THE CHINA GREENTECH REPORT™ 2009


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中国绿色科技
China Greentech Initiative
Uncover, Create and Promote Greentech Opportunities in China

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MangoStrategy

NAVIGATION GUIDE

REPORT STRUCTURE

The China Greentech Report 2009 is published in multiple editions in order for readers to access and use the findings easily.

EXECUTIVE OVERVIEW

Summarized findings which define greentech markets in China, identify China's greentech market context, describe the government's regulatory response, evaluate greentech solutions, identify challenges hindering China's greentech market, suggest stakeholder opportunities to accelerate greentech development and provide brief snapshots of seven greentech sectors (English and Chinese editions).

FULL VERSION

Includes *Executive Overview* plus detailed chapters on seven China greentech sectors: Cleaner Conventional Energy, Renewable Energy, Electric Power Infrastructure, Green Building, Cleaner Transportation, Cleaner Industry and Clean Water (English only).

SECTOR CHAPTERS

Individual greentech sector chapters published as stand-alone documents (English only).

All editions will be available in PDF format at www.china-greentech.com by late September 2009.

RECOMMENDED READING PRIORITIZATION

Given the large amount of content, it may be useful for readers to prioritize their reading based upon their interests. To help with this prioritization, the Initiative suggests the following starting points:

GENERAL READERS	**Knowledgeable:** Introduction, Market Context, Challenges and Opportunities chapters in *Executive Overview* **Limited Knowledge:** Entire *Executive O*verview
GREENTECH PROVIDERS AND ADOPTERS	**Knowledgeable:** Introduction, Challenges and Opportunities chapters in *Executive Overview*, followed by relevant sector chapters in *Full Version* **Limited Knowledge:** Introduction, Market Context, Regulatory Response, Challenges and Opportunites chapters in *Executive Overview,* followed by relevant sector chapters in *Full Version*
FINANCIAL INVESTORS	**Knowledgeable:** Introduction, Market Context, Solutions and Opportunities chapters in Executive Overview, followed by relevant sector chapters in *Full Version* **Limited Knowledge:** Entire *Executive Overview*
REGULATORS AND OTHER STAKEHOLDERS	**Knowledgeable:** Introduction, Challenges and Opportunities chapters in *Executive Overview*, followed by relevant sector chapters in *Full Version* **Limited Knowledge:** Entire *Executive Overview*, followed by relevant sector chapters in *Full Version*

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PREFACE

Dear reader,

We are delighted to provide you with *The China Greentech Report™ 2009*, the first public deliverable of the China Greentech Initiative. The Initiative is an open source commercial collaboration of over 80 of the world's leading green technology companies, entrepreneurs, investors, NGOs and policy advisors, including founding partners PricewaterhouseCoopers and the American Chamber of Commerce in Shanghai (AmCham Shanghai), and is produced by MangoStrategy, LLC.

We hope we have been able to provide a good starting point for helping people understand greentech market opportunities and challenges, through structured analysis and insights that help people make better decisions, and serve as the basis for rich, constructive dialogues aimed at accelerating greentech progress in China. We feel we will have been successful if we are able to provide businesses and policy makers with a fact base from which to understand these markets better, and a set of hypotheses about what can be done to accelerate progress in the country. Throughout this report we have strived to provide a balanced perspective, highlighting not only the issues and challenges China faces, but also the progress China has made and the opportunities available to the market.

When we first conceptualized the Initiative in January 2008, we never expected the tremendous outpouring of support and enthusiasm it would receive from organizations and people in China and the rest of the world. We knew that climate change was real, environmental sustainability issues were growing and that China was one of the critical markets globally for greentech solutions. But it took some of our partners, such as China International Capital Corporation, General Electric, KPCB China (Kleiner Perkins) and Philips, to validate and give life to our hypothesis that the "opportunities in China are too big, the problems too urgent and the market too complex" for any single organization to understand on their own.

