be forecasted fairly accurately within parks, and different cooling, heating, and power needs can be applied to various industrial users. This model increases the likelihood of fully utilizing all the benefits of hybrid DE systems, particularly in cases that some opportunities are not feasible. For example, a natural gas power plant may not have enough rooftop area for a commercially viable solar system, but a manufacturing facility may, and together the two parties may coordinate solar with CCHP systems to increase their combined energy efficiency and share cost-savings through a win-win business partnership.

**Key factors shape the 2020 outlook for distributed energy**

***Distributed energy development between now and 2020 will depend largely on future policies, energy pricing reforms, and the adoption of innovative financial and business models. The development of new DE technology and the implementation of existing technologies such as smart grid will also be important in determining whether China will achieve its 2020 DE targets.***

The central government has set 2017 DE targets of 30 GW and 35 GW for distributed gas and solar capacity, respectively. Government subsidies and State Grid's plan to connect solar projects to the grid more quickly can help accelerate the DE market, but these policies alone are not enough to ensure that targets will be met. The extent to which China achieves the central government's goals depends on a variety of factors. These four major dimensions include distributed energy policies, energy market reforms, technology development, and finance and business models (Figure 2).

**Figure 2: Four Major Dimensions Determining Distributed Energy Development Prospects**




**Distributed Energy Policies**

- Formulation of DE policies, including level of policy support, policy consistency and transparency
- Implementation of DE regulations, standards and incentives

**Energy Market Reforms**

- Degree to which energy pricing is reformed to reflect true costs and become market responsive
- Level of grid support and participation from diverse industry players

**Technology Development**

- Pace of DE technology development driving down costs
- Deployment of smart grid, energy storage and other technologies to support DE system integration

**Finance and Business Models**

- Access to financing and diverse funding sources
- Types of business models that can help meet end-users needs and promote DE system adoption



Depending on how these four dimensions develop during the coming years, a few different growth scenarios are possible. If State Grid successfully implements new grid connection procedures, retail electricity prices are allowed to rise, technology improves, and new business models can finance upfront investment costs, then DE may enjoy a cycle of greater adoption and additional cost reductions. On the other hand, if policy reforms and investments do not materialize, the pace and extent of growth will be unpredictable, with differing implications for the overall power sector.

## Conclusion

Distributed energy development is essential to propel China toward a cleaner and more flexible energy future

Distributed energy development is essential to propel China toward a cleaner and more flexible energy future. There are a growing number of opportunities for both domestic and international players to participate in China's distributed energy boom, whether it is through investment in natural gas or solar PV. Improved connection to the grid serves as an opportunity to fully utilize China's solar capacity, small wind developments and a growing number of gas-fired CCHP projects. China Greentech will continue to track developments in this area and share updates on evolving DE opportunities and partnership models that can help companies best realize their business goals as they relate to China's distributed energy growth trends and priorities.


Courtesy of Julian Schwabe

# ACHIEVING ENERGY SAVINGS THROUGH DEMAND-SIDE MANAGEMENT

***"As China's economy has developed, the electric power sector has not kept up with the pace of development. DSM can help alleviate China's challenges of strained power supply." —Solution provider***

**Demand-Side Management—Definition and Scope**

Demand-side management (DSM) describes grid-company and end-user efforts to reduce electricity peak load and overall power consumption. DSM encompasses a range of stakeholders, including government, utilities, end-users, energy service companies (ESCOs) and solution providers. To maximize benefits, DSM measures are customized to the electricity requirements and consumption patterns of the end-user, through various combinations of technologies and incentives.

## Overview

This opportunity assessment summarizes China Greentech's strategic research on the development of demand-side management (DSM) in China. Its key insights include the following:

**China's power supply shortages are driving stronger government focus on DSM.** Growing energy demand has outpaced energy production in the past decade, leading the government to prioritize end-user energy efficiency. Demand-side management can help close the supply-demand gap and offer a host of other benefits. Electricity savings and peak load reduction improve grid stability and reduce spending; less power consumption alleviates air pollution.

**Potential gains exceed China's targets.** National targets and a pilot city program launched in 2011 and 2012 show the government's commitment to capture savings through investments aimed at reducing power demand. However, while mandatory reductions could save nearly 50 billion kilowatt-hours (kWh) between 2013 and 2015, recent DSM projects and related studies indicate a much higher savings potential of 1 trillion kWh by 2020—exceeding China's targets by a factor of 20.

**NDRC-endorsed pilot cities will set the tone for future DSM development.** Suzhou, Beijing, Foshan and Tangshan were announced as DSM pilot cities in 2012. Among these four pilot cities, Suzhou has taken an early lead with ambitious targets and a DSM technology platform, while other cities have not yet shown tangible progress in developing DSM.



**For success in the pilots and beyond, challenges must be addressed.** Low financial incentives, limited information on power consumption patterns, and cumbersome access to funding constrain further development of DSM projects. Large-scale success will require more effective strategies and incentives, innovative financing models and greater awareness of the many benefits of DSM. State Grid's push to update grid technologies can also boost DSM development.

## Opportunity Assessment

**Manage demand or suffer power shortages**

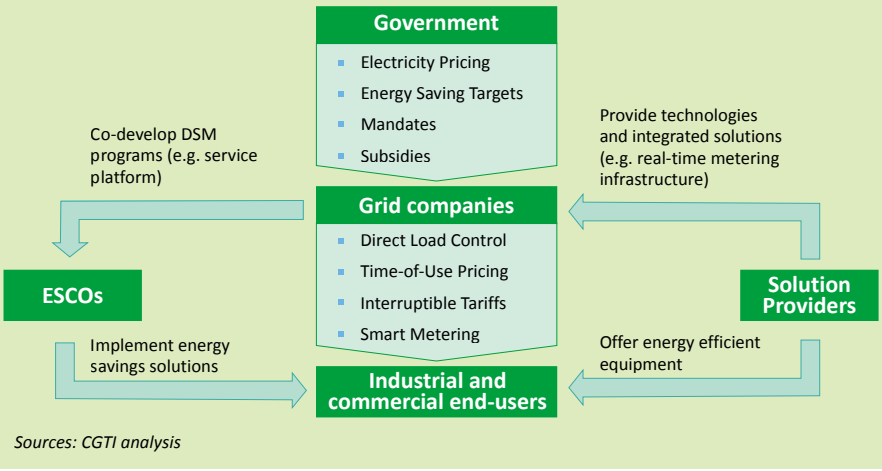
***California successfully capped the growth of electricity consumption through a range of efforts including DSM, suggesting significant potential benefits from DSM in China.***

The United States has doubled its per capita power consumption since the 1980s, yet in California consumption has held steady—saving billions of kilowatt-hours (kWh) over the decades. An important reason is that the California government capped power demand by decoupling utility income from electricity sales and providing reward payments for achieved energy savings to utilities and end-users.[6] This scheme creates a business case for DSM, and its success indicates that DSM in China could achieve vast energy savings.

The term 'demand-side management' refers to efforts to lower overall power consumption and to adjust electricity prices and usage in response to peaks in demand. Stakeholders for DSM include end-users, governments, utilities, energy service companies (ESCOs) and solution providers (Figure 3).

*6. "California's Energy Efficiency Success Story," NRDC, July 2013, www.nrdc.org*

**Figure 3: DSM Stakeholders and Roles**




*Sources: CGTI analysis*

The Chinese government has begun promoting DSM to alleviate power shortages and achieve numerous economic and social benefits. With continued economic growth and increasing power demand, peak power shortages increased from 8 to 40 GW between 2009 and 2012,[7] causing blackouts and economic losses. Saving electricity through DSM helps stabilize the power supply and bring benefits for government, grid companies and end-users alike:

**Fewer blackouts.** Power shortages during peak demand cause blackouts with high costs for end-users such as industrial firms, public buildings and offices. Reducing peak loads and overall energy usage helps to prevent these problems.

**Cost savings.** The cost savings to end-users such as industrial plants and offices can be significant. For example, by reducing power use by just 5%, a medium sized office building consuming 10 million kilowatt-hours of electricity per year could save about RMB 650,000 in annual energy costs (at peak tariffs of RMB 1.3/kWh, assuming that all savings fall under peak time). Energy-intensive industrial plants would achieve greater savings.

**ESCO opportunities and technology growth.** ESCOs implement DSM measures and guarantee savings in end-users' factories and buildings. With a national push for DSM, demand for ESCOs will grow—good news for policymakers who want to promote high-level technology and services in China's economy.

**Less pollution.** Consuming less electricity means burning less coal. Cuts in emissions like particulate matter, sulfur and nitrogen oxide contribute to China's goal of improving air quality.

### DSM policy sets ultra-conservative targets

***Between 2007-2009, isolated DSM projects in China saved nearly 100 billion kWh of electricity. The new national DSM policy aims to cut consumption by only half that amount from 2013-2015.***

*7. Bo Shen et al. "What China can learn from international experiences in developing a demand response program," Lawrence Berkeley National Laboratory, June 2012, www.eetd.lbl.gov*

In the past, China dealt with electricity supply crunches by forcing power cuts in selected regions, but recently the government is trying more market-based incentives. These include California-like subsidies, higher prices at peak times ('time-of-use pricing') and discounted 'interruptible tariffs' for users who agree to accommodate power interruptions.[8]

China's growing interest in DSM led to two recent milestones. In 2011, NDRC laid out the first national-level policy on the issue, the "Demand-Side Management Implementation Measures,"[9] mandating grid companies to reduce peak load and power use by 0.3% annually. Moreover, in 2012, the NDRC announced four pilot cities for DSM development. Projects in Suzhou,Beijing, Foshan and Tangshan will set the tone for DSM promotion until 2015.



Although these are steps in the right direction, the new targets have been set extremely conservatively. Between 2007 and 2009, stand-alone DSM projects in Beijing, Shanghai, Jiangsu, Guangdong and other regions saved nearly 100 billion kWh of electricity. That is the rough equivalent of Sha'anxi's entire electricity consumption in 2011. Peak load was reduced by 16 GW nationwide, 54 million tons of coal saved, and 135 million tons of $CO_2$ emissions avoided.[10]

With effective incentives, China can potentially achieve power savings up to about 1 trillion kWh by 2020

By comparison, the mandate of 0.3% less annual power use and peak load would save China 48.4 billion kWh of electricity and reduce peak load by 11.2 GW between 2013 and 2015—much less than the cuts already achieved from 2007 onwards.[11] With effective incentives, China can build upon its initial DSM experience and potentially achieve power savings up to about 1 trillion kWh by 2020, according to a study by the China Sustainable Energy Program.[12]

**Suzhou leads NDRC's four DSM pilot cities**

***Suzhou has already connected 1,500 enterprises to a central DSM monitoring platform, while Beijing is still developing its DSM strategy and progress in Foshan and Tangshan appears limited.***

Wide-scale adoption of DSM in China will depend in great part upon the success of NDRC's four pilot cities: Suzhou, Beijing, Foshan and Tangshan. With the most ambitious energy saving targets and largest number of ongoing projects, Suzhou is the clear leader (Figure 4). Early DSM projects in Suzhou have reduced energy consumption at end-user premises by 5-16%. By 2013, the long-term load reduction through DSM reached an estimated 150 MW.[13] The city aims to achieve 80% of its energy savings through 'efficiency power plants'[14] and point-of-demand reductions. Before 2015, Suzhou also plans to integrate 3,000 industrial end-users into a DSM service platform, the centerpiece of its strategy.

*8. 'Time–of-use pricing' refers to electricity price differences by time of the day. With higher prices during peak hours, users are encouraged to shift operations to non-peak times. 'Interruptible tariffs' refers to the agreement of end-users to reduce power use during critical peak periods. The end-user is compensated by the utility for suspending operations.*

*9. Bo Shen et al. "What China can learn from international experiences in developing a demand response program," Lawrence Berkeley National Laboratory, June 2012, www.eetd.lbl.gov*

*10. "我国实施电力需求侧管理三年节电 1000 亿度" [China has saved 100 billion KWh through DSM during last three years], State Grid, December 21, 2010, www.sgcc.com.cn*

*11. China Greentech calculation based on 12th FYP targets for electricity industry*

*12. "Demand-Side Management in China-Commitment to a Little Bit Could Go a Long Way," Johnson Controls, April 2011, www.institutebe.com*

*13. "苏州市 2013 年电力需求侧管理城市综合试点工作有序开展" [Suzhou 2013, Demand-Side Management Pilot Program is Launched], National Development and Reform Commission, February 18, 2014, www.sdpc.gov*

*14. 'Efficiency Power Plant' refers to a central platform which remotely manages electric appliances of multiple end-users with the goal of reducing power consumption. The amount of achieved power savings can be equivalent to one power plant.*

The platform uses IT solutions for real-time monitoring of electricity usage. Co-established by local grid companies and ESCOs, the system has been collecting data from 400 enterprises in 2013. Approved ESCOs help users install monitoring systems and provide analysis and energy saving solutions based on usage information from the DSM platform. End-users, ESCOs and grid companies are all incentivized for investments in energy saving and load reduction measures: End-users and ESCOs receive up to RMB 0.5 per kW of load reduction, and the DSM service platform receives a one-time payment between RMB 10,000 and RMB 30,000 for connecting an end-user. Though Suzhou shows the greatest momentum thus far, Beijing is also showing progress. Beijing is developing a DSM strategy focused on commercial office buildings, with its first projects launched in October 2013.[15] Like Beijing, DSM programs in Tangshan and Foshan are in their initial stages, with a number of pilot projects kicked off in 2013.



## Figure 4: Overview of DSM Strategies and Plans in Pilot Cities

| | Suzhou | Beijing | Foshan | Tangshan |
|---|---|---|---|---|
| **2013-2015 Load Reduction Target (MW)** | 1,000 | 800 | 450 | 400 |
| **Permanent<br>Temporary** | 800<br>200 | 650<br>150 | 360<br>90 | Not Available |
| **Total Budget (million RMB)** | ▪ Central: 300<br>▪ City: 300 | ▪ Central: 300<br>▪ City: 100 | ▪ Central: 180<br>▪ City: 270 | Not Available |
| **Electricity Pricing Schemes** | ▪ Interruptible Tariffs<br>▪ Real Time Pricing | ▪ Peak Load Pricing | ▪ Cooling Storage Pricing | Not Available |
| **Targeted End-Users** | ▪ Industries<br>▪ Municipal facilities | ▪ Commercial buildings<br>▪ Municipal facilities | ▪ Industries<br>▪ Municipal facilities | ▪ Industries |
| **1st Round of Projects** | ▪ 400 enterprises connected to DSM-service platform | ▪ 129 projects including 49 enterprises | ▪ 80 efficiency power plant-projects<br>▪ 30 peak shaving projects | ▪ 28 projects |

*Sources: "市政府关于印发苏州市电力需求侧管理城市综合试点实施方案的通知" [Notice on Suzhou DSM Pilot Program Working Plan] March 27, 2013, "关于开展北京市电力需求侧管理城市综合试点工作的通知" [Notice on Beijing DSM Pilot Program Working Plan], July 17, 2013, http://www.bjpc.gov.cn, "佛山入选国家首批电力需求侧管理城市综合试点" [Foshan selected among the first batch of DSM pilot cities], FS Online, May 11, 2013, http://www.fsonline.com.cn, "电力需求侧管理城市综合试点工作简报" [DSM Pilot Program Briefing] Energy Research Institute, July, 2013*

*15. "北京市电力需求侧管理城市综合试点工作启动会" [Kick off meeting for Beijing's Demand-Side Management Pilot Program], Beijing DRC, November 28, 2013, www.bjpc.gov.cn*

**Looking ahead: Challenges and success factors**

***A clear development strategy, effective financial incentives, innovative financing models and improved awareness of benefits are all important to DSM development.***

To curb electricity demand in the pilot cities and beyond, China must overcome the three main challenges to DSM adoption: the business case, funding and infrastructure. Investment returns remain uncertain; with electricity prices inflexible and artificially low, end-users are not typically incentivized to monitor their power consumption and there is no standardized baseline to estimate savings. Consequently, grid companies and end-users lack incentive to invest in DSM beyond the state-mandated minimum and traditional banks are reluctant to provide loans. Furthermore, grid infrastructure does not support real-time communication of electricity load between end-users and utilities, preventing the implementation of advanced DSM measures, such as adjusting operations based on real-time dynamics in power demand and supply. Suzhou's decision to introduce an IT-based platform for DSM is an important breakthrough in this regard.



China Greentech's research identified four success factors for accelerating DSM in China:

- **Holistic strategy.** Suzhou offers an example of a city-wide DSM initiative that includes connecting end-users to its central DSM platform. This strategy enables energy use modeling, sophisticated pricing and real-time load management on a large scale, providing a model other cities may replicate.

- **Effective incentives.** The case of California shows the effectiveness of financial incentives for utilities, ESCOs and end-users. These can include flexible electricity pricing, decoupling utility income from electricity sales, and reward payments for energy savings and peak load reduction.

- **Innovative financing models.** End-users are most willing to join DSM programs if their financial risk is minimized. ESCOs can undertake part of that risk and guarantee end-user cost savings; in turn, ESCOs need funding to implement DSM programs. Besides subsidies, dedicated banks for DSM projects or state bonds could be innovative ways to fund DSM.

- **Information and awareness.** Fiscal incentives can be combined with improved end-user awareness of DSM benefits. Transparent and timely information from local governments on DSM-related policies and incentives allows stakeholders to make informed investment decisions.[16]

Furthermore, DSM can be implemented most effectively if real-time metering and flexible pricing mechanisms are in place. State Grid is dedicating RMB 57 billion to expand communications infrastructure between 2011 and 2020, which may lay the foundation for sophisticated DSM schemes on a larger scale.

*16. China Greentech interviews*

## Conclusion

DSM will play an increasingly important role in China's efforts to curb energy consumption and improve grid reliability. NDRC's annual 0.3% power consumption reduction target could be easily achieved if the government follows through on its plans, and potentially by as much as a factor of 20. By offering electricity savings, peak load reduction, less power consumption, and improved grid stability, DSM's potential to help China manage its energy and environmental needs is vast.

DSM growth will expand opportunities for collaboration among end-users, utilities, ESCOs and solution providers. Initial success using time-of-use pricing and interruptible tariffs show that even with basic methods, DSM can significantly contribute to power savings. For more advanced applications with real-time metering infrastructure in place, end-user operations can be adjusted based on imbalances between power demand and supply. However, infrastructure is only one part of the equation: international case examples show that DSM is best scaled when the right economic incentives and sufficient funding are in place and if end-users are aware of the benefits from investing in DSM. Suzhou's pilot central DSM platform provides an attractive model for potential replication.

## Definition—Built Environment Ecosystem and Green Buildings

The Built Environment Ecosystem refers to all stakeholders engaged in the broad green building markets and related industries—including developers, designers, building material suppliers, HVAC providers, lighting system solution providers, information technology companies, maintenance and operations companies, financial institutions and others.

We define green building as planning, building and operating solutions that are more efficient, healthy and sustainable than conventional solutions for an equivalent level of comfort and service throughout all stages of a building's life cycle.

*Courtesy of Caitlin Rhodes*


## Parkview Green: A Beacon for a Greener China

Recent pollution events in Beijing have generated a wave of discussion as citizens become painfully aware of the impact of air pollution on health and everyday life. Severe environmental conditions are also compelling corporations to reduce the environmental impact of their operations. The opportunity is particularly large in the building sector, which accounts for as much as 20% of China's energy consumption.

Contrary to popular belief, resource efficiency in buildings goes far beyond the use of greener building materials or energy efficient light bulbs. More important, yet too frequently overlooked, is the critical role of property developers and managers in ensuring that a building is operated at its optimal performance throughout its lifecycle.

Parkview Green, one of Beijing's newest landmarks, is setting a new standard for green building development. China's only LEED Platinum-certified building and the first mixed-use commercial project in the nation, Parkview Green demonstrates the importance of incorporating environmental elements into the earliest stages of building design.

Parkview Green's environmental envelope is one of its most unique features of the building. Made of a lightweight material with high corrosion resistance, the translucent envelope allows natural light to penetrate the structure and creates a microclimate that serves as a buffer between office space and the external environment. This envelope, combined with the glass curtain walls of individual office buildings, reduces lighting and heating requirements, allowing office tenants to enjoy lower electricity bills in comparison to other buildings.

All environmental elements considered, the Parkview Group values customer experience just as much as environmental design. Combining retail, office space and a boutique hotel, tenants and visitors have access to many of their everyday needs all under a single roof, reducing the need for long-distance travel and saving resources. If replicated, these mixed-use principles could transform city planning. Reduced traffic congestion, curbed vehicle emissions and improved quality of life are just a few of the benefits.

Our vision is for Parkview Green to become a model for China's building industry. We will continue to adopt energy efficient technologies and practices as we refine our approach to sustainable building design, and look forward to collaborating with new partners for greater impact and reach.


Courtesy of Julian Schwabe

# GREEN BUILDING SOLUTIONS BY CLIMATE ZONE

There is a unique opportunity to capture energy savings across China by adopting climate-specific solutions for buildings, which account for about 20% of China's energy consumption. Designing buildings based on climate conditions and replicating proven solutions is essential to achieving energy savings.

### Definition and Scope—Green Building Solution by Climate Zone

Green building solutions by climate zone refers to energy-saving building solutions including the building envelope and HVAC, as well as related policies and incentives that are customized based on surrounding climate conditions. This Opportunity Assessment focuses on building solutions for the "Cold" and "Hot Summer, Cold Winter" climate zones as defined in the "1993 Standard of Climatic Regionalization for Architecture."

## Overview

**Climate matters:** Buildings should be designed based on local climate conditions to maximize energy and other resource savings. The building sector accounts for about 20% of China's energy consumption—and with its rapidly expanding building floor area, presents a huge opportunity to improve energy efficiency through the adoption and replication of solutions tailored to climate conditions.

**Regional solutions are essential:** Design choices and operational practices based on regional climate differences are essential to maximizing energy savings in buildings. China consists of five climate zones, each of which requires a different approach to building design. While reducing heat energy consumption is critical in northern China, improving air conditioning efficiency is one of the highest priorities in the south. Retrofit projects in Beijing and Shanghai demonstrate that building energy consumption can be reduced by up to 66% through adopting insulation and shading solutions for improved temperature conservation based on local climate conditions.

**Solutions can be replicated:** Proven energy efficient solutions can be replicated to increase savings nationwide. Envelope insulation or external shading for instance can be replicated across climate zones with only minor adaptations. Jiangsu, Zhejiang and Shandong show great potential for replication of green building solutions in new public and commercial buildings due to high construction rates.

**Challenges still need to be overcome:** Policy, design and operational challenges continue to impede green building solution adoption. There remains a need for policies that: 1) encourage incorporation of green building solutions from early design stage, 2) streamline subsidy allocation and 3) improve the capacity of building-operating personnel.

## Opportunity Assessment

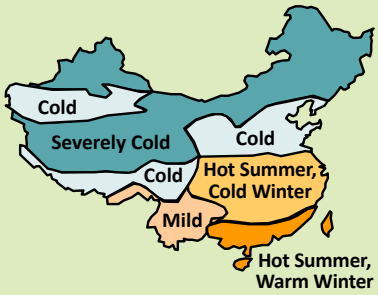
**Climate is a major factor in determining green building solutions**

***The building sector accounts for about 20% of China's energy consumption. Designing buildings based on climate conditions will lead to significant energy savings.***

Buildings should be designed based on local climate conditions to improve energy and resource savings. Local temperature, sunlight, rainfall and wind patterns are key factors that determine building solutions such as passive heating and cooling or HVAC systems. In all climate zones, buildings should be designed to provide comfortable indoor temperatures of 18-26°C, while minimizing energy consumption.

China has drafted several building related regulations based on climate zones. The "1993 National Standard of Climatic Regionalization for Architecture," for example, serves as a framework for provincial and municipal building codes (Figure 1). The Standard specifies five major climate zones and 20 sub-regions that are defined based on temperature, precipitation, sunlight and wind patterns. Regulations on energy conservation and temperature control, such as wall insulation or winter heating requirements, are based on these five climate zones.

## Figure 1: Major Climate Zones for Building Construction




- Five major climate zones in China
- The eastern "Cold" zone and the "Hot Summer, Cold Winter" zone combined account for 74% of building floor area in use or under construction in 2012

| | Average Temperature (°C) | | Precipitation (mm/year) | Annual Sunshine Hours | Sunshine Intensity (w/m²) |
|---|---|---|---|---|---|
| | January | July | | | |
| Severely Cold | <-10 | <25 | 200-800 | 2100-3100 | 140-200 |
| Cold | -10-0 | 18-28 | 300-1000 | 2000-2800 | 150-190 |
| Hot Summer, Cold Winter | 0-10 | 25-30 | 1000-1800 | 1000-2400 | 110-160 |
| Hot Summer, Warm Winter | >10 | 25-29 | 1500-2000 | 1500-2600 | 130-170 |
| Mild | 0-13 | 18-25 | 600-2000 | 1200-2600 | 140-200 |

*Sources: "建筑气候区划标准 (GB 50178-93)"[Building Standards by Climatic Region (GB 50178-93)], National Administration of Technology Supervision and Ministry of Construction, 1993*

With the building sector consuming about one-fifth of China's energy, building energy efficiency offers a tremendous opportunity for resource savings.[1] China's target to achieve 1 billion m² of certified green building floor area by 2015, up from about 70 million m² in 2012, will drive near-term investments in the green building sector.[2] The more these investments capture energy savings through climate-specific designs, the more impactful they will be.

China's target to achieve 1 billion m² of certified green building floor area by 2015 will drive near-term investments in the green building sector

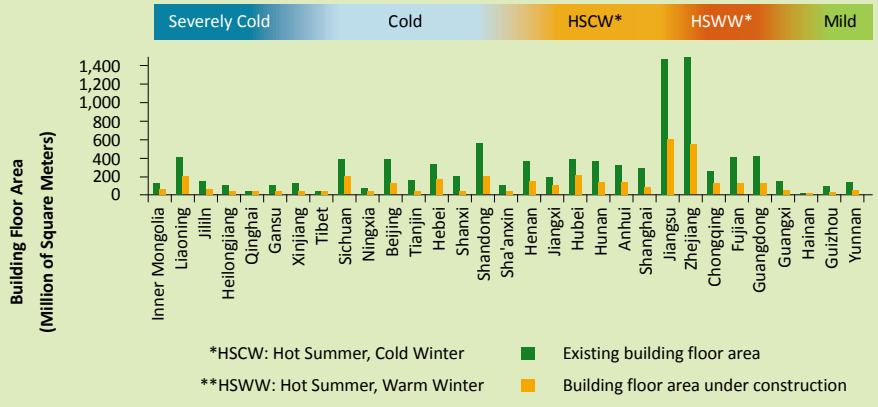
### Differences in northern and southern climate conditions call for regionally-specific solutions

***Reducing heat energy consumption is critical in northern China, while air conditioning efficiency can save considerable electricity in the south. Projects in Beijing and Shanghai demonstrate how energy savings can be achieved.***

1. *"Building Energy Efficiency Policies in China–Status Report," Global Buildings Performance Network, June 2012, www.gbpn.org*
2. *"我国绿色建筑标识项目统计分析" [China Green Building Programs Statistics and Analysis], May 21, 2014, www.chinagb.net*

Region-specific solutions are essential to achieving energy savings in buildings, with the largest potential savings to be achieved in areas with the highest density of construction projects. Provinces in China's eastern "Cold" zone (Hebei, Shanxi and Shandong) and "Hot Summer, Cold Winter" (HSCW) zone combined accounted for about 74% of all building floor area in use or under construction in 2012 (Figure 2). In these two zones, most energy in buildings is consumed for heating and cooling purposes. Both zones share equally hot summers, while the Cold zone experiences more extreme winter temperatures. In northern China, coal-fired central heating accounts for 40% of urban building energy use.[3] In Shanghai, located in China's HSCW zone, space cooling and heating contributes up to 40% to overall electricity load.[4]

**Figure 2: Building Floor Area by Province—Existing and Under Construction (2012)**




*Sources: CStatistical Yearbook 2013: "建筑业房屋建筑面积"[Building Floor Area], National Bureau of Statistics of China, 2013, www.stats.gov.cn*

**Cold zone solutions:** Reducing heat energy consumption is critical in cold climate zones. Energy use can be reduced through effective insulation using Expanded Polystyrene (EPS) or Extruded Polystyrene (XPS) boards (of at least 100mm in thickness) and internal walls and breakers to improve thermal performance.[5]

The 2007 Gesellschaft für Internationale Zusammenarbeit (GIZ)-managed apartment building retrofit in Beijing is one example of how energy savings can be achieved in the cold climate zone: Project developers installed 100mm of EPS wall insulation, aluminum inward opening windows, and 60mm XPS boards for roofing, resulting in improved heat conservation and a 34% reduction in building energy consumption.[6]

*3. Ksenia Chmutina, "Building Energy and its Regulations in China," University of Nottingham, October 2010, www.nottingham.ac.uk*
*4. Long Weiding, Bai Wei, "The Impact of Air-Conditioning on Shanghai's Energy Use 2010," Tongji University, 2006, www.efchina.org*
*5. Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) are two common types of external thermal insulation materials and are often manufactured as boards, which can be attached with a high degree of flexibility to walls and roofs; "Insulation: EPS and XPS," BUILDINGS, June 1, 2009*
*6. "演讲稿—北京惠新西街 12 号楼的节能改造"[Energy Retrofit of Beijing Huixin West Street No.12 Building], Beijing Un-construction Group*

**Hot Summer, Cold Winter zone solutions:** Energy use in China's HSCW zone can also be reduced through adoption of insulation solutions that are specific to local climate conditions. Between 1997 and 2008, electricity use from air conditioning units (used for both heating and cooling) increased by 70%. Poor building insulation and the lack of heating systems in China's south contributed to this sharp increase in power use.[7]

Architects emphasize that improved insulation, external shading and customized heating systems can reduce reliance on air conditioning units and minimize the amount of energy used to regulate indoor temperature.[8] EPS or XPS wall insulation of 60mm in thickness, combined with heating systems for zero-degree temperatures to reduce energy use during the winter, is one simple pairing of solutions that can be applied in all building types. During the summer months, outdoor shading systems provide cost-effective cooling. Window panels suit buildings of eight stories or less, while automatic systems are more appropriate for high-rise buildings. Due to a lack of readily-available automatic systems, outdoor shading is rarely used for high rises, posing an innovation opportunity for solution providers.[9]



The retrofit of the Zhangjiang ( 张江 ) Riverfront Harbor office building in Shanghai shows how energy reductions can be achieved in the HSCW zone through combining insulation and shading solutions. Installed XPS insulation, external sun-shading curtains and a double-layer low-emissivity (heat reflecting) glass curtain wall contributed to a 66% reduction in building electricity consumption, while the installation of a 40 KW solar PV system on site reduced the compound's reliance on external power sources.[10]

Insulation, external sun-shading curtains and a double-layer low-emissivity (heat reflecting) glass curtain wall contributed to a 66% reduction in building electricity consumption

**Scale matters: Solutions for energy efficiency should be replicated to increase savings nationwide**

***Jiangsu, Zhejiang and Shandong show the greatest potential for replicating energy-efficient solutions for new public and commercial buildings both within and across climate zones.***

Wherever possible, proven green building solutions should be promoted and applied across different geographic and climate locations. While each climate zone has specific needs for optimizing building performance, several sets of solutions can be replicated across climate zones with only minor adaptations. This holds true for the aforementioned projects in Beijing and Shanghai, where winter and summer temperatures are beyond human comfort levels and indoor temperature control is needed; for example, insulation and solar shading can be used across both climate zones with only minor adaptations to insulation thickness or with storm-proofing shading systems.

*7. "Building Energy Efficiency Policies in China: Status Report," American Council for an Energy-Efficient Economy, July 3, 2012, www.aceee.org*
*8. China Greentech interviews*
*9. China Greentech interviews*
*10. "张江集电港办公中心改造工程" [Zhangjiang Riverfront Harbor Office Building Retrofit Project], www.wenku.baidu.com*

Government advisors and solution providers estimate that more than 90% of green building solutions will be seen in new construction as opposed to retrofits. Jiangsu, Zhejiang and Shandong accounted for nearly 40% of China's new building floor area under construction in 2012, showing the largest opportunity for scaling up green building solutions.[11] Public and commercial buildings are likely to be the earliest adopters since they are developed and used by the same party. Thus, developers directly benefit from investments in energy savings.[12]

Broad Sustainable Building Co., Ltd. sets an example in replicating green building solutions across climate zones. Pre-fabricating standardized modules with flooring, piping, ventilation shafts, walls and windows translates into stunningly fast construction times on-site: In 2010, Broad constructed a 15-story hotel building in just 48 hours. The company uses solutions like external shading and 15cm glass curtains that allow for heat recovery rates of 70-90%. Broad has also completed construction of commercial and public buildings in Shandong, Shanghai and Hunan, with further projects under construction or in planning.



**Challenges: For green building solutions to be effective, policy, operation and design improvements are needed**

***Incorporation of green building solutions from the early design stage, streamlined subsidy allocation and training of personnel for building operations are necessary to realize the full benefits of energy-efficient solutions.***

Real estate developers across China consider green building subsidies a potential "game changer" for industry development;[13] if implemented effectively they could accelerate the overall green building market. Subsidies for green building solutions could incentivize developers (who act as key decision-makers) by potentially off-setting any additional investment costs associated with energy-efficient solutions. However, application processes and subsidy allocation remain unclear. Thus, despite the benefits offered, some developers would rather forego potential subsidies than undertake the time-consuming application process.

In addition to subsidy allocation, design and operational challenges also exist. To avoid costly retrofits and unnecessary operation and maintenance costs, green building solutions should be considered in the early design stage of new construction projects. This requires local architectural firms to adopt new solutions that have not traditionally been part of their portfolio.

Even if optimal solutions are installed, their impact will be severely limited if building operators fail to take advantage of their resource-saving potential. China lacks the trained personnel needed to install green building solutions and operate buildings in a resource-efficient manner. One example of this is simply closing entry and exit doors to prevent heat or air-conditioning from escaping. Stronger emphasis on green building design and operation in university and vocational trainings can also help overcome these challenges.

*11. Statistical Yearbook 2012: "建筑业房屋建筑面积" [Floor Area for the Building Sector], National Bureau of Statistics of China, 2012, www.stats.gov.cn*
*12. China Greentech interviews*
*13. China Greentech interviews*

## Conclusion

Heating and air conditioning remain the most energy intensive applications in buildings. Nevertheless, there is a unique opportunity to capture energy savings across regions by adopting climate-specific solutions to achieve optimal thermal performance. In cold regions, a stronger focus on external insulation is vital. Regions with mixed climates should combine shading and insulation with customized heating systems to maximize efficiency. Zhejiang, Jiangsu and Shandong provinces offer the greatest opportunities for implementing and replicating energy-efficient solutions for the construction of new buildings given the high density of construction projects.

Transparent allocation of subsidies is also needed to spur development in China's green building sector. Subsidies can encourage project developers to increase their investments in energy-efficient solutions, providing opportunities for equipment and material suppliers to participate in China's nascent but rapidly growing green building market.

Investment in energy-efficient solutions should be accompanied by improved building operation and maintenance practices to ensure that users and property owners maximize energy savings. As proven energy-efficient solutions are scaled up and replicated across climate zones, stakeholders across the Built Environment Ecosystem can realize the many benefits offered by integrated solutions.

# BUILT ENVIRONMENT

Courtesy of Parkview Green

## CAPTURING ENERGY EFFICIENCY OPPORTUNITIES IN NEW AND RETROFIT BUILDINGS

Both new and retrofit green building projects offer sizable opportunities for building developers, operators, owners and solution providers. Stakeholders that engage in these opportunities can be more competitive in China's emerging green building market and earn reputations as innovative market leaders.

### Definition and Scope—Energy Efficiency in Buildings

Energy efficiency in buildings refers to the opportunities for developers, owners and operators to use less energy in the construction, operation and maintenance of buildings. Energy efficiency opportunities can be applied to both new buildings and building retrofits. We focus on opportunities for solution providers to drive overall market development through innovative technology, marketing and financing solutions

## Overview

A combination of high upfront costs, limited understanding of the long-term benefits of green buildings and too few financing options continue to hinder adoption of green buildings

Developers' attitudes towards green buildings are changing in China. Instead of waiting for market conditions to improve, an increasing number are actively pursuing energy-efficient building projects—and, from a small base, the number of green buildings across the country has grown dramatically since 2008, driven by supportive policies. The 12th Five-Year Plan and 2013 Action Plan for Green Building, for example, contain mandatory green building and building energy efficiency targets for 2015.

Yet even with strong support from government, a combination of high upfront costs, limited understanding of the long-term benefits of green buildings and too few financing options continue to hinder adoption of green buildings. Low return on investment (ROI) and long payback periods remain challenges for developers and operators; a lack of reliable energy consumption baselines also make it difficult for companies to estimate and measure savings; project owners continue to have difficulty obtaining financing from financiers accustomed to conventional building solutions.

Despite these and other constraints, both new and retrofit green building projects offer opportunities for building developers, operators, owners and solution providers. China Greentech has identified strategies for stakeholders to overcome challenges and meet needs in this growing sector:

**Government: Improve access to subsidies and raise awareness.** Various subsidies for green buildings are in place, but access is often challenging due to low awareness of their availability.

**Building developers and operators: Take on new green buildings and retrofit projects sooner, not later.** Rather than waiting for market conditions to improve, companies can boost their brands and capture long-term energy savings by leading the market to adopt these solutions.

**Solution providers: Offer integrated technologies and market directly to end customers, including consumers.** Combining and promoting the solutions of multiple partners highlights the value to end customers. Energy savings solutions can even be promoted to consumers who are direct and indirect beneficiaries.



**Financiers: Work with smaller-scale projects.** Smaller projects are often neglected by traditional commercial lenders even though they are easier to develop due to lower complexity and variables. They are often also in a better position to take advantage of alternative financing sources such as energy service companies (ESCO). Using financiers to develop business cases raises the comfort level of commercial lenders who, combined with ESCOs, can make smaller projects feasible.

Companies that engage in these opportunities will not only be more competitive in China's emerging green building market, but will also earn reputations as innovative market leaders.

## Opportunity Assessment

**Policies and subsidies help, but are not enough**

***Favorable policies have encouraged developers, owners and operators to undertake green building projects, but greater government support in the form of subsidies is necessary to accelerate green building adoption.***

Green buildings are on the rise in China, but not quickly enough. In the period from 2008-2012, the number of green buildings increased 55-fold[14] —yet compared to the national target for 2015, the completed floor area of these projects is still less than 8% of China's goal.[15] Through interviews with key stakeholders, China Greentech noted a cautious change of attitude: developers, owners and operators increasingly view new and retrofit green building projects as worthwhile investments, mainly because of government support, though financial incentives remain relatively weak.

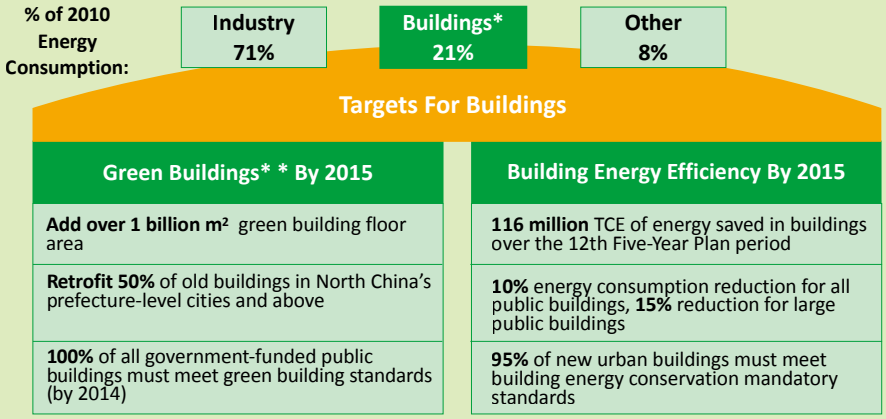
*14. "全国绿色建筑评价标识项目数量" [National Certified Green Building Projects], www.docin.com*
*15. Jianqing Wang, Xuefeng Gao et al., "2012 年度绿色建筑评价标识统计报告"[2012 Green Building Evaluation Statistical Report], Ministry of Housing and Urban-Rural Development, April 9, 2013*

Developers say current subsidies for new building projects are insufficient to offset higher initial investments. Subsidies of RMB 45/m² and RMB 80/m² for 2-and 3-star green buildings respectively are available only after projects are completed and receive green building certification. Furthermore, implementation details and subsidy criteria are unclear and vary by region, which makes applying for subsidies complicated for developers.