Our partners are presented on the front and inside covers of this report. We have been extraordinarily fortunate in both the number and quality of partners and strategic advisors who've been involved in the creation of this report. Our partners and strategic advisors represent a cross section of the global community, with approximately one-third from China, one-third from North America and one-third from other countries. In addition to financial support, they provided the time and expertise of their people, introductions to business partners, industry experts and government officials, access to key resources, and in some cases, contributions of products and services which further enabled the Initiative. We could only have achieved this milestone with this valuable support.

This report is the culmination of an open source, collaborative research process, started in 2008 and concluded in August 2009, which has involved literally several hundred people in China and around the world. This process combined a dedicated strategic research team with ongoing and significant input from the Initiative's partners and strategic advisors. The research process included the collection and consolidation of data from a wide range of Chinese and English language external sources; conducting of interviews with partners, strategic advisors and other industry experts; and in-depth analysis of the market. Based on this research and considerable rounds of interaction with partners and strategic advisors, the Initiative developed the key findings included in this report.

Notably, the Initiative hosted 21 sector working sessions – three sessions for each of seven sectors – involving partners and strategic advisors, between December 2008 and June 2009. These working sessions allowed the Initiative to gain input upfront to frame and prioritize issues, test preliminary insights as the research progressed and validate findings prior the publication of this report. Each session generally involved 25-30 participants, lasted five hours, was hosted simultaneously at PricewaterhouseCoopers' Beijing and Shanghai conference facilities, connected via videoconferencing and simultaneously translated into Chinese and English. One session was also held at Suntech's corporate headquarters in Wuxi, China. The use of videoconferencing connecting Beijing

and Shanghai not only allowed organizations to participate more easily, but dramatically reduced the need for people to fly to meetings between the two cities, saving money and CO_2 emissions.

With over 80 organizations and hundreds of people involved, we are unable to name everyone who has participated in this effort individually. We would, however, like to mention a few partners explicitly. Founding partners PricewaterhouseCoopers (PwC) and AmCham Shanghai supported the Initiative broadly in multiple critical ways. PwC has been fundamental to the overall Initiative and has contributed a herculean effort to the research and writing of the report itself. PwC partners and staff took the lead in developing three sectors of the report and were core to the report writing team. PwC also provided a full-time project manager and hosted all but one of the sector working sessions. AmCham Shanghai and its Environmental Committee spurred the Initiative from the beginning, introduced multiple partners and strategic advisors to the Initiative and helped to broadly disseminate the report. The Chamber also took the lead role in coordinating the editing, production and printing of the report and, in September 2009 organized *Greentech: A Call to Action,* a landmark conference held in Shanghai which showcased the Initiative's findings.

In addition to providing Ellen Carberry's time, Hao Capital opened up its Beijing offices, which became the home for the Initiative's team. Haworth furnished the Initiative's offices with its sustainable line of office furniture, while Dell provided Energy Star efficient notebook computers. Other contributions included legal assistance from Nixon Peabody, government relations support from APCO and marketing communications guidance from Ogilvy. A complete list of all partners and strategic advisors is included on the inside back cover of the report.

We also want to thank profusely the many individuals who've invested their personal time, both as dedicated staff members and volunteers, over the last year, to make the Initiative and this report a reality. A complete listing of these talented professionals is provided in the Acknowledgments chapter.

As an extended team, we've learned a tremendous amount in the development of *The China Greentech Report 2009*, and hope the report will help a broad group of stakeholders, including greentech solution adopters, providers, financers, regulators and others, in their quest to uncover, create and promote greentech opportunities in China.

We've also been reminded of the incredible power of collaboration, especially when stakeholders come together around a shared mission. The success of the China Greentech Initiative is based on tangible objectives (i.e. the publication of *The China Greentech Report 2009* and creation of deliverables for partner and strategic advisor use), which brought organizations and people together through a structured, open source approach, guided by a consultative methodology.

Given climate change and other environmental sustainability issues that the world faces, we have the unique responsibility of a shared, generational mission to successfully address these issues. While government plays a critical role in guiding these changes, our overriding belief has been that the commercial sector must develop and deploy the solution innovations that enable the transformation required. Through the China Greentech Initiative, we hold up as an example a collaboration model of how commercial, government and other organizations can come together, partner and accelerate our common path to an environmentally sustainable future.

Finally, while this report represents the end of the first phase of the China Greentech Initiative, we know that there is much more work to do. Given the scale, complexity and dynamic nature of China, we recognize that we haven't been able to cover everything, and that what we do cover will continue to evolve rapidly. We look forward to continuing to collaborate with our partners, strategic advisors and others involved in the China greentech market, both in person and online, as this important, fascinating, complex and rapidly-changing market continues to evolve. To that end, please visit the China Greentech Initiative at www.china-greentech.com to join in the discussion. We also welcome your input at feedback@china-greentech.com.

Ellen G. Carberry and Randall S. Hancock
Managing Directors, The China Greentech Initiative
September 2009

INTRODUCTION

China's market requirements for greentech solutions are tremendous. Chinese government policies are positive drivers for greentech market development and a wide range of businesses are beginning to deploy greentech solutions to address a broad spectrum of environmental issues. While significant challenges remain, stakeholders have clear opportunities to accelerate market development and create a more environmentally sustainable China.

THE CHINA GREENTECH REPORT 2009 IS THE CULMINATION of an open source, commercial collaboration of over 80 of the world's leading technology companies, entrepreneurs, investors, NGOs and policy advisors. These organizations joined the China Greentech Initiative to address many of the important questions facing those interested in participating in this complex, rapidly changing market:

- How should one frame the greentech opportunities that exist in China?
- What are the most important environmental issues impacting China and what are the forces driving them?
- How has China's government and the international regulatory community responded to these issues?
- Which existing and emerging greentech solutions are most attractive for China in the short, medium and long terms?
- What are the biggest challenges facing China's greentech markets?
- How might stakeholders overcome these challenges in order to accelerate China's greentech market development?

This report aims to answer these questions based on the research process that the China Greentech Initiative has undertaken and the information avail able at this point in time. The story that has emerged is largely an optimistic one, tempered by the complexity of China's markets and the significant challenges that must be overcome.

China's greentech markets include a broad range of sectors, segments and solutions

DEFINITIONS

The term 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 and maximizing the efficient and sustainable use of energy, water and other resources. The Initiative identified nine greentech market sectors, focusing on seven in this report – Cleaner Conventional Energy, Renewable Energy, Electric Power Infrastructure, Green Building, Cleaner Transportation, Cleaner Industry and Clean Water.

Three decades of formidable economic growth have transformed China into a colossal and resilient economy, resulting in radical improvements in living standards for many of its citizens

FORMIDABLE ECONOMIC GROWTH

China's economic transformation over the last thirty years is unlike anything the world has ever seen. With an average 10% annual growth rate, China is now the third largest economy and second largest consumer of energy in the world.

RADICAL IMPROVEMENTS IN LIVING STANDARDS

Economic growth, accompanied by massive urbanization, has driven radical improvements in China's living standards, decreasing the percentage of people living in poverty, vastly improving life expectancies, and fostering an emerging consumer market.

RESILIENT ECONOMY

China's economy has been more resilient to the global economic crisis than any other large country. With the world's largest foreign exchange reserves, the government's four trillion yuan (US$586 billion) economic stimulus package was the second largest in the world. China's economy grew 7.1% in the first half of 2009 and is projected to grow at 9% in 2010.

COLOSSAL SCALE

With over 1.3 billion people, China is home to nearly one-fifth of the world's population, or nearly twice that of the U.S. and Western Europe combined. Eighteen million people migrate from rural to urban areas in China annually. China has more than twice the building floor space as the U.S. and installs more electricity generation capacity each year than the total capacity of the U.K.

Yet China's economic development has come at significant environmental cost

POLLUTED AIR

China is now the world's largest emitter of greenhouse gases (GHGs), responsible for over 20% of annual CO_2 emissions from the burning of fossil fuels, although emissions per capita are still low relative to most developed countries. Eighty percent of these emissions come from burning coal, China's predominant energy source. China's air quality also suffers from other pollutants, such as particulate matter, which cloud the air and have negative health effects.

STRAINED WATER RESOURCES

China faces the dual problems of water scarcity and pollution. With 20% of the world's population, China has less than 7% of the world's fresh water resources. The country's water resources have declined due to high demand, inefficient use and decreasing natural supplies. Moreover, water pollution has seriously impacted water quality throughout the country.