China's 2013 Action Plan for Green Building signals the government's commitment to this sector, but it is not clear that the new policies will address key barriers for development. The Action Plan is aggressive in that it enforces mandatory energy efficiency standards for new buildings in urban areas and requires all government-funded buildings and affordable housing projects in selected cities to meet national green building standards by 2014.[16] The Plan also sets specific guidelines for retrofit programs; by 2015, heat metering and energy-saving retrofits will be implemented in 400 million m² of residential buildings in North China, plus another 50 million m² of residential buildings and 120 million m² of public buildings in China's Hot Summer, Cold Winter Region.[17]



**Figure 3: 12th Five-Year Plan Green Building and Building Energy Efficiency Targets**




*Sources: *Building energy consumption here only covers the energy consumed in public buildings. Figures are based on China Building Energy Model (CBEM) developed by Tsinghua University*
***Green Building refers to the buildings that achieve at least 1-star Green Building certification*

Nevertheless, the plan does not provide information on additional subsidies or new financing options, which are essential for success. Although overdependence on government subsidies can hinder green building development in the long-term, they are needed to maintain short-term growth. Some officials seem prepared to take more aggressive measures to ensure 2015 targets are met: China Greentech Partners indicated that some local governments may double or even triple subsidies for new building projects, though there is concern that quality may suffer.

*16. "关于加快推动我国绿色建筑发展的实施意见" [Opinions on Accelerating Green Building Development], MOHURD and MOF, April 27, 2012*
*17. "The State Council Accelerates the Action Plan on Green Building," China Council for International Cooperation on Environment and Development, January 30, 2013, www.cciced.net*

**Leadership offers benefits for developers and operators**

***Developers and operators can raise their profile through innovative projects and partnerships with other green companies, while capturing long-term energy savings and new project opportunities.***

Despite constraints in the current market, building developers and operators need not wait for improved conditions to benefit from green building projects or retrofits. Companies who act early can establish reputations as market leaders and enjoy long-term energy savings.

For example, Parkview Green in Beijing demonstrates the benefits of developing new green buildings. Through a combination of solutions such as passive lighting and efficient heating and cooling, the building has cut its energy consumption by half compared with other grade-A office buildings in China.[18] With its LEED Platinum certification, strategic marketing partnerships and high-end tenants, Parkview Green is now recognized as a leader in China's green building market. Key to Parkview Green's success is that ownership, development, operations and management are all integrated within a single company. By removing complex partnerships and conflicts of interest at various stages of the building lifecycle, this model helps ensure high quality and cost-effectiveness.

Key to Parkview Green's success is that ownership, development, operations and management are all integrated within a single company



Comprehensive retrofitting offers similar potential, and a premier example is the Empire State Building in New York City. This project combines energy savings of up to 38% with financial savings that allow for a five-year payback period. The Empire State Building is also gaining market visibility with its replicable model, and the upgrades will generate rent premiums estimated at 1-9%. Given that the building's owner is also the operator, installing energy efficiency solutions was naturally incentivized. The timing of the Empire State Building retrofit made large cost savings possible, as the project was initiated when an old basement chiller plant needed remodeling. The management team had the choice to install an expensive replacement plant or to reduce energy demand through an efficiency retrofit program while also implementing a smaller-scale upgrade of the plant. Selecting the latter option saved USD 17.3 million, enabling a payback period of less than five years.

These cases offer lessons for developers and operators of both new and retrofit green buildings:

**Build your brand through innovation.** Green buildings stand out from the competition, attract impressive tenants and earn premium rents. Strategic partnerships give companies the opportunity to cross-promote one another's green brands.

**Align incentives through integration.** When operators are also owners or developers, the alignment of interests improves quality and lowers costs.

**Combine retrofits with necessary maintenance.** To lower costs, commercial building operators should consider energy efficient retrofits at times when equipment already needs replacement.

*18. China Greentech interviews and analysis*

**Solution providers and financiers will drive market development**

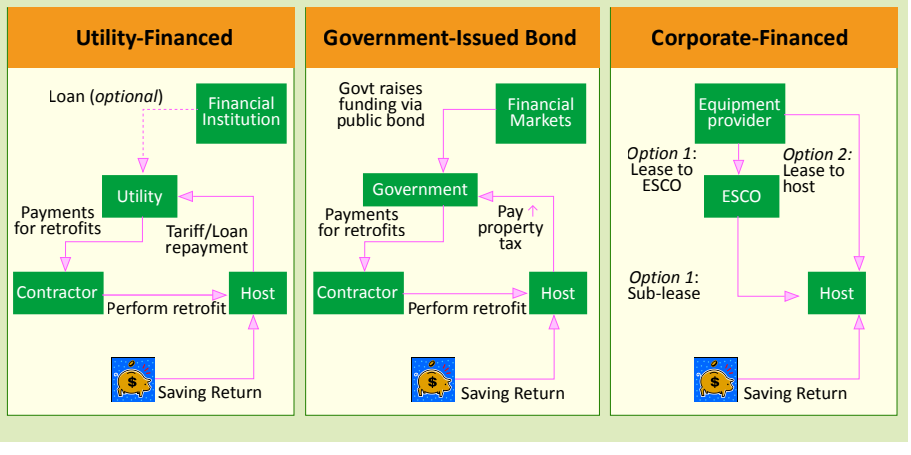
***Integrated technologies and customer-centric products can make green buildings more attractive. Meanwhile, it is crucial to develop alternative financing options that will support a wider range of projects.***

In addition to larger and more transparent government subsidies, what the green building market needs most is new approaches from solution providers and more accessible financing. Technology and finance companies can drive growth in this sector through innovation:

**Develop, own and operate buildings with integrated solutions.** Green building solution providers can market their products more effectively by developing, owning and operating buildings that use their solutions together with those of their partners. Participating in both building development and operations offers the chance to showcase and prove green solutions, while integrating technologies from multiple partners can raise the value of all partners by making them more efficient and scalable. Bayer Material Science has taken this approach with its Eco-Commercial building in Qingdao, where integrated solutions from Bayer and partners save 195 tons of $CO_2$ emissions per year. The building's energy efficiency will allow Bayer to redeem initial investments within just a few years, and is a cost-effective model for other developers in China.[19]

**Create new financing options for small-scale projects.** Given the high upfront costs of both new green buildings and retrofits, reliable financing is crucial for large-scale adoption. Currently, most projects are financed by conventional commercial loans, but these channels are often limited to large-scale projects. Smaller projects tend to have low rates of return and limited involvement of third-party financial advisors and auditors, and are therefore considered risky investments by most commercial banks. One way to address this obstacle is for small projects to improve their reputability by making more use of professional financiers. But these projects also need alternative financing options such as the energy service company (ESCO) model, in which a solution provider takes responsibility for funding and guarantees energy savings.

**Figure 4: Innovative Financing Models for Green Buildings**




*19. "Bayer Material Science EcoCommercial Building Program Launched its first Lighthouse Project in China," October 24, 2012, www.china.ecocommercial-building-network.com*

Corporate financing, utility financing and government bonds are other alternative capital sources that could fund a wider range of green building projects in China. In corporate financing, an internal division of one company leases equipment for a specific project to another company. Direct financing from utilities may also be viable. Central and local governments could work with utilities to develop this option. Governments could also issue bonds for projects that are repaid through property taxes, an approach used in California.[20] Such government backing may make projects more attractive for traditional finance. Investors and banks will not provide funding without a guaranteed return, but bonds or ESCO contracts can improve investor confidence.

**Market solutions directly to consumers.** Energy-efficient technologies will be adopted more widely if they appeal to end customers and consumers. Technology providers should develop products and solutions that are user-friendly and designed to raise awareness of individual energy consumption and savings. Haier's smart air conditioning system, which provides real-time energy consumption and air quality monitoring through the user's smart phone, is an example of a unique product focused on the end-user. Although many solution providers partner with utilities, few sell directly to consumers—solution providers can increase profits by doing both. For instance, the innovative thermostat company NEST, recently acquired by Google, partners with utility companies in the United States and also sells its product online to individual consumers.



## Conclusion

The growing number of developers, owners, and operators willing to invest in green building projects is an indication of overall market development, but stronger policy and implementation support is needed to maintain this trend. Without more effective policies for green buildings, low ROI and long payback periods will outweigh the energy saving and other benefits of new and retrofit projects.

Nonetheless, there are market opportunities despite these constraints. For example, integrating building development and operation for greater cost-effectiveness; using innovative financing options; and forming strategic partnerships or nurturing end-user demand for energy efficiency solutions. Capitalizing on these and other opportunities will not only enable companies to position themselves as innovative green building leaders, but also contribute to overall market development.

*20. "United States Building Energy Efficiency Retrofits: Market Sizing and Financing Models," Deutsche Bank Climate Change Advisors & the Rockefeller Foundation, March 2012*

## Sustainable Industry Ecosystem

China Greentech defines sustainable industry as scaling industrial activities in economically, socially and environmentally sustainable ways to reduce energy usage as well as air, water and other forms of pollution.

We subscribes to the United Nations definition of sustainability: “sustainable development ensures that it meets the needs of the present without compromising the ability of future generations to meet their own needs.” [1]

*1. “Our Common Future,” The World Commission on Environment and Development, 1987*

*Courtesy of Mike Hawkins*


## A Paradigm for Creating Value and Driving Progress in the Use of Alternative Energy Sources

DP CleanTech (DPCT) has successfully delivered biomass solutions in China since 2004. During this time we have observed the introduction of ambitious, forward-thinking environmental policies and targets in China, which have underpinned an unparalleled and unprecedented scale of biomass power deployment. The industry's resulting growth has been substantial: in 2006, DPCT built China's first straw-fired power plant; by 2012, China had connected nearly 150 agricultural-and forestry-based biomass plants to the grid. As an early advocate and key player in China, DPCT has built almost 50 plants (totaling 1356MW in capacity) using our core European technology. By contrast, fewer than 40 biomass plants were built in Europe during this period.

Participation in the China market has provided exceptional opportunities to innovate and refine solutions to address specific industry challenges worldwide. DPCT's understanding of the complete value chain, both in China and abroad, has advanced the development of the entire industry. A breakthrough project with Shougang Holdings, for example, to design and deliver the first biomass-to-power project in China using lignin by-product from second generation ethanol production now serves as a blueprint for further application. Our expertise in complex fuel combustion has also helped drive the industry forward, providing great insight for the design of a world-pioneering plant in Thailand. This plant, which will begin operation in 2015, will produce energy derived from the waste residue from coconuts–a fuel source in local abundance, which until this point, was considered too complex to combust.

DPCT's global operations platform, flexible designs and affordable solutions have allowed it to play a major role in shaping development of China's biomass industry. Astute customers typically question existing, rigid European solutions and the associated costly working practices. Equally, they reject low-quality, unproven China products and poor delivery. Instead, they demand proven, flexible solutions that are high-quality and affordable, and delivered within a world-class framework. DPCT is able to address these needs as the company is unrestricted by legacy structures or hampered by lower-performing technology. Rather, our organization is built with unique competitive advantages and qualities; our technology is proven, and importantly, our global operations platform embodies a holistic approach towards project design and execution. Our executive team is intentionally decentralized and multicultural to provide strategic vision to develop the diversity of global opportunities, while also considering local needs and values in solution development. By integrating ideas, capabilities and functional disciplines we will continue to combine knowledge and best practice to enhance our solutions and create long-term value for our clients and industry stakeholders.


Courtesy of Chris Suderman

# ADDRESSING CHINA'S INDUSTRIAL AIR POLLUTION CHALLENGES

This Opportunity Assessment provides a summary of China Greentech's 2013 strategic research on China's air pollution challenges and the business opportunities arising from increased regulation of pollutants, especially particulate matter below 2.5 micrometers ($PM_{2.5}$).

**Definition and Scope—Industrial Air Pollution**

China Greentech defines industrial air pollution as the introduction of gases, chemicals, particulates or other materials into the atmosphere from industrial activity. Our scope focuses on the non-greenhouse gas air pollutants $PM_{2.5}$, NOx and SOx.

## Overview

All eyes are on China as the world awaits an action plan that will address and eventually help solve China's increasingly severe air pollution problem. From international governments, companies, and investors to local citizens, research institutes and independent scholars, there has never been more involvement in these efforts. This diverse spectrum has opened up a space for innovation and increases the likelihood of a more comprehensive approach to pollution prevention and remediation. Many of the potential opportunities will depend on the future development models of China's dirtiest industries—and while there is a role for all stakeholders, the responsibility weighs primarily on the shoulders of the government to provide clear guidance and enforcement.

Despite aggressive targets established in the 11th and 12th Five-Year Plans, China's air pollution challenges have continued to escalate. In 2010, the Ministry of Environmental Protection's (MEP) Academy of Environmental Planning estimated that RMB 1.1 trillion was lost due to pollution, representing 3.5% of annual GDP, a figure which did not include the cost of health care.[2] This significant economic cost, in addition to growing public awareness of the severity of the issue, has prompted the Chinese government to ramp up its pollution reduction efforts.

In 2013, China Greentech conducted a detailed opportunity assessment examining the impact of air and water pollution in collaboration with China Greentech Partners, government organizations, and other stakeholders. This Opportunity Assessment will discuss growing public awareness of $PM_{2.5}$, evaluate new policy measures for near-term potential to reduce air pollution, and identify greentech opportunities resulting from these measures.

## Opportunity Assessment

**Worsening pollution and heightened public concern turn attention to $PM_{2.5}$**

***Growing public awareness of the adverse health effects of $PM_{2.5}$ is compelling the Chinese government to increase its pollution reduction efforts.***

In October 2012 (before the "Airpocalypse" made international headlines), the Chinese government released a report requiring 74 cities to publish $PM_{2.5}$ data from 496 different monitoring stations beginning in January 2013. By December 2012, MEP released the 12th Five-Year Plan for Pollution Reduction in Key Regions, which established annual average reduction targets of 6% from 2010 levels for the Pearl River Delta and Yangtze River Delta, and 15% for Beijing by 2015.[3] The Plan also set non-binding $PM_{2.5}$ reduction targets ranging from 4-7% in other major cities.

In response to government actions and public demand, $PM_{2.5}$ data is now available for tens of cities across China and can be monitored on an hourly basis. With pollution data more readily available to the public, a growing number of Chinese citizens are becoming aware of the adverse health effects of $PM_{2.5}$, and in turn have taken to social media to express their concerns. In January 2013, Pan Shiyi, Chairman of SOHO China—one of the largest real estate development companies in the country and a delegate to the National People's Congress—used Sina Weibo, China's largest microblogging site, to call for a new clean air act. In less than 10 hours, Mr. Pan's post received more than 30,000 positive responses. Non-government organizations are also helping to raise awareness; the Institute for Public and Environmental Affairs (IPE), a Chinese non-profit organization that operates a public online database and digital map to identify major polluters, recently launched a "take a picture, locate a polluter" campaign encouraging citizens to take photos of environmental violators and upload them to the Internet. Through its own research and with support from concerned citizens, IPE has exposed over 90,000 air and water violations by local and foreign enterprises in China.

*2. "1.1 Trillion Yuan in Economic Losses in 2010, China Report Says," South China Morning Post, April 3, 2013, www.scmp.com; "China Set to Lose 2% of GDP Cleaning Up Decades of Pollution," Bloomberg, September 17, 2010, www.bloomberg.com*

*3. "重点区域大气污染防治'十二五'规划"[12th Five-Year Plan for Air Pollution Prevention and Control in Key Regions], MEP, NDRC, and MOF, October 2012*

### The sources of $PM_{2.5}$ are diverse and complex

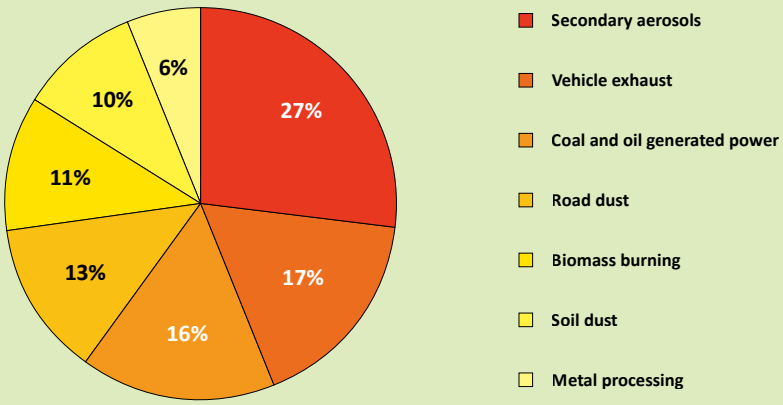
***Secondary aerosols are the largest contributor to $PM_{2.5}$; six industries account for 80% of total sulfur dioxide (SOx), nitrogen oxide (NOx) and soot emissions.***

While some $PM_{2.5}$ particles are emitted directly, others are formed when pollutants such SOx and NOx react in the atmosphere. Combustion is the main source of $PM_{2.5}$ emissions, whether for electricity, heating, transportation or other energy services.

A 2010 study assessed the sources of $PM_{2.5}$ at one site in Beijing (Figure 1). It found that secondary aerosols represented the largest proportion of $PM_{2.5}$, at 27%, which are created via a chemical reaction between particulate emissions and pre-existing atmospheric particulates. Although the study did not specify the original source of the particulate emissions, other studies suggest that most of these secondary emissions are the result of industrial activity related to coal.[4]

Six industries account for more than 80% of total SOx, NOx and soot emissions

**Figure 1: $PM_{2.5}$ Particles in Beijing by Pollutant Source, 2010**




*Source: Lingda Yu et al. "Characterization and Source Apportionment of $PM_{2.5}$ in an Urban Environment in Beijing," Taiwan Association for Aerosol Research, November 2012*

Another study in 2011 that monitored emissions from 38 industries found that six industries account for more than 80% of total SOx, NOx and soot emissions. Of those emissions, power and heat generation account for 47.5% and 66.7% of SOx and NOx, respectively. The study also showed that non-metallic minerals, ferrous non-ferrous metal processing, chemical products, petroleum and refining were also significant contributors. Given that $PM_{2.5}$ pollution sources vary by region and city, adopting a localized approach to reduce emissions is essential.[5]

*4. Big Bang Measures to Fight Air Pollution, Deutsche Bank Market Research, February 28, 2013, www.businessweek.com*
*5 . China Statistical Yearbook on Environment, 2012*

**New policy indicates stronger regulation and enforcement**

***The Air Pollution Prevention and Control Action Plan, announced by the State Council in September 2013, can help improve air quality over the next five years if enforcement is a priority.***

On September 12, 2013, the State Council released the Air Pollution Prevention and Control Action Plan, which builds on the State Council's June 2013 statement outlining 10 measures for curbing air pollution (Figure 2)

**Figure 2: Government Measures to Curb Air Pollution**

| | | | |
|---|---|---|---|
| 1 | Reduce emission of multi-pollutants | 6 | Allow market mechanisms and improve environmental economic policies |
| 2 | Promote industrial restructuring and upgrades | 7 | Strengthen environmental law and improve implementation and enforcement |
| 3 | Accelerate technology upgrades and enhance innovation | 8 | Establish joint prevention and control mechanisms in key regions |
| 4 | Accelerate energy restructuring and increase clean energy supply | 9 | Establish monitoring and early warning systems for heavy air pollution |
| 5 | Set stricter energy conservation and environmental standards for new projects | 10 | Clarify roles of government, private sector and civil society in environmental protection |

Compared to investments under the 12th Five-Year Plan for Pollution Reduction in Key Regions (RMB 350 billion),[6] public and private investment under the new Action Plan is expected to reach RMB 1.7 trillion for the next five years.[7] In 2013, the government allocated RMB 5 billion for initiating and subsidizing pollution reduction programs in Beijing, Tianjin, Hebei, Inner Mongolia, Shanxi and Shandong alone.[8] The Action Plan aims to reduce $PM_{2.5}$ density by 10% from 2012 levels in cities at or above the prefectural level by 2017. Specifically, it establishes annual average reduction targets from 2012 levels for three key regions—25% for the Beijing, Tianjin, Hebei, 20% for the Yangtze River Delta and 15% for the Pearl River Delta.

In addition, the Action Plan sets strict restrictions on both coal consumption and vehicle emissions, and requires all provincial capitals to establish monitoring and early warning systems by 2015. In particular, the three key regions must devise three-tier monitoring systems that correspond to regional, provincial, and city levels. According to Zhang Xiaoye, a researcher from the Chinese Academy of Meteorological Sciences, "the meteorological departments of the three key regions are working closely with the relevant environmental departments to develop the systems."[9]

*6. "重点区域大气污染防治'十二五'规划 "[12th Five-Year Plan for Air pollution Prevention and Control in Key Regions], October 2012.*
*7. 为解"雾锁京城"中央财政 50 亿元"以奖代补"治理大气污染 [The Central Government Allocates RMB 5 Billion to Address Beijing's Smog], October 19, 2013, www.ifeng.com*
*8. 推进生态建设：50 亿元背后的决心与行动 [Promoting Ecological Construction: Action Plan Behind the Government's RMB 5 Billion], November 15, 2013, cpc.people.com.cn*
*9. 为解"雾锁京城" 中央财政 50 亿元"以奖代补"治理大气污染 [The Central Government Allocates RMB 5 Billion to Address Beijing's Smog], October 19, 2013, www.ifeng.com*

### Lessons from the United States' $PM_{2.5}$ Experience

In the 1990s, cities and industrial centers across the United States once experienced unhealthy levels of fine particulate matter on a daily basis. Since the US set its first $PM_{2.5}$ standards in 1997, federal and state governments have made noteworthy progress in curbing air pollution. Although China's current levels of $PM_{2.5}$ far surpass those of the US in previous years, the nation's approach to setting, monitoring, and enforcing health standards can provide valuable lessons for China as it seeks to devise its own pollution reduction strategy. Specifically, China can learn from the following measures:

***Annual and hourly $PM_{2.5}$ standards:*** In 1997, the US Environmental Protection Agency (EPA) established its first annual and hourly air standards for $PM_{2.5}$ after research revealed that the health impacts of pollutants smaller than PM10 are more severe than those of the pollutants typically monitored by the EPA. EPA began monitoring $PM_{2.5}$ in 1999, and between 2000-2010 the national average annual concentration fell 27% from 13.6 to 9.9μg/$m^3$.[10]

***State level implementation:*** Under the US Clean Air Act (CAA), the nation's premier air pollution control law originally drafted in 1963, each state is required to develop its own State Implementation Plan (SIP), which describes how the state will achieve and maintain standards established by EPA. States also work with the EPA during the development of these plans to identify areas where pollution continuously exceeds national air quality standards, and address ways to help states meet those standards. To enforce SIP standards, states can bring lawsuits against non-compliant polluters to spur compliance.

***Local pollution control requirements:*** Due to regional differences and individual state needs, not all SIP pollution control requirements are the same. When deciding which requirements to adopt, states can refer to a list provided by EPA that contains more than 100 possible measures. This enables states to choose SIP requirements based on factors such as regional differences in pollution sources.



**Increased regulation and investment creates business opportunities**

***Continued government support for curbing air pollution will incentivize adoption of air pollution control and industrial energy efficiency technologies.***

China's increasing commitment to reducing $PM_{2.5}$ levels will create opportunities in both technology and professional services. Based on China Greentech research, we forecast opportunities in the following areas:

*10. National Trends in Particulate Matter Levels, United States Environmental Protection Agency, September 4, 2013, www.epa.gov*

- ***Clean energy sources:*** As China attempts to reduce its dependency on coal in the coming decades, cleaner energy sources will comprise a larger percentage of the nation's energy portfolio. Many of these cleaner energy sources are likely to be deployed through distributed energy (DE) systems, which will add flexibility and reliability to China's grid. In particular, solar DE has already become commercially competitive for industrial and commercial end users. Gas-fired DE is also likely to see accelerated growth in the coming years. Favorable policies and subsidies will create opportunities for businesses in this sector to implement their solutions. There will also be opportunities for Chinese and foreign businesses to partner with local governments on specific projects.

- ***Energy efficiency:*** China's air pollution challenges have compelled the government to adopt measures to improve energy efficiency by targeting industrial energy use and demand-side management (DSM). Recent initiatives announced by China's National Development and Reform Commission (NDRC) will experiment with more flexible electricity pricing, innovative financing, technology, and business models, as well as the development of ESCOs (energy services companies). State Grid's Smart Grid Investment Plan will also support DSM-related initiatives such as smart metering and customized load management. Successful implementation of these programs will help accelerate nationwide DSM development during the 13th Five-Year Plan period.

- ***Air pollution control technologies:*** Policy support to curb air pollution will incentivize the adoption of air pollution technology solutions. At present, scrubber systems, flue-gas desulfurization systems, and monitoring systems are all needed, as well as closed-loop systems that not only reduce waste air discharge, but also process waste air to be resold as chemical products. Technology bundles that collectively remove mercury, SOx and NOx are also desired solutions. Given that many foreign companies possess advanced pollution control technologies, opportunities exist for companies to work with the government on creating technology transfer models.

- ***Professional services:*** Without well-trained personnel to effectively install, operate, and manage new and existing technology solutions, they will inevitably be underutilized. ESCOs can play a major role in the implementation of these solutions, as well as in the financing, construction, operation, and maintenance of new projects. Nonetheless, issues such as fragmentation, insufficient fixed assets, lack of qualified talent and weak management must be addressed to maximize the potential of ESCOs.

## Conclusion

China's air pollution problems can no longer be ignored. In October 2013, the World Health Organization established the link between air pollution and lung cancer, classifying it for the first time as a leading cause. According to the report, more than half of worldwide lung cancer deaths attributable to ambient fine particles in 2010 were projected to have been in China and other East Asian countries.[11] This persistent pollution throughout 2013 and growing public awareness of its undeniable health implications has compelled the Chinese government to devise a more effective strategy to reduce $PM_{2.5}$ and other harmful pollutants.

Surely, China can combine international experience and local lessons to reduce its $PM_{2.5}$ emissions. By adopting a more collaborative planning, implementation, and enforcement strategy, China can make significant progress in cleaning up its air. The October 2013 Air Pollution Action Plan is an indicator that the government is increasing its commitment to address pollution. More prominent media coverage of fines imposed on polluters (including state-owned enterprises) and the State Council's support of disclosing more pollution data to the public are also signs of a changing attitude towards sustainable growth.

China Greentech will continue to monitor China's progress in air pollution prevention and control. Businesses can expect to see opportunities in energy efficiency, technology adoption and operation, as well as clean energy development. Several businesses are already leading the way in forming strategic partnerships to capture opportunities arising from China's growing commitment to clean up its air. China Greentech will continue to track developments and share updates on evolving opportunities and partnerships models that can help Partners best realize their business goals as they relate to China's priorities.



*11. "Air Pollution and Cancer," World Health Organization, International Agency for Research on Cancer, October 2013, www.iarc.fr*
*12. "2005 Circular Economy Report," CCICED, www.cciced.net*


Courtesy of Julian Schwabe

# APPLYING CIRCULAR ECONOMY CONCEPTS IN CHINA'S INDUSTRIAL PARKS

### Definition and Scope—Circular Economy in Industrial Parks

A circular economy is one that reduces waste by reducing, reusing and recycling energy and resources. This can refer to individual enterprises recycling their own waste, nearby companies sharing and reusing waste products, or an entire economic system operating on the philosophy of circular design principles.[12] This Opportunity Assessment focuses on regional circular economy networks within industrial parks. The main waste streams considered include energy, solid waste and water.

## Overview

This Opportunity Assessment summarizes China's goals for circular economy development in industrial parks, and analyzes benefits and challenges for energy, solid waste, and water recycling. It makes three main recommendations to stakeholders

**Strengthen enabling environments for circular economy projects, especially wastewater sharing.** Industrial parks are natural catalysts for a circular economy, but still face economic and policy barriers. In particular, low water prices fail to reward efficiency, requiring governments to instead offer predictable public investments and incentives for wastewater projects.

**Design new industrial parks with energy and waste recycling in mind.** Resource reuse is economically attractive but introduces new challenges. Planners, industry and solution providers should collaborate on tailored recycling systems for each new park, such as water pipe infrastructure for recycling and reuse.

**Use Corporate Social Responsibility (CSR) initiatives to catalyze change.** Large multinationals can use their CSR budgets for China to fund demonstration projects with unattractive economics—then work toward policy reforms and a sustainable business model to improve the project's economics over time.

## Opportunity Assessment

In the Jinqiao Industrial Park, Coca-Cola Shanghai has broken new ground in resource recycling. The Coca-Cola plant is selling its treated wastewater directly to a Sharp factory—the first private wastewater trading deal in China. A second Coca-Cola project has pioneered another way to reuse water, through an international partnership that restored a local wetland with treated water from Swire Coca-Cola Zhengzhou.[13]

**Figure 3: Coca-Cola Shanghai Jinqiao Inter-Company Grey Water Trading Project**


Figure 3 shows how these two companies adopt circular economy concepts to share or sell reclaimed waste to neighbors. As the waste from one product becomes the input for another, new cash flows are created while the cost of waste disposal drops and the resource efficiency of the park increases.

### Barriers to resource reuse

***"We like circular economy projects. However, sometimes it is very difficult to get government approval for a project even with our strong support." —Industrial park government official***

China has set national targets for energy and water intensity, industrial water recycling and solid waste reuse. In addition, 50% of national industrial parks and 30% of provincial industrial parks are targeted to achieve circular economy transformation by 2015, as measured by rising output of recycled resources and declining waste discharge.[14] The issue also merited a 2008 national law specifically promoting a circular economy.

*13. China Greentech field research in Zhengzhou and Shanghai*
*14. 《循环经济与可持续发展：中国工业园区案例介绍》[Circular Economy and Clean Production: China Case Study], 2012*

Yet despite all the attention, obstacles still hinder circular economy projects. While China's central and local governments have announced numerous policies, regulations and financial incentives for circular economy development, the scale of the challenge is massive and many projects have encountered problems.

Although there is clear potential for businesses in industrial parks to trade wastewater, waste heat and other byproducts, China Greentech's interviewees pointed to a range of economic and policy barriers:

- Circular economy projects have relatively long payback periods
- Resource prices remain artificially low, failing to account for the full environmental and social costs, which reduces the incentives for circular economy practices
- Infrastructure such as water treatment systems and pipelines have high up-front costs and financing options are limited
- The Circular Economy Promotion Law is not mandatory, and China lacks strict evaluation systems for industrial resource use
- Government subsidies and tax incentives have been provided through short-term programs, whereas companies need predictable, institutionalized support to cover the payback periods of projects
- Some government agencies are held to performance indices that run counter to promoting circular economy—such as water utilities that lose revenue from wastewater recycling projects

In China, it is estimated that 17-67% of industrial energy consumption is ultimately discharged as waste heat—but as much as 60% of this waste energy is recoverable

We found that industrial park officials are usually enthusiastic about circular economy development, but companies need better support from government and clearer economic benefits in order to implement projects. Innovative projects for recycling energy, solid waste and water provide business models and show how policies and incentives could be adjusted to promote wider transformation.

**Energy and solid waste: Designing industrial parks with circular solutions**

***"The key for inter-company waste heat and pressure recycling projects is to have a well-designed plan at the industrial park level even before factories and companies begin to move in."—Solution provider***

Energy recycling projects are an effective way to boost efficiency in energy-intensive industries like petrochemicals, cement and steel. In China, it is estimated that 17-67% of industrial energy consumption is ultimately discharged as waste heat—but as much as 60% of this waste energy is recoverable. Gas recovery turbines and heat pumps can capture and convert this waste energy to useful heating, cooling or power generation.

Energy is also the waste stream in China with the strongest incentives for efficiency and reuse given the economic benefits. In addition to high resource costs and financial incentives, a combination of international pressures and mandatory policy requirements all combine to support industrial energy recovery and recycling. Projects for waste heat power generation (WHPG) generally enjoy 15-25% ROI and have a payback period of six to eight years. On the policy side, China's National Development and Reform Commission has targeted 31 GW of installed capacity by 2015.[15]

China also has rising targets for industrial solid waste recycling, with the 12th Five-Year Plan aiming for a 72% multi-purpose utilization rate. Approaches include converting industrial byproducts into energy sources, and some circular economy projects could connect both wastewater and solid waste with energy to improve energy efficiency.

An example of this kind of integration is the recycling operation in Suzhou Industrial Park, developed and operated by Suez Environment's two subsidiaries, Degremont and Sino French Water. A wastewater treatment facility receives the park's combined wastewater and separates treated water from sediment called 'wet sludge'. The sludge is then dried and burned with coal in a combined heat and power plant, where waste energy in the form of steam is recaptured to power the drying facility. Uncontaminated wastewater is a byproduct of the drying process, and ashes from the power plant are reused as building materials.[16]

When it comes to sharing reused water within an industrial park, the economics are less favorable than for energy recycling, as water prices in China are markedly low


The profit potential and policy leverage for energy recycling have helped to spread circular economy practices. Energy is reused most widely in China's cement sector, and the market is starting to expand into steel, chemicals and glass. But China Greentech partners noted that more fundamental challenges need to be addressed in industrial park designs.

**Water: Meeting weak market signals with stronger policy support**

***"Lack of economic incentives is a key obstacle for water recycling projects. In China, water prices are about one-tenth to one-fifth of other countries."—International financial institution***

China reduced its water use per economic unit by two-thirds from 2000 to 2010, in part due to water recycling within individual enterprises. Wastewater from industry—usually classified as 'grey water'—can be treated and reused for cooling and other manufacturing processes, or for landscaping. Though China's water intensity still remains 10 times the US level, the government aims to halve it by 2030. There are opportunities to recycle more wastewater, particularly from industries that discharge the most: paper and pulp, chemicals, textiles, and food and beverage processing.[17]

But when it comes to sharing reused water within an industrial park, the economics are less favorable than for energy recycling, as water prices in China are markedly low. Coca-Cola's wastewater deal with Sharp in Jinqiao shows that water recycling can be profitable, but also highlights the challenges of high upfront costs and modest returns.

*15. China Greentech research and analysis*
*16.《"江苏省产业共生发展"项目介绍》Jiangsu Industrial Symbiosis Project Overview, Suzhou Environment Energy Exchange, www.szeeex.com; China Greentech interviews*
*17. China Greentech research and analysis*

The Jinqiao project required investments in a pipeline and wastewater recycling technology, supported by a government greentech fund and by the Coca-Cola Global Initiative, respectively. The Coca-Cola plant could pay off its RMB 900,000 wastewater facility in four to five years, but only if it engages additional water customers to boost revenue. Coca-Cola, Sharp and the local water authority have had to work together to plan a scalable business model, obtain funding for the pipeline and satisfy concerns over water quality. Alignment of interests among these stakeholders is central to the project's success.

The water recycling partnership in Zhengzhou brought similar challenges. The Coca-Cola Global Initiative, the company's global CSR fund, allocated USD 2 million to the United Nations Development Programme (UNDP), the Zhengzhou Environmental Science Academy, and the local government for a Lianhu Wetlake upgrade project. The local water bureau and affiliated agencies were responsible for all related public infrastructure investment and maintenance, while the Swire Coca-Cola Zhengzhou factory provided recycled wastewater from its own production to Lianhu Wetlake for landscaping purposes. However, the project faced initial delays due to the lack of upfront capital available for a pipeline that was only partially funded by the government—further underlining the need for institutionalized government support. The economic benefits to the company are still being negotiated with local authorities.

How could the lessons learned from these projects be applied to make wastewater sharing easier and more rewarding for other businesses? While water price jumps have spurred innovation in cases like the BP Kwinana Refinery Water Minimisation Program in Australia,[18] China's water prices are unlikely to rise in the near future. China Greentech found that pipeline construction approvals and costs are often the biggest challenges facing water recycling projects, so authorities should streamline the process and establish stable funding. Water utilities must play by market rules, for example by waiving wastewater discharge fees for recyclers. The finance sector, from local banks up through multilateral development banks, could be more involved in backing circular economy investments.



### BP's Water Minimisation Program Helps Company Save Millions

Driven by increasingly severe water restrictions and the potentially high cost of water in water-scarce western Australia, BP Kwinana Refinery, the largest water user in the region, launched a Water Minimisation Program in 1997. Since its launch, the company has saved AUD 5 million in water purchase and wastewater disposal costs annually. The plant undertook a two-pronged approach: 1) water efficiency within the plant and 2) the reuse of low-quality and reclaimed water to nearly halve the volume of freshwater intake from 1997 to 2009.

*18. China Greentech interviews*

**Corporate Social Responsibility: Making projects possible**

***"A new approach could be a parallel two-way effort: 'bottom-up', we successfully demonstrate replicable circular economy projects; 'top-down', we advocate for more regulatory reforms to facilitate the scale-up of projects." —NGO***

As seen in the Coca-Cola cases, companies with tangible CSR initiatives are leading forces in promoting circular economy projects that are not yet economically attractive. Other international funding sources can likewise act as catalysts for local projects.

Once a demonstration project has proven the concept of waste recycling within industrial parks, its corporate owner can push for policy and regulatory reform to make the project economically sustainable. According to Coca-Cola, stakeholders in the Jinqiao and Zhengzhou projects are continuing to explore how to create profitable and self-sustaining business models. In this way, pioneers lay the foundation for many other companies and industrial parks to adopt circular economy practices.

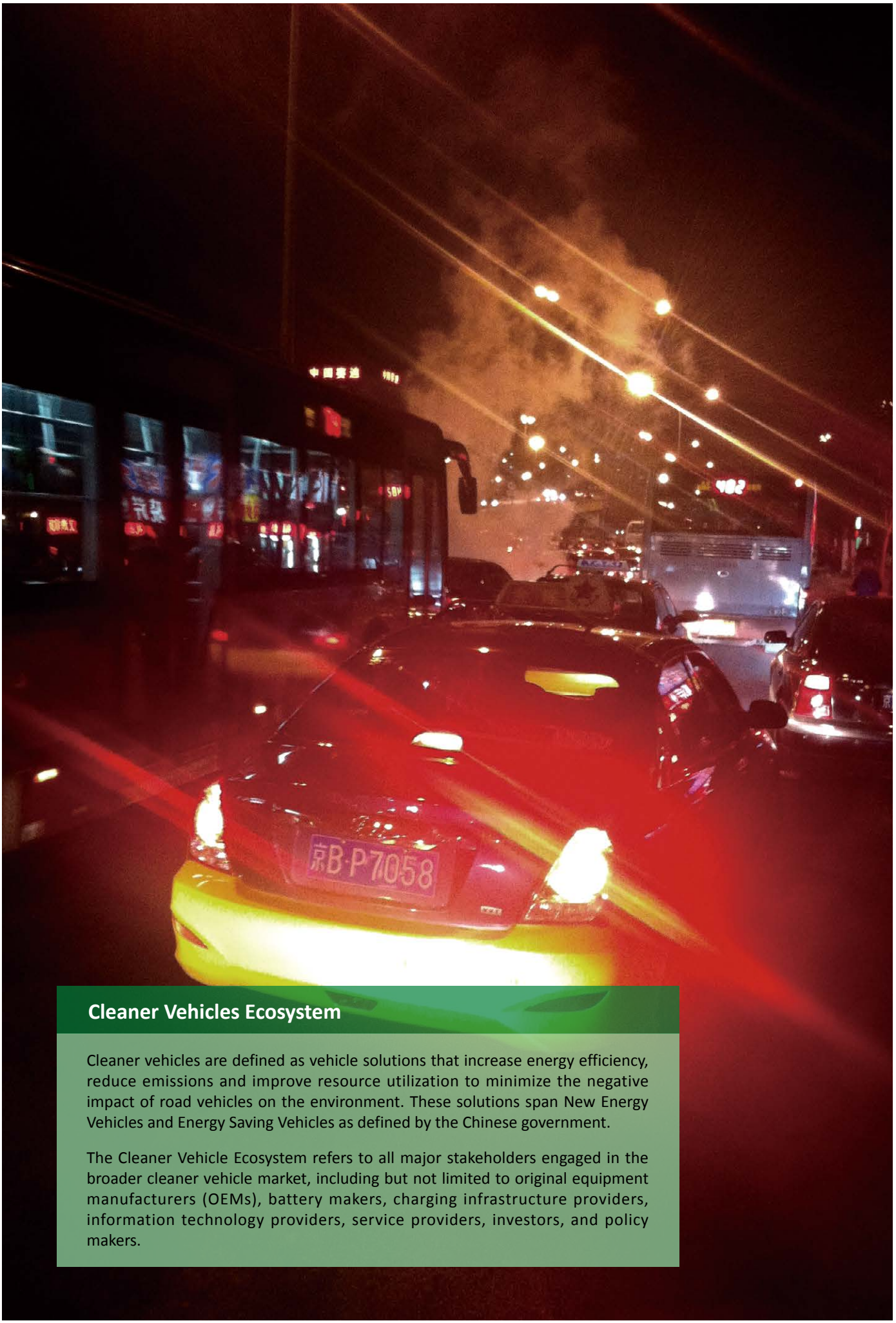
## Conclusion



Considering the number of policy programs for circular economy projects in Chinese industrial parks, progress is slow. China Greentech found that although park officials support recycling of energy, solid waste and water, projects still must overcome significant economic, regulatory or technical barriers to implementation.