LAND DEGRADATION

Forces degrading China's land include desertification, land contamination from waste landfills and hazardous waste. For example, almost half of official landfills in a recent study were found to not comply with China's environmental standards, and e-waste from the recycling and dumping of used electronic products is a major issue.

A NEW ERA

While China's environmental issues are not dissimilar to the industrialization experiences of other countries throughout history, China's immense scale, speed of economic development and the state of the world's climate and resources make the environmental impact of China's development an issue of global concern.

China's economic development will become environmentally sustainable out of necessity

ECONOMIC DEVELOPMENT OF EPIC PROPORTIONS

China is expected to become the world's largest economy within the next 20 to 40 years, driven by a growth rate that will continue to outpace the world average. Massive urbanization will continue over the next 15-20 years, causing the country to double its building space, have more than 200 cities with a population over one million people and continue with the large scale deployment of infrastructure.

RESULTING SURGE IN RESOURCE DEMAND

Continued growth will demand huge increases in energy, water and material resources. If China were to maintain its historic practices, the additional strain on the environment would be unsustainable. For example, at current growth rates, China's CO_2 emissions could represent nearly 30% of the world's total by 2030, with coal currently expected to continue to account for the majority of China's energy supply for decades to come.

VISION FOR ENVIRONMENTAL SUSTAINABILITY

The China Greentech Initiative believes that China will, out of necessity, embrace environmentally sustainable growth in which green technologies have been developed and deployed, new business models established and compliance with government regulations brought up to a high level. This vision for an environmentally sustainable China includes widespread adoption of alternative and cleaner conventional energy sources, curtailed growth in GHG emissions, reduction in air and water pollution, improved water use efficiency and mitigated solid waste problems.

China has laid the foundation for greentech market growth, with the first signs of a green transformation already appearing

LAYING THE FOUNDATION

China has made impressive progress in laying the foundation for future growth in green technologies and is emerging as a leader in many environmental areas, including wind power adoption, Solar Photovoltaic and Hot Water Heater manufacturing, vehicle fuel economy and emissions, and energy efficiency. China's wind power capacity, for instance, has doubled for four consecutive years since 2005, with China now ranking fourth in the world and representing 10% of total installed capacity.

UNTAPPED POTENTIAL

There is opportunity to do more. China has set a target of deriving 20% of energy from renewable sources by 2020. Even if it achieves this aggressive goal, 80% of its energy would still be derived predominantly from coal. While China's energy intensity of GDP has declined significantly, it is still almost three times that of the U.S. and more than four times that of Japan. And estimates suggest that less than 1% of all floor space expected to be built in 2009 will be certified by any green certification standard.

UNIQUE MOMENT IN TIME

Despite the magnitude of China's environmental issues, the first signs of a new transformation are promising, with government, businesses, non-governmental organizations and other stakeholders aligning around the vision of a more environmentally sustainable China.

Guided by policy principles, China's government has already established plans and programs, laws and standards, fiscal incentives and subsidies, industrial promotion and price management policies that positively impact the environment and enable greentech markets

CHINA'S POLICY ENVIRONMENT

China's policy environment is complex, with a large number of entities exerting control at both the national and local levels. The Initiative identified 19 different national government agencies with responsibilities related to greentech markets. Most of these have corresponding bodies at local levels that are influenced by both the national and local governments.

GUIDING POLICY PRINCIPLES

China's government uses a variety of policy principles to guide the development of its greentech policies. Specific policy principles identified by the China Greentech Initiative as influencing China's greentech policies include: Scientific Approach to Development, Harmonious Society, Equal Emphasis on Mitigation and Adaptation, Efficiency Improvement and Conservation, Energy Structure Optimization, Ecological Preservation and Construction, Agricultural Productivity Enhancement and Indigenous Innovation.

POLICYMAKING PRACTICES

China's government has made significant progress in the development of greentech-relevant policies. Policy making processes often take into account legal practices of legal systems outside of China, and may include deliberations in special committees under the National People's Congress, expert round tables or public hearings.