Much more can be done to promote circular economy projects by institutionalizing rules, providing financial incentives and using specialized infrastructure funds. Project owners play an important role in identifying effective technologies and business models. At the same time, solution providers can support both officials and project owners, particularly in the early stages of designing industrial parks.

Water recycling currently has the weakest business case and needs more public support, whereas energy recycling is leading circular economy growth in China. Projects motivated by CSR can serve as catalysts, allowing more sustainable models to take shape over time. The long-term solution may involve more projects integrating different waste streams to capture economies of scale and the full benefits inherent in circular economy projects.

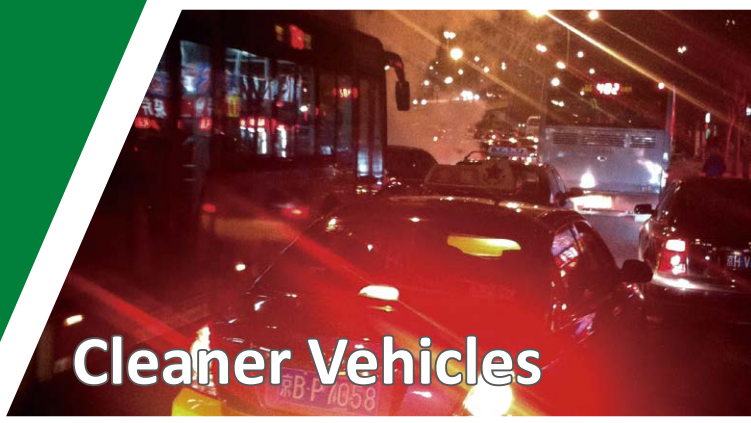



## Cleaner Vehicles Ecosystem

Cleaner vehicles are defined as vehicle solutions that increase energy efficiency, reduce emissions and improve resource utilization to minimize the negative impact of road vehicles on the environment. These solutions span New Energy Vehicles and Energy Saving Vehicles as defined by the Chinese government.

The Cleaner Vehicle Ecosystem refers to all major stakeholders engaged in the broader cleaner vehicle market, including but not limited to original equipment manufacturers (OEMs), battery makers, charging infrastructure providers, information technology providers, service providers, investors, and policy makers.

*Courtesy of Mike Howkins*




## Developing a Low-Carbon Transport System

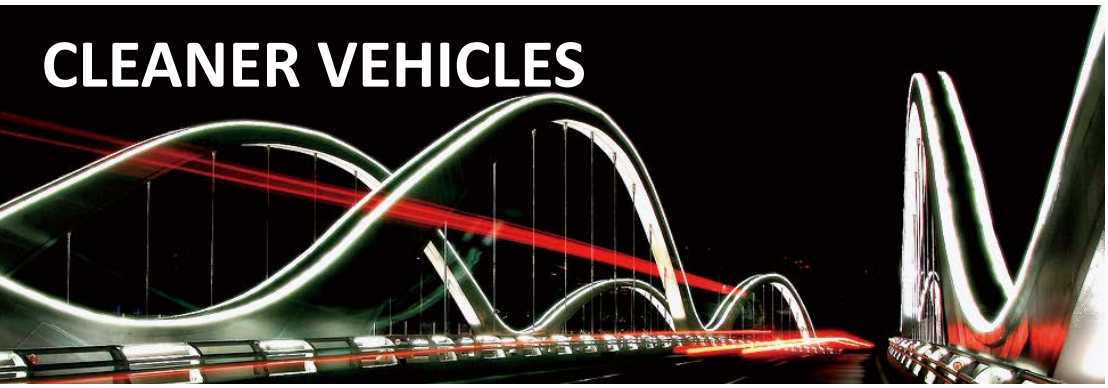
The transport sector is a major source of $PM_{2.5}$ pollution in Beijing, with most transport-related emissions coming from diesel-fueled buses and trucks. As private vehicle ownership continues to grow by about 10% annually, vehicle emissions and their impact on public health will intensify. Currently, over six million vehicles in China do not comply with the most basic fuel emission standards.

China recognizes the need to develop a high-performing, low-polluting transport sector. These efforts must go far beyond improving the fuel efficiency of conventional vehicles. We need to reconsider our patterns of mobility and shift towards smarter modes of transportation that use alternative fuels and combine public transit, car sharing and individual transport in ways that minimize congestion and resource use.

The goal of the Beijing New Energy Vehicle Promotion Center is to support Beijing to deploy 200,000 New Energy Vehicles by 2017. We are actively engaged in the deployment of EV fleets for taxis, buses and sanitation vehicles. The Promotion Center will continue to research EV use patterns and deepen our understanding of the challenges associated with EVs to maximize the benefits of our deployment program. Lessons learned will serve as valuable knowledge for New Energy Vehicle-related plans and help us develop recommendations for the Beijing government.

We are happy to play a role in creating a greener and smarter transport system for China. Transport systems must accommodate the growing number of vehicles on China's roads as cities urbanize and populations swell. The Beijing New Energy Vehicles Promotion Center will continue to promote the use of New Energy Vehicles while deepening collaboration with international partners and Chinese cities to accelerate development of cleaner transportation systems.

# CLEANER VEHICLES



Courtesy of Flickr user kele_jb1984

## FUTURE URBAN TRANSPORTATION SYSTEMS TO HELP SOLVE CHINA'S TRAFFIC, EMISSIONS AND ENERGY CHALLENGES

This Opportunity Assessment examines the current state of China's urban transportation systems, and recommends approaches to achieve a "blue sky" urban transportation future. It also summarizes China Greentech's scenario analysis that examines the future state of urban air quality based on the level and nature of adoption of different measures and incentives.

### Definition and Scope—Cleaner Urban Transportation

Urban transportation systems encompass several elements including: public transport, non-motorized transport (such as pedestrians and cyclists), private motorized traffic, and commercial traffic. The major objective of cleaner urban transport is to meet the demands for both accessible and efficient transportation services while promoting sustainable transportation networks suited for high-density urban populations, as well as minimizing congestion and vehicle emissions like carbon dioxide, nitrous oxides and particulates.

## Overview

China's economic growth and rapid urbanization over the past two decades have intensified urban mobility demands. Vehicle ownership ballooned from only 5.3 million in 1990 to 136 million by 2013. This exponential growth has led to severe traffic congestion, higher energy demands, and worsening air pollution from vehicle emissions. These figures do not account for the growing number of trucks on the road, which are the largest emitters. There are both long and short-term measures that can be adopted to minimize the environmental impact of China's rapidly expanding transportation networks.

China's vehicle ownership ballooned from only 5.3 million in 1990 to 136 million by 2013

**Near and long-term planning.** There are measures that can be adopted both immediately and in the long-term to minimize the environmental impact of urbanization and growing demand for vehicles. Short-term economic measures such as congestion pricing and price reductions for public transportation can be applied in the next one to three years. In the long-term, accessible public transit options, bicycle-friendly communities, as well as mixed-use zones that minimize travel time between home, work and shopping areas, should be prioritized in city planning. These relatively simple aspects of planning can reduce traffic congestion and help curb vehicle emissions.

**Next-generation transportation options.** Long-term planning should also consider the development of next-generation transportation systems in addition to the improvement of existing infrastructure. Proposed next-generation systems, such as the Beijing Straddling Bus and the California SkyTran, are unique in that they can operate alongside existing infrastructure, accommodate large populations, and deliver flexible on-demand services. While there may be higher upfront costs associated with such systems, they have the potential to offer long-term solutions that accelerate the overall development of cleaner urban transportation.



## Opportunity Assessment

China's cities have expanded rapidly over the past two decades. With a fast growing economy and swelling population, the demand for personal mobility is rising sharply. In a nation where vehicle ownership has become a status symbol, the number of additional vehicles squeezing onto the roads each day poses significant environmental and infrastructural challenges. To create a sustainable urban transportation that can counter the demands of rapid urbanization (as well as its negative impact on the environment), China should prioritize transportation system optimization, targeted economic incentives, and smarter urban design. Integrating advanced infrastructure and technology with long-term planning will prove essential.

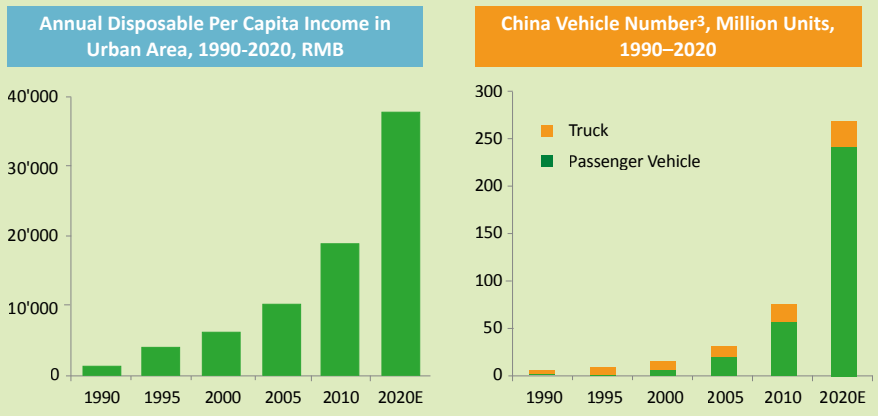
**Rapid urbanization is contributing to China's increasingly severe air quality**

Rapid urbanization in China has come at great environmental cost. China's national urbanization rate (which was just 26% in 1990) doubled to 50% in 2012 and is expected to exceed 60% by 2020; this growth has resulted in urban sprawl and inefficient road networks. Periodic restructuring of Beijing's ring roads to reduce congestion is one example of the high cost of suboptimal planning. While the current urbanization rate is still far below that of developed countries like the United States and the United Kingdom (81% and 80%, respectively), the rate of growth is unprecedented.[1]

According to the Chinese Academy of Sciences (CAS), the nation's top 15 cities with the longest daily commutes lost a combined RMB 1 billion per day from time spent on the road

China's urbanization has been accompanied by a sharp increase in per capita vehicle ownership, a figure that doubled over the past 10 years in Beijing alone.[2] In 2013, there were over 136 million vehicles on the road nationwide, forecasted to grow to 270 million by 2020.[3]

**Figure 1: Growing Vehicle Ownership Accompanies Rising Disposable Income**




**Socioeconomic Impact.** The socioeconomic impact of growing vehicle ownership in China is clear. According to one study by the Chinese Academy of Sciences (CAS), the nation's top 15 cities with the longest daily commutes lost a combined RMB 1 billion per day from time spent on the road.[4] In Shenzhen, Shanghai, Guangzhou and Beijing, average travel times to work are the longest, with Beijing topping the list with 52 minutes.

*1. Qiulin Chen and Li Qi, China's Push for Urbanization and Its Accompanying Challenges, (2013: Vol. 12, No. 1) China Research Center*
*2. Beijing Transportation Development Annual Report (2011) [2011 北京市交通发展年度报告 ], Beijing Transportation Development Research Institute*
*3. 2012 中国车用能源展望 [China Automotive Energy Outlook 2012], Tsinghua University, 2012; "2014 中国汽车市场展望 " [2014 Outlook for Automotive Development in China], wjshw.com, April 21, 2014, www.wjshw.com*
*4.《中国新型城市化报告 2012》[China 2012 New Urbanization Report], Chinese Academy of Sciences*

While the government is seeking to address the environmental consequences of growing vehicle ownership, investment strategies remain unclear. The Central Government's 2013 draft budget appropriates RMB 397 billion to the transportation sector, but does not specify how the funds will support the development of a cleaner transportation network. Some of the funds will be allocated for public transportation infrastructure development, but the exact figure is unknown.[5] Despite the lack of clear guidance from the Central Government, municipalities like Beijing have taken the initiative to minimize emissions through fuel efficiency improvements; for example, Beijing has adopted the highest fuel efficiency standards nationwide—China V.[6]

**System optimization, targeted economic incentives, and long-term planning are key measures to creating a sustainable urban transportation network**

China Greentech research and interviews indicate that China can reduce fuel consumption, traffic congestion, and vehicle emissions by focusing on six strategic areas:

**Figure 2: Strategic Areas to Reduce Fuel Consumption, Traffic Congestion and Vehicle Emissions**

| | | |
|---|---|---|
| **Regulatory Control**<br>Vehicle quotas, driving and infrastructure restrictions (such as parking limitations, plate lotteries and plate auctions) | + | Relatively simple to implement when compared to large-scale programs or new infrastructure projects |
| | – | Loopholes allow some car owners to obtain multiple license plates; compliance will be a challenge. Programs could also face resistance from automobile original equipment manufacturers (OEMs) and related state-owned enterprises |
| **Economic Measures**<br>Disincentives (such as congestion fees, higher parking fees and fuel taxes) | + | Road fees are a proven mechanism for reducing congestion in cities abroad |
| | – | May face resistance from oil and gas companies or auto OEMs |
| **Urban Design and Planning**<br>Long-term city planning and mixed-use development | + | Smarter urban design encourages non-passenger vehicle methods of transport and minimizes congestion |
| | – | Zoning issues and multiple stakeholder interests can cause delays in planning |
| **Technology Innovation**<br>Development of new technologies or improvement of existing technologies to improve vehicle efficiency (such as alternative fuel vehicles, new energy vehicles, and cleaner internal combustion engines (ICE) | + | This represents a strategic short-term investment for China since the market and technologies have matured and consumer acceptance is high |
| | – | Stimulating the private EV market can help China achieve its 2015 EV targets, but limited charging infrastructure, suboptimal EV performance and high costs impede adoption through natural market demand<br>Implementation of existing cleaner ICE technologies is often overlooked in favor of EV adoption, despite the two solution sets being complementary to creating sustainable urban transportation |
| **System Optimization**<br>Optimized use of existing vehicles and infrastructure (such as car-sharing systems, vehicle leasing programs, intelligent vehicles, and company shuttle buses) | + | Optimization is relatively simple to implement given the low cost, limited stakeholder involvement and few infrastructure requirements |
| | – | No obligatory regulations in place to incentivize system improvements in vehicles; no training available for drivers |
| **Public Education**<br>Awareness-building initiatives to emphasize the benefits of non-motorized transportation options, public transportation, and efficient private vehicle use | + | Campaigns reflecting the benefits of cleaner transportation can garner citizen support for future policies and economic measures |

5.《关于 2012 年中央和地方预算执行情况与 2013 年中央和地方预算草案的报告》,*[Report on 2012 Budget Implementation of Central and Local Governments and Plans for 2013] First Session of the Twelfth National People's Congress, Ministry of Finance of the People's Republic of China, March 5, 2013, www.china.org.cn*
*6. China to Publish National V Fuel Standard this Year, China Daily, February 22, 2013, www.chinadaily.com*

Based on these strategic areas, China Greentech developed three scenarios representing the future state of urban air quality in Beijing depending on China's approach to urbanization: 'blue sky', 'gray sky' and 'black sky'. Specifically, the scenarios demonstrate the environmental impact of vehicles on the road based on the nature and level of adoption of 1) economic disincentives 2) vehicle optimization and 3) sustainable urban design between now and 2015. Results from our survey of 22 industry experts following an in-depth discussion of Beijing's current traffic situation showed that 72% of participants expect the city's traffic woes to improve only moderately by 2015, resulting in 'gray sky' conditions. The remainder of participants felt that Beijing's traffic would worsen by 2015, resulting in the 'black sky' scenario. Similar experiments can be performed in cities across China to better understand how short-sighted development will impact regional air quality. Furthermore, lessons learned in Beijing can be used to inform planning schemes for second and third tier cities that are still in the early stages of development.

**Figure 3: Scenario Analysis for Beijing's Urban Transportation System**

| Scenarios | Black Sky | Gray Sky | Blue Sky |
|---|---|---|---|
| Regulatory Control | ▪ Policies are neither well-designed nor based on fact<br>▪ Policies are not implemented effectively | ▪ Policies are not well-designed but based on some facts<br>▪ Some policies are implemented effectively | ▪ Policies are well-designed and based on facts<br>▪ Most policies are implemented effectively |
| Economic Measures | ▪ Level of tax, fees and subsidies are not enough to change public behavior<br>▪ Use of effective economic measures is minimal | ▪ Level of tax, fees and subsidies are not enough to change public behavior<br>▪ More effective economic measures implemented | ▪ Level of tax, fees and subsidies are high enough to change people's behavior<br>▪ Useful economic measures implemented widely |
| City Planning | ▪ Ongoing lack of rational city planning and short-sighted decision-making<br>▪ No efforts to improve urban planning | ▪ Urban planning improves over the next five years<br>▪ Urban sprawl remains a problem in the near term | ▪ Fully adopt the new approach of urban planning<br>▪ Have improved the current suboptimal urban planning |
| Technology Innovation | ▪ Encourage vehicle technology innovation<br>▪ Ignore add-on device application | ▪ Encourage vehicle technology innovation<br>▪ Encourage add-on device application | ▪ Encourage vehicle technology innovation<br>▪ Promote extensively on add-on device application |
| System Optimization | ▪ No encouragement of vehicle sharing<br>▪ Minimal use of IT system to optimize urban transportation | ▪ Start to promote vehicle sharing<br>▪ Minimal use of IT system to optimize urban transportation | ▪ Encourage vehicle sharing<br>▪ Promote use of IT system to optimize urban transportation |
| Public Education | ▪ Encourage residents to walk, bike and take public transportation<br>▪ Educate the public on how to choose the best vehicles<br>▪ Education has no impact | ▪ Encourage residents to walk, bike and take public transport<br>▪ Educate the public on how to choose the best vehicles and modes<br>▪ Education effective to certain extent | ▪ Encourage residents to walk, bike and take public transportation<br>▪ Educate the public on how to choose the best vehicles, modes and driving habits<br>▪ Education is effective and influential |

**Short-to Medium-Term Solutions: Regulatory Measures, Smart Design, and IT.** There are several steps that cities can take in both the near- and long-term to minimize air pollution. In the short-term, congestion fees and affordable public transportation can help curb the increase in private cars on the road. Carpooling and shuttles for schools and companies should also be encouraged. In the medium- to longer-term, cities can prioritize the development of smarter road networks such as those that incorporate one-way couplets (pairs of one-way streets that provide higher vehicle capacity) to reduce congestion; promote cluster development to ensure that residences, offices, schools and shopping centers are all within reasonable distances; rebuild entries and exits of main roads to reduce congestion; and install traffic signs to alert drivers about changing traffic conditions. Mobile communications, 'free flow' traffic and intelligent traffic management systems could also be used to help minimize congestion.

**Next-generation transportation systems.** In addition to building on existing transportation networks, cities can also consider development of next-generation transportation systems to reduce emissions. Such systems have been proposed in China, the U.S. and the Netherlands, including the Beijing Straddling Bus, California SkyTran, and the Dutch Superbus. Next-generation systems are valuable given their ability to accommodate a high volume of passengers without impeding existing infrastructure and traffic, and delivering flexible and on-demand service. Though they are often overlooked due to high upfront costs and performance uncertainty, these systems have the potential to create new energy savings, alleviate congestion, and reduce vehicle emissions.

## Conclusion

China could achieve a "blue sky" transportation future if the right measures are taken. Creating sustainable urban centers will require Chinese cities to optimize current vehicles and infrastructure, and dramatically minimize emissions. Reducing vehicle emissions and increasing transportation efficiency (whether that be through shortening routes or improving access to public transportation) will only be achieved if a combination of regulatory measures, technical tools and economic incentives are adopted. Based on our research, infrastructure improvement and vehicle optimization are among the most promising opportunities to develop cleaner urban transportation systems in China. These efforts can then be bolstered with public awareness campaigns that promote the benefits of investments in cleaner vehicles.

In the short-term, congestion pricing and strict adoption of cleaner fuel standards are preferred methods to bring immediate relief to congested cities. In the long-term, it will be important for governments to implement regulations to support sustainable city planning and invest in next-generation transportation options, which have the potential to offer additional savings. Stakeholders across the entire Cleaner Vehicles Ecosystem will benefit as financing mechanisms, strategic planning resources, and partnerships are more carefully designed to support China to implement sustainable transportation networks.