PLANS AND PROGRAMS

National planning activities and programs provide frameworks for China's response to environmental issues and determine development targets. These plans include not only the Five Year Guidelines, but detailed plans released by ministries to guide the development of specific parts of the economy. National programs complement plans by providing policy directions or specific regulations across a range of implementing agencies. China's 4 trillion yuan (US$586 billion) economic stimulus plan, announced in November 2008 in response to the global economic downturn, allocates approximately 37% to greentech-related areas.

LAWS AND STANDARDS

China's government has put in place many laws and standards relevant to greentech markets. Important greentech-related laws in China include the Renewable Energy Law (2005) and the Circular Economy Law (2008). China's Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) is responsible for administering standards in technical, product quality, environment and product safety.

FISCAL INCENTIVES AND SUBSIDIES

China also uses fiscal and policy approaches to promote greentech markets. Tax exemptions, consumption related taxes, natural resource related taxes and other tax benefits promote environmental and greentech activities. The government also directly subsidizes greentech providers and adopters in areas like New Energy Vehicles, Building-Integrated Solar Photovoltaic Systems, Wind Turbines and Biomass Power Generation. Provincial and regional governments also have policy levers they can use to support greentech development in their jurisdictions, including tax holidays, discounted office rates, direct financing, assistance with capital markets financing and reimbursements for employee training.

INDUSTRIAL PROMOTION POLICIES

China's policymakers also support greentech through industrial promotion policies that leverage financial intermediaries. This may include directing favorable financing to greentech sectors, requiring commercial banks to incorporate environmental performance criteria into lending decisions, requiring environmental and energy disclosures from companies listing on domestic stock markets, and providing support for infrastructure construction.

PRICING MANAGEMENT

Price controls also influence the development of China's greentech markets. Although China's trend is towards allowing prices to fluctuate with market pressures, the government continues to exert control over the prices of electricity, gas, district heat and water utilities to enable the affordability of these goods for China's low-income households. In a positive development for Renewable Energy, the National Development and Reform Commission in July 2009 released a national feed-in tariff for wind power, giving it a significant premium over coal generated power.

International policy organizations, principles, agreements and relationships also impact China's greentech markets

INTERNATIONAL POLICY ORGANIZATIONS

Many international organizations and regulatory bodies also impact the development of China's greentech markets, including the United Nations, the World Trade Organization (WTO), the International Monetary Fund (IMF), the World Bank and the Asian Development Bank (ADB). The UN, through its specialized agencies such as the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP), has broad influence across many environmental and climate change issues.

INTERNATIONAL POLICY PRINCIPLES

International policy principles also exert influence on the development of China's greentech markets. Perhaps the most important of these are the concepts of *sustainable development* and *Common but Differentiated Responsibilities and Respective Capabilities* (CbDR/RC).

INTERNATIONAL AGREEMENTS

Certain international agreements commit China to specific policy actions related to the environment. The most well-known of these is the 1997 Kyoto Protocol. Nearly half of all certified emission reduction certificates (CERs) registered under the Kyoto Protocol have been generated by projects in China. Because the international emissions reductions targets under the Kyoto Protocol expire in 2012, parties to the agreement hope to successfully negotiate a successor agreement to be signed at the 15th United Nations Climate Conference, scheduled for December 2009 in Copenhagen, Denmark.

BILATERAL RELATIONSHIPS

Direct relationships with other countries and economic blocs also impact China's greentech markets. Example programs include the China-U.S. Strategic and Economic Dialogue (S&ED), the China-U.S. Science and Technology Agreement, and the EU-China Energy and Environment Programme.

A wide range of businesses are beginning to deploy existing and emerging greentech solutions to address a broad spectrum of environmental issues

HUNDREDS OF EXISTING AND EMERGING GREENTECH SOLUTIONS

The Initiative identified over 300 distinct greentech solutions applicable to China across seven sectors, which were then prioritized down to 125 solutions for further evaluation, or approximately 18 solutions per sector.