Courtesy of Mike Hawkins

# DEVELOPING SUCCESSFUL REGIONAL ELECTRIC VEHICLE ECOSYSTEMS

China's 2015 targets for EVs and charging infrastructure are aggressive and challenging. They demand an accelerated approach with strong cooperation between government and the private sector. Regional EV ecosystems, designed around current technology and concentrated market opportunities, could very well accelerate EV adoption. Unlike a city-wide EV program, an ecosystem requires only modest charging infrastructure in the right location to stimulate EV adoption.

### Definition and Scope—Regional Electric Vehicle Ecosystems

Regional electric vehicle (EV) ecosystems use available technologies and viable business models to introduce EVs within a contained physical environment. Vehicles and charging infrastructure are clustered at densely populated locations to serve customers with common and predictable driving needs. Commercially viable business models and value propositions for all stakeholders are essential requirements for regional EV ecosystems.

## Overview

This Opportunity Assessment examines opportunities for regional EV ecosystems, the enabling factors for success and potential deployment locations in Beijing. The key insights are as follows:

**A regional EV ecosystem approach can help China meet ambitious EV targets.** National targets announced in 2012 aim for an 18-fold increase of EV sales in just three years. The government is already subsidizing vehicle purchases to encourage this growth, but many experts suggest regional EV ecosystems will be essential for success.

**Concentrating EV infrastructure and services in suitable locations with sufficient demand is already commercially viable with existing EV technologies.** Despite underdeveloped infrastructure and technological limitations, there are niche markets in which EV vehicles can operate cost-effectively if the right incentives are in place.

**The most promising locations for regional EV projects in Beijing are business campuses dominated by high-tech companies and white-collar workers.** Zhonguangcun Haidian Science Park and the Guomao office complex, for example, have the population, socioeconomics and market drivers to support their own EV ecosystems.

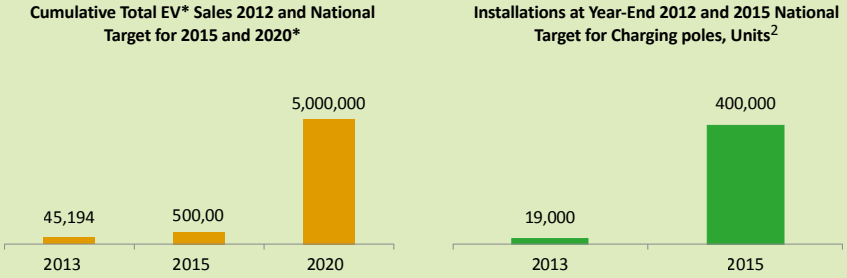
## Opportunity Assessment

### Policy environment: Aggressive EV targets for 2015

***"Government should play a key role in promoting EVs so that companies can have pilot projects in designated areas."—EV Manufacturer***

In 2012, when fewer than 28,000 electric cars and buses had been sold in China, the central government set a target to raise sales to 500,000 by 2015—an 18-fold increase in only three years. The target for 2020 is 5 million vehicles.[7] The number of charging poles is targeted to grow even faster.[8]

**Figure 4: EV and Charging Pole Deployment—2013 Status and National Targets**




*Includes Battery Electric Vehicles and Plug-in Hybrid Electric Vehicles

*Sources: 节能与新能源汽车产业发展规划 (2012-2020)[Energy Saving and New Energy Vehicle Industry Development Plan (2012-2020)], MIIT, April 2012, www.ycdpc.gov.cn; "2013 年中国汽车产销量双超 2000 万辆 再创全球最高纪录" [In 2013, car production in China exceeded 200 million units–the highest in the world], Guanchazhe, June 6, 2014, www.guancha.cn; "充电桩的中国式难题" [China's charging pole problems], cnfol.com, June 5, 2014, auto.cnfol.com*

7. "工信部公布 50 万辆新能源汽车规划" [MIIT Publishes the 500,000 New Energy Vehicle Plan], Ministry of Industry and Information Technology, February 23, 2012, www.sina.com; "节能与新能源汽车产业发展规划 (2012-2020)" [Energy Saving and New Energy Vehicle Industry Development Plan (2012-2020)], Ministry of Industry and Information Technology, April 2012, www.ycdpc.gov.cn
8. "电动汽车科技发展'十二五'专项规划" [MOST 12th Five-Year Plan on Electric Vehicle Industry], Ministry of Science and Technology, April 2011, www.most.gov; "中国成为世界上电动汽车充换电网络最完善的国家" [China to be the World Leader in EV Charging Network Completion], China News, March 3, 2012, www.chinanews.com

The intense push to accelerate EV adoption is driven partly by growing air pollution concerns. In Beijing, which suffered off-the-charts air pollution levels during the 'Airpocalypse' of January 2013, an estimated 22% of air pollution comes from transportation. An expanding market for low-emission EVs could contribute to clearer skies. In fact, Beijing has set its own ambitious target, aiming for 200,000 new-energy vehicles on the streets by 2017.

The new targets are far from current reality, and reaching them will require focused implementation over the next three to five years. The Tens of Cities, Thousands of Vehicles program, an EV scheme launched in 2009, appears to have missed its 2012 goals by a wide margin. Nationally, only 32% of the planned vehicles had been added by June 2012; more current figures are conspicuously unavailable.[9] Nonetheless, both central and local governments are redoubling their efforts to roll-out more EVs. China is starting another round of city-based EV promotion, with 28 cities and regions signed on as of November 2013. Some, such as Tianjin, have targets for 2015 that are ten times their 2012 targets.

The government strategy for "New Energy Vehicle Deployment Cities and Areas," released in September, relies on subsidies for vehicle purchases and public procurement of EVs.[10] But this approach will not necessarily resolve technical and infrastructure challenges that hinder EV development.[11] In China Greentech's interviews, many experts suggested the government should also subsidize regional EV ecosystem projects.

**Regional EV ecosystems: Making the most of current technologies**

***"Our priority is to accelerate our learning curve through small-scale implementation so we can have the data, knowledge and operational know-how essential for large-scale adoption." —Car rental company***



Regional EV ecosystems are underpinned by profitable business models using existing technologies, so that more EVs can be deployed with clear value propositions for customers, infrastructure providers, EV manufacturers and others. In an EV ecosystem at a large office building or industrial park, for example, charging stations for commuters can be concentrated at the workplace, even if infrastructure is still sparse elsewhere in the city. A typical commuter in Beijing drives only 50 kilometers per day; electric vehicles currently on the market have a range at least three times that and can be charged during the workday.[12] A variety of business models are possible: a car rental operator, for example, could lease cars to workers by the month or offer shared cars for travel to meetings during the day.

A typical commuter in Beijing drives only 50 kilometers per day; electric vehicles currently on the market have a range at least three times that and can be charged during the workday

Regional ecosystems create a laboratory for those in the EV industry to learn, mature and grow. All stakeholders have the chance to gather experience and data, and the ecosystems can uncover and address challenges to pave the way for larger-scale EV adoption.

*9. "十城千辆"示范城市节能与新能源汽车示范推广情况调研报告 [Tens of Cities Thousands of Vehicles Program Report], Ministry of Industry and Information Technology, May 2011, www.docin.com*
*10. "关于继续开展新能源汽车推广应用工作的通知" [Announcement on Advancing Development of New Energy Vehicles], Ministry of Finance, September 18, 2013, jjs.mof.gov.cn*
*11. Vision and Roadmap to Meet China's Electric Vehicle Goals, The China Greentech Initiative, 2013*
*12. China Greentech interviews and analysis*

To succeed, regional projects need supportive policies and incentives, appropriate technologies, and a favorable socioeconomic environment with the right types of customers and infrastructure. And of course, they need a commercially viable business model, with sufficient market demand and attractive economic benefits.

From its market analysis, China Greentech concluded that the first customers to target are companies, government departments and EV fleet operators. Individual consumers appear to be highly sensitive to price and infrastructure constraints, and may be slower adopters. China Greentech also modeled the potential cash flows and profits from an EV rental business: investment returns were highly sensitive to the cost of vehicles, rental prices and utilization rate—the percentage of the rental fleet in use at any given time. Achieving an acceptable return on investment (ROI) depends on lowering EV costs (through subsidies, for example), improving utilization, and charging high enough prices.

### The ecosystem operator: An important and commercially attractive role for companies

***"The four challenges impacting business model commercial viability are technology constraints, consumption attitudes, transportation models and balancing profits of different stakeholders."—Professor from North China University of Technology***

Regional EV projects involve several stakeholders, but operators are central to all stages of development and implementation. Companies hoping to benefit from involvement with EV ecosystems can consider taking on the role of operator to maximize their gains. A study by Bain & Co. looking at EV ecosystems in Europe found that profits tend to accrue downstream in the value chain, to sectors such as vehicle financing, electricity production and power management.[13]

Diverse types of businesses can become operators: office building operators, commercial building owners, retailers, managers of industrial parks or airports, vehicle manufacturers, charging providers and fleet owners could all operate regional ecosystems. In Europe, Bain & Co. reports that upstream providers such as car and battery makers are moving downstream to capture profit from higher-margin services. Likewise, companies in China can consider developing innovative business models to take advantage of the new opportunity for ecosystem operators during this national push for EV growth.

Business models for operators can be centered around vehicles or charging points. A vehicle-centered operator sells, leases or rents EVs, provides maintenance and offers value-added services such as reservation apps. Charging-centered operators install, maintain and manage the charging infrastructure, providing payment methods and other user services. Some EV manufacturers such as Renault-Nissan and Tesla deliver end-to-end solutions including vehicles, batteries, charging, financing and after-sales service. At least two EV ecosystem projects are already underway in China: Yika opened Beijing's first EV rental service in May 2013 at Tsinghua University Science Park, and Zhejiang Kangdi Group is preparing to launch a rental operation at Gudang Science Park in the city of Hangzhou.[14]

*13. "Is Your Electric Vehicle Strategy Shock-Proof?," Bain & Company, January 9, 2012*
*14. "电动北京伙伴计划在清华科技园启程" [E-Mobility Beijing Cooperation Program Kicks off at Tsinghua University Science Park], EVbeijing, May 20, 2013, www.evbeijing.cn; Beijing Introduces Electric Car Rental Service at 99 RMB Per Day, eChinacities, May 24, 2013, www.imqq.echinacities.com; "浙江康迪：将在杭州最高投放 1 万辆电动汽车，电动汽车时代，" [The Age of Electric Vehicles], June 18, 2013; "杭州纯电动汽车下周开租 20 元一小时", [Electric Vehicles Available for Rent in Hangzhou Beginning Next Week at RMB 20 Per Hour], Chexun Net, July 16, 2013*

**Attractive locations: Follow the knowledge workers**

***"Beijing has more than 160 science parks. We can start in a science park and then expand from there; gradually we can connect all the science parks into a larger regional network."—Service provider***

Focusing on EVs in Beijing, China Greentech surveyed locations for new regional ecosystems. Some of the best sites are business campuses filled with white-collar and high-tech workers, as well as certain high-density suburbs and airports. These areas share favorable socioeconomics for EV adoption: a good location must have the grid capacity to support an EV project, with affordable electricity prices. In addition, there should be enough people with sufficient disposable income and demand for cars or fleet vehicles. Highly educated, eco-and tech-friendly populations likely make for a better customer base; these upper-end customers can be motivated to adopt EVs because of the environmental costs of conventional vehicles. Furthermore, Beijing's license plate lotteries would make electric vehicles more readily available than conventional ones.[15]

China Greentech analyzed these socioeconomic factors in the assessment of key locations:

- **Beijing's industrial parks** have an attractive mix of large companies, residences and sometimes universities, with favorable socioeconomics and population density. Given that the campuses lie along the periphery of the city, convenient transportation is often left to the workers' devices. Of 13 sites, China Greentech singled out the Chaoyang, Changping and Zhongguancun Haidian parks for their large size and high-tech businesses.

- **In centrally located office buildings,** high-income and well-educated employees are the main targeted customers. Guomao, Parkview Green, Pangu Mansions and government buildings are examples of potential locations.

- **Suburban residential areas** with large populations, latent demand and inefficient mobility choices can be profitable locations. In addition, charging infrastructure at or near homes helps solve consumers' concerns about the ability to charge their vehicles and reduces dependence on public infrastructure providers such as State Grid.

- **Airports** with large passenger throughput can use EVs for pickup services and inter-terminal transport.

At China Greentech's Working Session on regional EV ecosystems held in September of 2013, participating experts selected the Zhongguancun Haidian Science Park and the Guomao office complex as the most attractive project opportunities.



*15. China Greentech interviews and analysis*

## Conclusion

China's 2015 targets for EVs and charging infrastructure are aggressive and challenging. They demand an accelerated approach with strong cooperation between government and the private sector. Regional EV ecosystems, designed around current technology and concentrated market opportunities, could very well accelerate EV adoption. Unlike a city-wide EV program, an ecosystem requires only modest charging infrastructure in the right location to stimulate EV adoption.

The viability of these projects depends on finding locations with sufficient customers who need innovative transportation solutions. Successful ecosystems also require government support, appropriate technologies, and business models that provide acceptable financial returns. Subsidies to help bring down upfront capital outlays and operating models that boost utilization are essential for profitability.

With a broad range of potential models, regional EV ecosystems are an invitation to innovate. Companies that seize the opportunity to launch and operate these projects will play a central role in China's EV rollout and be well-positioned to capture future market opportunities.

# GLOSSARY

*Courtesy of Eric Rindal*

| Term | Definition |
|---|---|
| **3-star certification** | A green building rating system initiated by the Ministry of Housing and Urban-Rural Development (MOHURD) in 2006. 3-star is the highest certificate and 1-star is the lowest |
| **Big Data** | Large and complex data sets produced at a rapid pace that can provide valuable insights for business decisions |
| **Big Data analytics** | The process of organizing and analyzing large volumes of data to extract useful information and patterns |
| **Billion cubic meters (bcm)** | A unit of measure of natural gas production and trade |
| **Biomass** | Organic material that can be converted to fuel |
| **Carbon intensity** | The average emission rate of carbon dioxide from a given source relative to the intensity of a specific activity, such as per unit of GDP |
| **Chinese People's Political Consultative Conference (CPPCC)** | An advisory body to the Chinese government consisting of delegates from various parties and organizations. The CPPCC normally holds annual meetings simultaneous to the plenary sessions of the National People's Congress (NPC) |
| **Circular economy** | Defined by Chinese government as activities involving volume reduction, reutilization and resource recovery during production, transportation and consumption |
| **Clean coal technology** | A collection of technologies being developed to mitigate the environmental impact of coal power generation |
| **Cleaner conventional energy** | The energy derived from non-renewable fossil fuels (e.g. coal, oil and natural gas) and nuclear power in ways that minimize their negative impact on the natural environment |
| **Cleaner transportation** | Solutions that increase energy efficiency, reduce emissions and improve resource utilization to minimize the negative impact of transportation on the environment. These solutions span four major subsectors: road, rail, air and waterways |

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| **Cleaner vehicles** | Solutions that increase energy efficiency, reduce emissions and improve resource utilization to minimize the negative impact of high speed road vehicles on the environment. These solutions span to New Energy Vehicles and Energy Saving Vehicles as defined by the Chinese Government |
| **Combined cooling heating and power (CCHP)** | CCHP, also known as trigeneration, refers to the simultaneous generation of electricity along with useful heating and cooling. CCHP can be used to capture and reuse waste heat from thermal plants and other industrial processes and sectors |
| **Cradle-to-cradle** | An economic, industrial and social framework that seeks to create systems that are efficient to the point of being essentially waste-free |
| **Distributed energy** | Energy generated onsite or near energy end-users—typically on a small-scale—that can either be connected to the grid or stand alone off-grid |
| **Distributed photovoltaic (PV)** | Solar energy generated onsite or near energy end-users—typically on a small-scale—that can be connected to the grid or stand alone off-grid |
| **Direct ammonia injection SCR** | A technique to reduce NOx emissions from power production. By injecting ammonia on exhaust emissions after fuel combustion, NOx is reduced to diatomic nitrogen and water |
| **Electric vehicle (EV)** | EVs are propelled by an electric motor (or motors) powered by rechargeable battery packs. Advantages over internal combustion engines (ICEs) include higher energy efficiency, less pollution, higher performance and reduction of energy dependence. Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electricity Vehicles (PHEVs) are the most common types of EVs |
| **Energy service company (ESCO)** | A specialized commercial business providing energy efficiency solutions to industrial or commercial clients over a specified payback period |
| **Energy use per unit of industrial added value** | The ratio of energy use to the contribution of a private industry or government sector to overall GDP. In China, this figure is only calculated for registered companies with annual revenues of more than RMB 5 million |
| **Expanded Polystyrene (EPS)/ Extruded Polystyrene (XPS) Insulation** | Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) are two common types of thermal insulation material usually manufactured as boards, which can be attached with a high degree of flexibility to building walls and roofs |
| **Five-Year Plan (FYP)** | The Chinese government's overarching policy framework shaping social and economic development, including both binding and non-binding targets for the specified period |

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| **Gesellschaft für Internationale Zusammenarbeit (GIZ)** | GIZ is the executive agency of the German government for development projects outside of Germany. GIZ project areas in China include electromobility, building energy efficiency and renewable energy |
| **Gigawatt (GW)** | A unit of power equivalent to one billion watts or 1,000 megawatts |
| **Green loans** | Loans provided by Chinese banks for environmental and resource saving projects. Criteria for green loans are determined by the China Banking Regulatory Commission |
| **Greentech** | Greentech refers to technologies, products and services that deliver benefits to users of equal or greater value than those of conventional alternatives, while limiting the impact on the natural environment as well as maximizing the efficient and sustainable use of energy, water and other resources |
| **Grid connectivity** | Qualitative connection of power generation utility to the grid |
| **Gross domestic product (GDP)** | The total value of goods produced and services provided in a country during one year |
| **Heating, ventilation and air conditioning (HVAC)** | The building climate control system that ensures that room temperature, humidity and air flow are adequate to sustain a comfortable indoor environment |
| **High efficiency cooling** | A system that consumes less energy while achieving equivalent cooling as alternatives |
| **Hybrid electric vehicles** | Powered by conventional or alternative fuels as well as electric power stored in a battery, HEVs use regenerative braking and the internal combustion engine (ICE) to charge |
| **Institute of Public and Environmental Affairs (IPE)** | A non-profit environmental protection organization in Beijing. Established in 2006, it is dedicated to promoting the disclosure of environmental information to the general public |
| **Internal rate of return (IRR)** | An indicator of the profitability of investments. It provides the percentage of investment returns over a period of time based on project-related cash flows, excluding environmental factors such as inflation or interest rates |
| **International Finance Corporation (IFC)** | The private sector investment arm of the World Bank Group. IFC provides funding and auditing services for development projects that are bankable under market conditions |
| **Intergovernmental Panel on Climate Change (IPCC)** | An intergovernmental body under the United Nations reporting on climate change. The IPCC gathers information from scientific sources to estimate options for mitigating climate change and provide policy recommendations |

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| **Joint Committee on Environmental Cooperation (JCEC)** | A platform for strengthening ongoing collaboration and cooperation between the United States Environmental Protection Agency (EPA) and the State Environmental Protection Administration (SEPA) of the People's Republic of China |
| **Key performance indicator (KPI)** | A set of quantifiable measures that a company or industry uses to gauge or compare performance in terms of meeting their strategic and operational goals. KPIs vary by company and industry, depending on priorities or performance criteria |
| **Leadership in Energy and Environmental Design (LEED)** | Rating system for the design, construction and operation of high-performance green buildings developed by the United States Green Building Council |
| **Life-cycle assessment** | A technique used to assess the environmental impact of all stages of a product's existence, from raw material extraction through materials processing, manufacture, distribution, use, repair, maintenance, and disposal or recycling |
| **Lithium-ion battery (Li-ion)** | Known for their use in consumer electronics, as well as increasing use in pure electric vehicle applications. Compared to nickel-metal hydride batteries, Li-ion batteries enjoy a higher energy density, longer life cycle, charge faster and perform better in colder weather |
| **Liquid hydrocarbons** | Byproducts of fossil fuel combustion that can be used as components for transportation fuels (such as diesel and gasoline) fertilizers, lubricants and other products |
| **Megawatt (MW)** | A unit of power equivalent to one million watts |
| **Ministry of Environmental Protection (MEP)** | Cabinet-level ministry charged with the task of protecting China's air, water and land from pollution and contamination. Directly under the State Council, it is empowered and required by law to implement environmental policies and enforce environmental laws and regulations. Complementing its regulatory role, it funds and organizes research and development. MEP also serves as China's nuclear safety agency |
| **Ministry of Housing and Urban-Rural Development (MOHURD)** | Ministry under the jurisdiction of the State Council regulating state construction activities in China |
| **Ministry of Industry and Information Technology (MIIT)** | Ministry responsible for the regulation and development of the postal service, internet, broadcasting, communications, production of electronic and information goods, software industry and the promotion of the national knowledge economy |
| **Ministry of Land and Resources (MLR)** | Ministry under the jurisdiction of the State Council, responsible for the regulation, management, preservation and utilization of natural resources such as land, mines and oceans |
| **Ministry of Water Resources (MWR)** | Ministry under the jurisdiction of the State Council, responsible for the regulation, management, preservation and use of China's surface and underground water resources |