SOLUTIONS EVALUATION APPROACH

A Solutions Evaluation Framework was developed to assess solutions by *unit environmental impact potential*, *solution attractiveness*, *addressable market size* and *market accessibility* according to short (under one year), medium (1-5 years) and long (5-10 years) time periods. This report focuses on the medium term evaluations.

CONSIDERABLE ENVIRONMENTAL IMPACT

Greentech solutions hold the potential to greatly mitigate the impact of economic activities on the environment. Solutions analyzed by the Initiative in the Renewable Energy, Electric Power Infrastructure and Cleaner Transportation sectors primarily impact the environment by reducing atmospheric emissions, including CO_2, and improving energy efficiency. Clean Water solutions address water shortages and pollution. Cleaner Conventional Energy solutions abate environmental impact on both air and water. Green Building and Cleaner Industry solutions address air emissions and energy, water and materials use. On average, Renewable Energy and Cleaner Transportation solutions have relatively higher unit environmental impact potential compared to other sectors, because many of these solutions, such as Solar Photovoltaic, Wind Turbines and New Energy Vehicles, abate up to 100% of the emissions associated with fossil fuel burning.

ALREADY ATTRACTIVE GREENTECH SOLUTIONS

Many greentech solutions are already attractive to adopters. Cleaner Industry and Green Building have relatively higher average solution attractiveness compared to other sectors, with many solutions in these sectors focusing on energy efficiencies and already economically feasible on a life cycle basis. Cleaner Conventional Energy, Clean Water and Renewable Energy solutions rank in the middle tier, driven by a large number of solutions that technologically are relatively mature or rapidly emerging, but not yet economically competitive in China. Electrical Power Infrastructure and Cleaner Transportation solutions are ranked, on average, as relatively lower in attractiveness, due to many solutions in early stages of technological maturity.

SIGNIFICANT MARKET SIZES

The China Greentech Initiative estimates the total addressable market size for the solutions highlighted in the report could be as much as US$500 billion to US$1 trillion annually, or as much as 15% of China's forecasted GDP, in 2013. Addressable market size estimates the total revenues greentech solutions could potentially achieve if they were attractive to adopters vis-à-vis conventional alternatives. This is not meant to be an annual forecast for solutions, but rather an estimate of what the market could be under specific conditions. Solutions in Cleaner Transportation and Renewable Energy have relatively larger average addressable markets, as they include solutions with large potential markets like New Energy Vehicles and Advanced Aircraft in Cleaner Transportation, and Solar Photovoltaic, Concentrating Solar and Biomass Combustion in Renewable Energy. Solutions in Clean Water, Cleaner Industry and Electric Power Infrastructure were found to have on average relatively smaller markets, mostly because many of these solutions are individual components of larger systems.

MIXED MARKET ACCESSIBILITY

Many of China's greentech markets are open to foreign and private players, while some remain limited or restricted. Market accessibility for solutions in Cleaner Industry and Green Building sectors is on average relatively higher compared to other greentech sectors. Cleaner Conventional Energy, Renewable Energy and Clean Water sectors place in the middle. For solutions in Cleaner Transportation and Electrical Power Infrastructure, on average, markets have relatively lower accessibility. For example, Cleaner Transportation includes railway and air transport segments, where access to many value chain elements is restricted, while the Electrical Power Infrastructure is controlled by the government and procurement often favors local state-owned enterprises, though exceptions exist.

While China's greentech market opportunities are generally attractive, market, technology, financing and regulatory challenges remain to be overcome

MARKET CHALLENGES

China's greentech-related market challenges constrain the ability of solution providers to deliver successful technologies, products and services, and limit market demand for such solutions. Limited awareness of the availability and benefits of greentech solutions causes adopters and end users to continue with conventional practices. Underdeveloped value chains result in disconnects between geographies and stakeholders, such as the lack of natural gas lines connecting reserves to demand centers. High levels of industry concentration in certain markets, including control by state-owned enterprises, may reduce efficiency and limit innovation.

TECHNOLOGY CHALLENGES

Technology challenges slow the development and application of greentech solutions in China, hindering solutions from meeting the cost and feature requirements of potential adopters. Greentech solutions are still often more expensive than conventional alternatives. Subsidized resource and utility costs may also limit the appeal of greentech solutions, as may the current low international market prices of natural resources and commodities. Many greentech solutions are not yet customized to meet China's environmental and market requirements. Intellectual property and technology transfer remain significant issues.