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| **Municipal solid waste (MSW)** | A combination of residential waste (including food scraps, packaging plastics, paper, electronics), commercial waste from offices, restaurants (including waste cooking oil), and non-process waste from industry |
| **National Development and Reform Commission (NDRC)** | The macroeconomic management agency under the State Council, with broad administrative and planning control over the Chinese economy. NDRC studies and formulates policies for economic and social development, maintains the balance of economic development, and guides the restructuring of China's economic system |
| **National People's Congress (NPC)** | China's legislative body or parliament, the NPC has various functions, including electing the President of the People's Republic of China and approving the appointment of the Premier of the State Council. The constitution of the National People's Congress provides for most of its power to be exercised on a day-to-day basis by its Standing Committee |
| **Natural Resources Defense Council (NRDC)** | A US non-profit, non-governmental organization that actively promotes and advocates environmental protection |
| **New energy vehicle (NEV)** | Vehicles that are not driven by gasoline or diesel internal combustion engines, but by engines powered by other sources (such as storage batteries, fuel cell, or solar power) |
| **Nitrogen oxides (NOx)** | Any of various oxides of nitrogen, including nitrous oxide, nitric oxide and nitrogen dioxide |
| **Original equipment manufacturer (OEM)** | An organization that makes devices from component parts purchased from other organizations. OEM is also often used to refer to the company that acquires a product or component and reuses or incorporates it into a new product with its own brand name |
| **Passive design** | A system for buildings that considers in the design the thermal processes of convection, conduction, absorption and radiation to maintain comfort levels and reduce or eliminate the need for mechanical systems that would be installed for these purposes |
| **Peak load** | Time of day during which electricity load on the grid is at its highest. Peak load corresponds with the time of greatest power demand and usually occurs during early afternoon and evening time. |
| **Plug-in hybrid electric vehicle (PHEV)** | Hybrid with an extension cord that can be plugged in to any 120-volt outlet to recharge |
| **PM10** | Particulate matter equal to or less than 10 micrometers in aerodynamic diameter |

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| **$PM_{2.5}$** | Fine particulate matter equal to or less than 2.5 micrometers in aerodynamic diameter |
| **Pollution Information Transparency Index (PITI)** | A database developed by Institute of Public and Environmental Affairs (IPE) and Natural Resources Defense Council (NRDC) that evaluates the disclosure of pollution information in 113 cities in China |
| **Regulatory Assistance Project (RAP)** | A global, non-profit team of experts focused on the long-term economic and environmental sustainability of the power and natural gas sectors, providing assistance to government officials on a broad range of energy and environmental issues |
| **Renewable energy** | Energy produced from sources that are naturally replenishing, such as sunlight, wind, waves, underground heat, surface water flows and biomass |
| **Scrubbers** | A device for removing pollutants from smoke or gas produced by burning high-sulfur fuels |
| **Shale gas** | Natural gas that is found within shale formations |
| **Smart grid** | Networks supported by digital technology capable of exerting "smart control" over all aspects of the electric power sector (including generation, transmission, distribution, customer service and power dispatch at all voltage levels). These networks deliver power in an efficient manner and can better integrate power from renewable sources |
| **Smart meter** | Electricity monitoring devices with two-way communication capabilities, allowing utilities and customers to analyze energy use. China's definition includes both automatic meter reading (AMR) and advanced meter infrastructure (AMI) |
| **Solar photovoltaic (PV)** | Devices that convert light into direct current using the photoelectric effect. Solar PV is the main technology used in China for the generation of electric solar power |
| **State Council** | The chief administrative authority of China. It is chaired by the Premier and includes the heads of each governmental department and agency. The State Council directly oversees the various subordinate People's Governments in the provinces, and maintains an interlocking membership with the top levels of the Communist Party of China, creating a fused center of power |
| **State Grid Cooperation of China (SGCC)** | China's largest power utility. SGCC and its subsidiaries hold a monopoly in the electricity transmission and distribution with the exception of a few provinces in southern China, where electricity is provided by China Southern Power Grid Company |

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| **State Electricity Regulatory Commission (SERC)** | Government agency responsible for the administration and regulation of the electricity and power industry. This includes regulating the development of electricity markets, setting tariffs, transmission, distribution, safety standards, technical standards, business licenses and environmental laws |
| **State Owned Enterprise Electric Vehicle Industry Alliance (SEVIA)** | National platform of state owned enterprises founded in 2010 with the purpose of coordinating development of the electric vehicle sector |
| **Strategic Emerging Industry (SEI)** | Seven industries that receive special support in the 12th Five-Year Plan period: energy saving and environment protection, new energy, new energy vehicles, new materials, high-end equipment manufacturing, next generation IT and biotechnology |
| **Sulfur dioxide ($SO_2$)** | A colorless poisonous gas or liquid with a strong odor. Formed naturally by volcanic activity, it is a waste gas produced by burning coal and oil and by many industrial processes, such as smelting. It is also a hazardous air pollutant and a major contributor to acid rain |
| **Sulfur scrubbing** | Process to remove harmful gas sulfur dioxide from the exhaust flue gases of fossil fuel power plants |
| **Supply chain** | A system of organizations, people, activities, information and resources involved in moving a product or service from supplier to customer |
| **Tens of Cities, Thousands of Vehicles Program** | A program, originally consisting of 13 pilot cities (raised to 25 in 2010) promoting the deployment of electric vehicles (EVs) in the public sector until 2012. Their targets ranged from 1,000 to 9,000 EVs. The central government pledged subsidies of up to RMB 420,000 (USD 64,615) per hybrid bus, RMB 500,000 (USD 76,923) per fully electric bus and RMB 600,000 (USD 92,307) per fuel cell bus |
| **Terawatt hours (TWh)** | A unit for a large amount of electricity. 1 TWh is equivalent to 100 kWh |
| **Time-of-use (TOU) pricing** | Time-of-use pricing refers to electricity price differences by time of the day. With higher prices during peak hours, users are encouraged to shift operations to non-peak times. The purpose of TOU pricing is to increase reliability of the power grid and avoid blackouts |
| **Tons of Coal Equivalent (TCE)** | Unit representing energy generated by burning one metric ton (1,000 kilograms or 2,204.7 pounds) of coal, equivalent to the energy obtained from burning 5.2 barrels (700 kilograms) of oil or 890 cubic meters of natural gas. The energy generated is equivalent to 29.4 gigajoules (GJ), 27.78 million Btu (MMBtu), or 8.14 megawatt hours (MWh) |

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| **United States Energy Information Administration (EIA)** | The primary United States federal government authority on energy statistics and analysis |
| **United States Environmental Protection Agency (EPA)** | An agency of the United States federal government responsible for protecting human health and the environment. The EPA is not a Cabinet department, but the administrator is normally given a cabinet rank |
| **Waste disposal** | The collection, transportation and processing of waste materials (liquid, solid, gaseous) to reduce their negative impact on human health and the environment |
| **Wastewater treatment** | Collection and treatment of water discharged after consumption for either secondary consumption or release into the environment |
| **Water reclamation** | Process by which wastewater from residential, commercial and industrial users is treated to be reused in commercial or environmental remediation projects. Also referred to as water reuse |
| **Water treatment** | Process by which raw water is made ready for use |
| **Water use per unit of industrial added value** | The ratio of water consumption over industrial added value. It is an indicator in the industry of water efficiency |
| **Watt (W)** | Unit to measure the amount of energy at a given point in time |
| **Watt hours (Wh)** | Unit to measure the amount of energy during a period of time (power). Common multipliers are kilowatt hour (1kWh = 1000Wh), megawatt hour (1mWh = 1000,000Wh) and terrawatt hour (1tWh = 1000,000,000Wh) |
| **World Health Organization (WHO)** | The directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters |
| **World Wildlife Fund (WWF)** | The WWF is an international NGO with the goal of conserving and restoring the environment. The organization is funded by donations and operates in over 100 countries |

# ACRONYMS

Courtesy of Eric Rindal

| Term | Definition |
|---|---|
| **AQI** | Air quality index |
| **bcm** | Billion cubic meters |
| **BMS** | Battery management system |
| **CHUEE** | China Utility-Based Energy Efficiency Finance Program |
| **CPPCC** | Chinese People's Political Consultative Conference |
| **CSR** | Corporate social responsibility |
| **EPA** | U.S. Environmental Protection Agency |
| **EPB** | Environmental Protection Bureau |
| **ESCO** | National Energy Administration |
| **EV** | Electric vehicle |
| **GDP** | Gross domestic product |
| **GW** | Gigawatt |
| **HVAC** | Heating, ventilation and air conditioning |
| **ICE** | Internal combustion engine |
| **IFC** | International Finance Corporation |

| Term | Definition |
|---|---|
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IPE** | Institute of Public and Environmental Affairs |
| **JCEC** | Joint Committee on Environmental Cooperation |
| **KPI** | Key performance indicator |
| **kWh** | Kilowatt hour |
| **LCA** | Life-cycle assessment |
| **LEED** | Leadership in Energy and Environmental Design |
| **MEP** | Ministry of Environmental Protection |
| **MNC** | Multinational corporation |
| **MOF** | Ministry of Finance |
| **MOHURD** | Ministry of Housing and Urban-Rural Development |
| **MSW** | Municipal solid waste |
| **MW** | Megawatt |
| **NDRC** | National Development and Reform Commission |

| Term | Definition |
|---|---|
| **NEA** | National Energy Administration |
| **NEV** | New energy vehicle |
| **NGO** | Non-governmental organization |
| **NOx** | Nitrogen oxides |
| **NPC** | National People's Congress |
| **NRDC** | Natural Resources Defense Council |
| **O&M** | Operations and maintenance |
| **PHEV** | Plug-in hybrid electric vehicle |
| **PITI** | Pollution Information Transparency Index |
| **$PM_{2.5}$** | Particulate matter with diameter smaller than 2.5 micrometers |
| **PV** | Photovoltaics |
| **RAP** | Regulatory Assistance Project |
| **$SO_2$** | Sulfur dioxide |
| **SOE** | State-owned enterprise |
| **TCE** | Tons of coal equivalent |
| **UN** | United Nations |

Courtesy of Greg Kaeuper

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**More than one thousand individuals from over 100 leading technology and services companies, entrepreneurs, investors, NGOs and policy advisors provided input to *The China Greentech Report™ 2014*. The logos of China Greentech's Partners, Advisors and Supporting Organizations are presented on the front and inside cover, as well as listed at the end of this document. This Report is only possible because of the support and direction provided by these organizations.**

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China Greentech Managing Director Elle Carberry ( 柯凯丽 ) leads the company in China. Business Development Directors Alex Ornik ( 欧健凯 ) and Caitlin Rhodes ( 周嘉莲 ) were responsible for developing relationships with international companies. Key Account Manager Cindy Jiang ( 姜新燕 ) worked to develop relationships with Chinese Partners and Supporting Organizations. We would also like to acknowledge Sarah Guo ( 郭雪 ) for her contributions in 2013.

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# ABOUT THE CHINA GREENTECH INITIATIVE

*Courtesy of Sherry Zhang*

**The China Greentech Initiative™** is the only collaboration platform that develops and connects strategic insights on China's greentech markets with an expert community of over 100 companies and governments. As a neutral third party, we accelerate the market by integrating expertise from different nations and municipalities, industries and ecosystems, as well as across stakeholder roles to facilitate collaboration. China Greentech's trusted position enables us to produce the most reliable and holistic analysis to inform business decisions around the China opportunity.

Our vision is to advance China's cities and zones toward greener, smarter and more productive development. China Greentech helps companies increase their profitability while supporting China's sustainable growth by developing intelligence on cities and zones, sourcing high-value project opportunities, creating insights on new go-to-market models, engaging with the government, and promoting successes to the market that can then be replicated for greater impact. China Greentech provides three distinct levels of support to companies:

- The Strategic Partnership—This exclusive group defines the models through which local and international companies can work together to dismantle market misconceptions, address obstacles to greentech solution adoption, and collaborate on specific market opportunities to drive cleaner development. Participating companies combine their collective resources with China Greentech's analysis, project intelligence and network to create integrated solutions for China's project owners and governments.

- The Member Program—Connects companies to market insights, project intelligence and other experts to help inform business decisions. Companies subscribe to an annual membership that gives them access to China Greentech's extensive knowledge and network.

- Advisory Services—Our network of Chinese and international experts and rich knowledgebase stand as our greatest assets. We bring the insights and best practices gleaned from working closely with hundreds of companies and government bodies to help define strategies for specific market and project opportunities on a proprietary basis.

For more information about China Greentech please visit www.china-greentech.com

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## Profile

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**DP Cleantech** Co Ltd is an independent, world leading renewable energy company specializing in the conversion of various waste by-products to energy. Founded in 2004, DPCT owns the IP for core European biomass to power technology; and also offers the engineering design; equipment manufacturing and sourcing; installation, commissioning and servicing capabilities to support a robust and integrated product and services proposition for the global renewables market. Headquartered in Europe, with an established reference list of over 70 biomass power plants around the world and over 30% share in the fast growing China market; DP CleanTech has strategically expanded its geographic scope and leveraged its technology expertise, depth of experience and global supply chain to pioneer new approaches to value engineering; supplying performance-guaranteed, end-to-end biomass power solutions to a wide and growing range of clients.
Website: http://www.dpcleantech.com/

### Parkview Green Fangcaodi

Developed by the listed Hong Kong Parkview Group, **Parkview Green Fangcaodi** is a green building setting new innovative standards for sustainable development. It houses office towers, a shopping mall, an art centre and a boutique hotel. It is also the first mix-use commercial project in China to be awarded the LEED Platinum.
Website: http://www.parkviewgreen.com/eng/

### RTI International

**RTI** International is one of the world's leading research institutes, dedicated to improving the human condition by turning knowledge into practice. Headquartered in the United States, RTI has more than 3,700 staff who provide research and technical services to governments and businesses in more than 75 countries. RTI's Beijing office specializes in energy and the environment, with a special focus on air quality monitoring.
Website: www.rti.org

## Strategic Partners

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3M captures the spark of new ideas and transforms them into thousands of ingenious products. Our culture of creative collaboration inspires a never-ending stream of powerful technologies that make life better. 3M is the innovation company that never stops inventing. With $31 billion in sales, 3M employs 89,000 people worldwide and has operations in more than 70 countries. For more information, visit www.3M.com or follow @3MNews on Twitter.
Website: www.3M.com

**BP**

Headquartered in London, **BP** is one of the world's largest oil and gas companies. It has operations in more than 80 countries and our major business activities include exploration and production; refining, marketing and chemicals; and renewables. BP hires over 80,000 employees worldwide and its shares are traded at the London and New York stock exchange markets.
Website: http://www.bp.com.cn

**Dow**

**Dow** combines the power of science and technology to passionately innovate what is essential to human progress. The Company connects chemistry and innovation with the principles of sustainability to help address many of the world's most challenging problems such as the need for clean water, renewable energy generation and conservation, and increasing agricultural productivity. Dow's diversified industry-leading portfolio of specialty chemical, advanced materials, agrosciences, and plastics businesses delivers a broad range of technology-based products and solutions to customers in approximately 160 countries and in high growth sectors such as electronics, water, energy, coatings and agriculture. In 2011, Dow had annual sales of $60 billion and employed approximately 52,000 people worldwide. The Company's more than 5,000 products are manufactured at 197 sites in 36 countries across the globe. Dow entered China as early as the 1930s. Since that time, the Company has invested US$ 1.2 billion in the Greater China region, with annual sales of more than US$ 4.45 billion in 2011, which makes it the second largest international market for Dow globally.
Website: http://www.dow.com

**Haworth**

**Haworth** is a global leader in the design and manufacture of office furniture and organic workspaces. Serving markets in more than 120 countries, Haworth brings together workplace knowledge and combines it with our global capabilities to create high performance environments that support truly successful organizations.
Website: http://www.ap.haworth-asia.com

**IBM**

**IBM,** the International Business Machines Corporation, founded in 1911 in the United States, is a world leader of information technology and business solutions. The company creates business value for clients and helps solve their problems through integrated solutions that leverage information technology and deep knowledge of organizational processes. In 2009, IBM put forward the vision of "Smarter Planet" globally to further boost the development of the next generation information technology and industry. In 2011, IBM's global business turnover has reached USD 106.9 billion. It has registered 6,180 patents in the US, ranking No.1 around the world for 19 consecutive years. In China, IBM has all business operations from R&D to products and services offerings. By June 2012, IBM has opened 50 branches in China and has established the R&D centers, the Global Procurement Headquarters and Global Delivery Centers in many China cities. IBM China was honored and recognized as "2012 Top Most Responsible Company" by Fortune China, "2011 Outstanding Enterprise of the Year Award" by China Business News and "2011 The 5-Star China Outstanding Corporate Citizenship Award" by the China Corporate Citizen Committee, just to name a few.
Website: http://www.ibm.com

## Game Changers Partners

**APCO Worldwide**

**APCO Worldwide** is an independent global communication, stakeholder engagement and business strategy firm with offices in more than 30 major cities around the world. We have been serving clients' interests in China since 1989. Today, our China team includes more than 100 professionals from a diverse range of backgrounds, including business, government, journalism, academic and civil society. We are based in well-established offices in Beijing, Shanghai and Hong Kong.
Website: http://www.apcoworldwide.com

**Bayer**

**Bayer** is a global enterprise with core competencies in the fields of health care, agriculture and high-tech materials. As an inventor company, it sets trends in research-intensive areas. Bayer's products and services are designed to benefit people and improve the quality of life. At the same time, the Group aims to create value through innovation, growth and high earning power. Bayer is committed to the principles of sustainable development and acts as a socially and ethically responsible corporate citizen. In fiscal 2012, the Group employed 110,500 people and had sales of €39.8 billion. Capital expenditures amounted to €2.0 billion, R&D expenses to €3.0 billion. For more information, go to www.bayer.com.
Website: http://www.bayer.com

**Coca-Cola**

The "**Coca-Cola**" brand is one of the most famous international brands in China. The brand enjoys its leading role in Chinese soft drinks market, with a vast portfolio products that are among the most welcomed drinks in China. Coca-Cola system together with its bottlers have been and will continue to operate as responsible corporate citizens, supporting local education programs, cooperative CSR projects and environmental protection projects for the benefit of sustainable community development in China. For more information on Coca-Cola's sustainability activities, please visit our website at http://www.coca-cola.com.cn/sustainability/
Website: http://www.coca-cola.com.cn

### Dorsey & Whitney LLP

Clients have relied on **Dorsey & Whitney LLP** as a valued business partner since 1912. Our Cleantech Industry Group has the privilege of serving hundreds of cleantech companies and investors across the globe, including many of the sector's most promising early and late stage technology companies.
Our group integrates over 70 lawyers located across offices in the United States, Canada, Europe, Asia and Australia, and practicing in a variety of specialty areas, including corporate finance, private equity, project finance, energy regulatory, tax, intellectual property, advocacy and others. This broad array of specialty practices allows the group to offer clients seamless service throughout their life cycle—from assistance with early stage venture financings, intellectual property counseling and patent procurement to mid-stage project financings and later stage capital markets and merger and acquisition transactions.
Website: http://www.dorsey.com/

### Eastman

**Eastman** is a global specialty chemicals company that produces a broad range of advanced materials, additives and functional products, specialty chemicals, and fibers that are found in products people use every day. As a world leader in the diverse markets it serves, Eastman is focused on delivering innovative and technology-based solutions while maintaining its commitment to safety and sustainability. Serving customers in approximately 100 countries, Eastman had 2011 pro forma combined revenues, giving effect to the Solutia acquisition, of approximately $9.3 billion. The company is based in Kingsport, Tennessee, USA, and, with the completion of the Solutia acquisition, now employs approximately 13,500 people around the world.
Website: http://www.eastman.com

### Greentech Capital Advisors

**Greentech Capital Advisors** is a specialist investment banking firm advising companies transforming the world's energy, industrial, and resources infrastructure. We provide financial advisory services—for M&A, strategic joint ventures, private placements and project finance—to the global corporations and emerging growth companies that are driving the transition to a more efficient and productive growth economy. Through our offices in New York, Zürich, and San Francisco, we maintain an extensive global network of relationships with investors and senior decision makers at sustainable infrastructure companies. With more experience and expertise, in addition to deeper relationships, we provide our clients tailored solutions designed to meet their needs.
Website: http://www.greentechcapital.com

### HAO Capital

**HAO Capital** is a China focused Private Equity firm based in Beijing and Hong Kong, providing growth capital to Chinese companies. Founded in 2005 by three seasoned investment professionals, we currently manage total assets of USD 500mn across two funds. Our skilled and diverse China team has more than 125 years of cumulative experience in investment and operating management. Our LP's include institutional investors and high net worth individuals. We are biased for investments in Consumer, Healthcare and Light Industrial, including Clean/ Greentech. Our targeting investments vary from RMB 80mn to RMB 300mn with target ownership ranging from 10-25%.
Website: http://www.haocapital.net

**Kleiner Perkins Caulfield & Byers**

**Kleiner Perkins Caufield & Byers** (KPCB), since 1972 has backed hundreds of entrepreneurs in building over 600 ventures, including such major names as AOL, Amazon.com, Bloom Energy, Compaq Computer, Electronic Arts, Genentech, Google, Netscape, Sun Microsystems, and Zynga. By forming partnership with TDF Capital, KPCB officially launched operation in China with offices in Beijing and Shanghai in 2007. KPCB China team has backed successful ventures such as 360buy, Alibaba, Baidu, Focus Media, A8.com, Sungrow, Autonavi, Kanghui and CAR. KPCB China manages two USD funds, one RMB fund and together with KPCB US manage over U.S. $3.5 billion of funds. KPCB China is well positioned to assist Chinese entrepreneurs and to promote innovation in high-growth industries, including Greentech, TMT, and Life Sciences.
Website: http://www.kpcb.com/focus/china

**MAN**

**The MAN Group** is one of Europe's leading manufacturers of commercial vehicles, engines and mechanical engineering equipment with annual revenue of approximately €16.5 billion and around 52.500 employees worldwide. MAN supplies trucks, buses, diesel engines and turbomachinery as well as turnkey power plants. MAN's divisions hold leading positions in their respective markets. MAN is at the leading edge of developing green solutions such as for cleaner transportation, efficiency, cleaner coal utilization and renewable energy.
Website: http://www.man.eu

**OgilvyEarth**

**OgilvyEarth** is a global sustainability practice that helps brands harness the power of sustainability through innovative business thinking, strategic planning and communications. OgilvyEarth works with visionary companies that are looking to make sustainability a growth driver for both their business and the communities they serve. OgilvyEarth is a unit of Ogilvy & Mather, a WPP company (NASDAQ: WPPGY), one of the world's largest communications services groups. For more information, please visit www.ogilvyearth.com.
Website: http://www.ogilvypr.com and http://www.ogilvyearth.com

**PwC**

**PwC** helps organisations and individuals create the value they are looking for. We are a network of firms in 158 countries with more than 180,000 people who are committed to delivering quality in assurance, tax and advisory services. Tell us what matters to you and find out more by visiting us at www.pwc.com.
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**Qiming Venture Partners**

**Qiming Venture Partners** is a leading venture capital firm in China with offices in Shanghai, Beijing, Hong Kong, Suzhou and Seattle. Founded in February 2006. Qiming currently manages five funds with $1.1 Billion in assets and focuses on early to growth stage investments in Information Technology, Internet and Consumer, Healthcare, and Cleantech. Qiming's over 20 partners and investment professionals who all have strong operational experience and successful investment track records add a great deal of value to the portfolio companies. Qiming has invested in over 70 companies and many of them have gone IPO or mergers and acquisitions. Qiming has established a great reputation and strives to be the top investment partner by the Chinese entrepreneurs.
Website: http://www.qimingvc.com

## Saint-Gobain

**Saint-Gobain,** the world leader in the habitat and construction market, designs, manufactures and distributes building materials, providing innovative solutions to today's critical challenges of growth, energy efficiency and environmental protection.
Saint-Gobain ranked 161st on the 2012 Fortune 500 list and is among the world's hundred leading industrial corporations.
Present in China since 1985, Saint-Gobain has 54 subsidiary companies employing over 10,000 people throughout China today. By proposing quality products for green solutions as well as a high level of services to domestic customers, the sales in China totalized more than 1 billion Euros in 2012.
Website: http://www.saint-gobain.com.cn

## Sasaki Associates

**Sasaki** was founded 60 years ago on the basis of interdisciplinary planning and design. Today, our services include architecture, interior design, planning, urban design, landscape architecture, strategic planning, civil engineering, and graphic design. Among these disciplines, we collaborate with purpose. Our integrated approach yields rich ideas and surprising insights.We approach our work from a foundation of wide-ranging expertise and bring fresh energy and innovation to each project. Our culture is inquisitive—we are passionate about ideas. Our professionals embark on research efforts and contribute to thought leadership in our respective disciplines. From our studios in Boston and Shanghai, we work in a variety of settings—locally, nationally, and globally. We ask the right questions and listen attentively. We are team-based, both internally and with our clients. Together, we examine the problem and the context in which it exists. Sasaki is an innovator. We play a leading role in shaping the future of the built environment through bold ideas and new technologies. We approach sustainability through the lenses of economics, social context, and the environment. Our solutions are not only effective—they are poetic and enduring. Our approach helps clients make smart, long-term decisions that result in greater value for them, and a better future for the planet.
Website: http://www.sasaki.com/

## Scania

**Scania** is one of the world's leading manufacturers of trucks and buses for heavy transport applications, and of industrial and marine engines. A growing proportion of the company's operations consists of services, assuring Scania customers a holistic offer of sustainable, cost-effective transport solutions, and maximum reliability.
Founded in 1891, legendary Scania enjoys a great reputation in the industry as "King of the Road". Employing some 38,500 people, Scania operates in about 100 countries. Research and development activities are concentrated in Sweden, while production takes place in Europe and South America, with a global production system for both components and complete vehicles.
Website: www.scania.com

## Tishman Speyer

**Tishman Speyer** is one of the leading developers, owners, operators, and asset managers of first class real estate worldwide. Active across North America, Europe, South America and Asia, Tishman Speyer is relied upon by many of the world's most prestigious corporations to meet their office space needs. The firm had acquired, developed and/or managed a portfolio of approximately 123 million square feet (equivalent to approximately 11.5 million square meters) with a total value of over USD $63.6 billion since its founding in 1978. Signature assets include New York's Rockefeller Center and the Chrysler Center, São Paulo's Torre Norte, Ventura Corporate Towers in Rio de Janeiro, and Opernturm in Frankfurt. Tishman Speyer also has projects at different stages of development currently in Brasília, Chengdu, Frankfurt, Gurgaon, Hyderabad, Paris, Rio de Janeiro, São Paolo, San Francisco, Shanghai, Suzhou and Tianjin.
Company URL: www.tishmanspeyer.com

**Tsing Capital**

Established in 2001, **Tsing Capital** is the pioneering and leading cleantech venture capital firm in China. Through its China Environment Fund and Yiyun Cleantech Fund series, Tsing Capital works intimately with its portfolio companies across China in areas of renewable energy, energy efficiency, environmental protection, new materials, sustainable transportation, smart grids, sustainable agriculture and cleaner production. Tsing Capital's dedication to cleantech investment is recognized via a series of awards, including the Cleantech Group Cleantech Leadership Award and the China VC/PE Green Investment Leadership Award by the China Environment Investment Network.
Website: http://www.tsingcapital.com

**United Technologies**

UTC Climate, Controls & Security is the leading provider of heating, air conditioning and refrigeration systems, building controls and automation, and fire and security solutions. UTC Climate, Controls & Security is a unit of **United Technologies** Corp. (NYSE: UTX), a leading provider to the aerospace and building systems industries worldwide.

**Volkswagen Group China**

Volkswagen Group is the largest and most successful international partner of China's automobile industry, whereby the initial contact between the company and China already dated back in 1978. In 1983, Shanghai Volkswagen Corporation Ltd. was established as the first joint venture of Volkswagen Group in China, followed by FAW-Volkswagen Corporation Ltd. in 1991 as the second joint venture. In 2012, **Volkswagen Group China** delivered more than 2.8 million vehicles to customers in mainland China and Hong Kong.
Website: http://www.volkswagen.com.cn

## General Partners

**DSM**

Royal **DSM** is a global science-based company active in health, nutrition and materials. By connecting its unique competences in Life Sciences and Materials Sciences DSM is driving economic prosperity, environmental progress and social advances to create sustainable value for all stakeholders. DSM delivers innovative solutions that nourish, protect and improve performance in global markets such as food and dietary supplements, personal care, feed, pharmaceuticals, medical devices, automotive, paints, electrical and electronics, life protection, alternative energy and bio-based materials. DSM's 23,500 employees deliver annual net sales of around €9 billion. The company is listed on NYSE Euronext.
Website: www.dsm.com

**EDF**

**EDF** Group is a leading player in the European energy market, and the largest nuclear operator in the world. As an integrated electricity company with more than 60 years of power development experiences, EDF has comprehensive world-class industrial competitiveness in nuclear power, thermal power, hydropower and new energy power generation. Active and specialized in all aspects of power supply including electricity generation, transmission, distribution, sales, energy efficiency and energy trade, EDF can provide various integrated energy solutions in power project investment, engineering and management or grid transmission and distribution.
Website: www.edf.com

### GDF Suez

**GDF SUEZ**, the number one utility services company in the world, is active across all utility services (water, waste, power, gas, energy services).
In China the group is active in water and waste since 40 over years under SUEZ ENVIRONNEMENT Brand (see the water and waste chain panels).
In energy, it started its activities in 2009.
GDF SUEZ develops heating and cooling networks and energy efficiency solutions, offers engineering services and addresses all segments of the gas chain (LNG sales, underground gas storages, infrastructures management).
GDF SUEZ is the leader of the Gas Chain in Europe.
Website: www.gdfsuez.com

### General Motors Company

**General Motors** Co. (NYSE:GM, TSX: GMM) and its partners produce vehicles in 30 countries, and the company has leadership positions in the world's largest and fastest-growing automotive markets. GM's brands include Chevrolet and Cadillac, as well as Baojun, Buick, GMC, Holden, Isuzu, Jiefang, Opel, Vauxhall and Wuling. More information on the company and its subsidiaries, including OnStar, a global leader in vehicle safety, security and information services, can be found at http://www.gm.com.
Website: http://www.gm.com

### HSBC

**HSBC Bank** (China) Company Limited started operations on 2 April 2007 as a locally incorporated foreign bank. It is wholly owned by its parent, The Hong Kong and Shanghai Banking Corporation Limited, which is based in the Hong Kong Special Administrative Region. HSBC China incorporated the previous Mainland offices of its parent, which retains a branch in Shanghai that conducts foreign currency wholesale banking. Established in Hong Kong and Shanghai in 1865, The Hong Kong and Shanghai Banking Corporation Limited has had a continuous presence in mainland China for nearly 150 years. It is the founding and a principal member of the HSBC Group, which has around 6,900 offices in more than 80 countries and territories, making it one of the world's largest banking and financial services organisations. Update to January 2013, the Bank has a branch network across 45 cities, having the largest number of outlets and the widest geographical reach of any foreign bank in mainland China.
Website: http://www.hsbc.com.cn

### Huaneng Invesco WLR

**Huaneng Invesco WLR** (Beijing) Investment Fund Management Company Ltd. ("HIWLR") is a joint venture between Huaneng Capital, financial services platform of China Huaneng Group and Invesco with its private equity arm WL Ross & Co. HIWLR takes advantage of the unique combination of strengths of Huaneng as the largest power company in China, and Invesco's global reach in capital markets as well as WLR's rich private equity experience to provide advice on energy related investment in China. HIWLR focuses on opportunities in cleaner traditional energy, new energy, energy logistics, smart grid, energy storage and conservation and other related areas.
Website: NONE

**Jones Lang LaSalle**

**Jones Lang LaSalle** (NYSE:JLL) is a professional services and investment management firm offering specialized real estate services to clients seeking increased value by owning, occupying and investing in real estate. With annual revenue of $3.9 billion, Jones Lang LaSalle operates in 70 countries from more than 1,000 locations worldwide. On behalf of its clients, the firm provides management and real estate outsourcing services to a property portfolio of 2.6 billion square feet and completed $63 billion in sales, acquisitions and finance transactions in 2012. Its investment management business, LaSalle Investment Management, has $46.7 billion of real estate assets under management. For further information, visit www.jll.com
Website: http://www.joneslanglasalle.com.cn

**Kardan Water**

**Kardan Water**, the water sector operational platform of Kardan Group in the Chinese market, develops, operates and invests in water-related projects in mainland China, focusing on water treatment, wastewater treatment and water reclamation. Kardan Water enjoys Kardan Group's extensive know-how, robust financing capabilities, and international experience in water-related projects across the globe. This has enabled the company to develop a strong presence in China—manifested in 10 projects in four provinces—and to become a reliable long-term partner to the Chinese Government, supporting China's efforts for cleaner, more sustainable development.
Website: http://www.kwigwater.com

**Liaoning Huafu Group**

Established in 1992, **Liaoning Huafu Group** is engaged in technical consulting, fabrication, EPC , BOT and capital operation from oil production, environmental, energy conservation and NG processing industries. The Group is a private high-tech enterprise evaluated by National Science & Technology Ministry with 12 domestic and overseas subsidiaries and offices, and also possesses its own Consulting and R&D Institute, manufacturing and chemical factory and several professional companies. Huafu Group is composed of several companies, including Liaoning Huafu petroleum Hi-tech Corp. Ltd, Liaoning Huafu Environmental Engineering, Liaoning Huafu-Andmir Environment Equipment, Shandong Huafu petroleum & Environmental, and Panjin Huafu LengJia Wastewater Treatment Plant, etc.
Website: http://huafugroup.com.cn

**LP Amina**

**LP Amina** is a US-based energy and environmental company that focuses on sustainable coal utilization for power generation and innovative coal-to-chemicals production processes.
Website: http://www.lpamina.com

**Michelin**

**Michelin**, the leading tire company, is dedicated to sustainably improving the mobility of goods and peopleby manufacturing and marketing tires for every type of vehicle, including airplanes, automobiles, bicycles/motorcycles, earthmovers, farm equipment and trucks.It also offers electronic mobility support services on ViaMichelin.com and publishes travel guides, hotel and restaurant guides, maps and road atlases.Headquartered in Clermont-Ferrand, France, Michelin is present in more than 170 countries, has 111,200 employees and operates 67 production plants in 17 different countries.The Group has a Technology Center in charge of research and development with operations in Europe, North America and Asia.
Website: www.michelin.com.cn

**Xuwei New Zone**

Xuwei New Area, approved by the State Council, is a pilot area for regional cooperation between the eastern, central and western parts of China, located in the southeast of Lianyungang. Xuwei will strive to become an important gateway to China's central and western regions, acting as a pioneering demonstration area for regional cooperation and pilot area of innovative regional cooperation. Xuwei has focused on five main areas of industry: The integration of refining, fine steel, advanced equipment manufacturing, clean energy and modern port logistics. It's expected that by the end of the 12th Five-Year Plan, Xuwei New Area will become the main force for the new coastal industrialization and development in Jiangsu Province, making itself the new center of economic growth on the Jiangsu coast.
Website: http://www.xwxq.gov.cn

## Supporting Organizations

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Friends of Nature
Goldwind
Lishen Battery Group
National Institute of Clean-and Low-Carbon Energy (NICE)
RCC Group
Sinohydro Road & Bridge Engineering
Tianjin TEDA Low-Carbon Economy Promotion Center
Tsinghua University
UN Global Compact
United States Department of Energy (US DOE)
United States Foreign Commercial Service

## Advisors

American Council on Renewable Energy (ACORE)
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China Energy and Environment Technology Association (CEETA)
China Institute
China National Chemical Economic and Technical Development Centre, CPCIA
China-US Energy Efficiency Alliance
Clean Air Task Force (CATF)
Duke University
Econet, German Industry & Commerce
Energy Branch of China Information Industry Association, NDRC
Innovation Center for Energy and Transportation (iCET)
Jiangsu Modern Low Carbon Technology Research Institute
Natural Resources Defense Council (NRDC)
Rocky Mountain Institute (RMI)
VISIONEDGE Technologies
Wisconsin Economic Development Corporation (WEDC)

## Government Advisors *from*

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Center of Science & Technology and Industry Development, Ministry of Housing and Urban-Rural Development (MOHURD)
China International Investment Promotion Agency, Ministry of Commerce (CIPA-MOFCOM)
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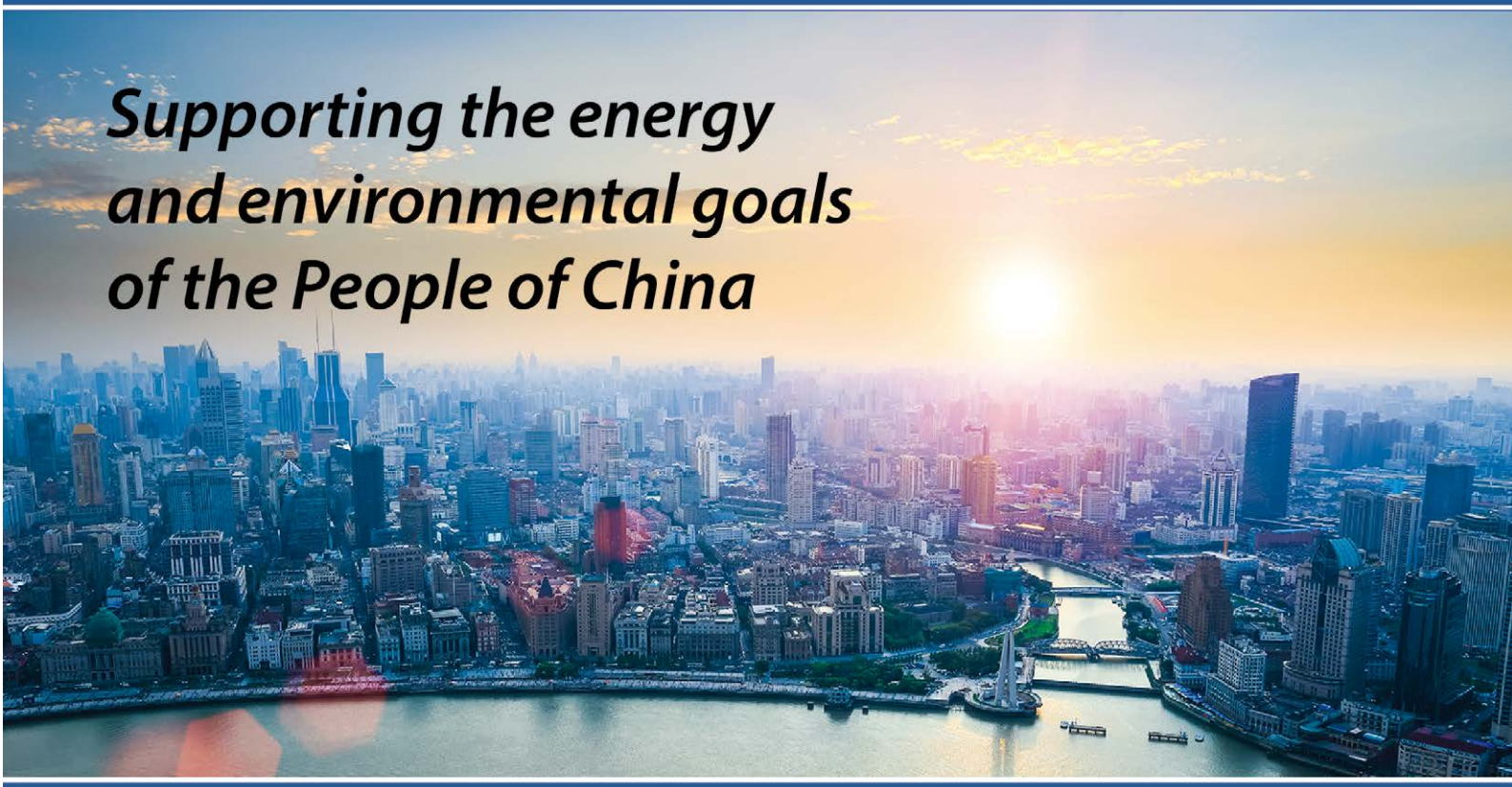

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