FINANCING CHALLENGES

Despite strong policy support and government funding, greentech financing in China is limited by the relatively early stage of development of the country's financial markets. Compared to developed markets, there are generally fewer options in China for raising debt or equity capital across the life cycle of greentech solutions. Greentech investments also often have unique characteristics that complicate financing, such as high front-end capital needs and long payback periods.

REGULATORY CHALLENGES

While China's regulatory environment is a clear, positive driver for change, regulatory challenges remain. The complex policy environment is often difficult to understand. Even though the overall direction of greentech incentives is positive, potential issues related to the size of payouts, timing and eligibility exist. Monitoring and enforcing compliance of existing environmental policies is also an issue, especially given China's size, regional variations and dynamically changing economy. Finally, market participants often have

limited visibility into policy specifics and timing, complicating their business decisions.

Clear opportunities exist for stakeholders to accelerate greentech markets in China

FIVE KEY STAKEHOLDER GROUPS

Solution adopters, solution providers, financial investors, government regulators and other stakeholders have significant roles to play in the acceleration of greentech markets in China.

OVERALL OPPORTUNITIES

The Initiative identified five over-arching opportunities, relevant to all sectors and involving every stakeholder group. These are to raise decision-maker awareness about greentech benefits, drive the maturity of standards-based solutions that enable widespread adoption, support fair market playing fields which incorporate environmental costs into conventional solution pricing, enhance greentech skills and capabilities, and encourage collaboration between commercial, governmental and non-governmental stakeholders.

SOLUTION ADOPTERS

Organizations and other adopters can accelerate China's greentech markets by promoting environmental sustainability, buying greentech products and services whenever feasible, and complying with existing Chinese environmental policies.

SOLUTION PROVIDERS

Companies providing green technologies, products and services have opportunities to better match solutions with China's local market requirements, educate adopters on greentech benefits, minimize life cycle costs of end products and leverage partnerships to help strengthen and integrate China's greentech value chains.

FINANCIAL INVESTORS

Investors have opportunities to enhance existing and build new capabilities targeted to greentech investments and utilize new financing mechanisms across greentech product cycles, from early-stage R&D through demonstration, deployment and diffusion of greentech solutions.

GOVERNMENT REGULATORS

China's policymakers have already made substantial progress in protecting the environment and enabling the greentech markets. Policymakers have opportunities to continue to refine policies and optimize standards, better enforce compliance with existing policies, facilitate financing of greentech solutions, liberalize target markets to promote efficiencies and innovation, and support the development of national and international environmental exchanges.

OTHER STAKEHOLDERS

Academic institutions, NGOs, international organizations and other stakeholders also have an ability to accelerate China's greentech markets. Key opportunities include driving greentech education and training initiatives in China, building links and communications within and across other stakeholder groups, supporting research in basic science and solutions, and creating and supporting mechanisms for tracking compliance with existing policies.

From this effort it is clear that China will become one of the world's largest markets for greentech technologies, products and services. Given its large market size combined with the high level of activities across all greentech sectors, it is also certain that China's local industries will become major producers of many greentech solutions, both for local consumption as well as for export to the rest of the world. Yet there are also significant opportunities for foreign companies, particularly those with advanced technologies and other capabilities that can be adapted appropriately to China's unique market requirements.

What is less certain is the degree to which China will become the center of greentech innovation. This potential certainly exists, driven by factors which include strong local demand, coordinated government support, entrepreneurial culture, availability of human capital and the country's strong industrial base. On the other hand, China's companies have historically been successful more for their low-cost manufacturing of existing technologies than for their innovation of leading technologies. The Initiative believes that the jury is still out in this case, but would not discount the real possibility that China emerges as an innovator in many greentech markets within the next several years.

DEFINING

CHINA'S GREENTECH MARKETS

This report refines the term 'greentech,' provides a map of China's greentech markets, and defines a set of greentech market sectors and segments

AS GREENTECH MARKETS ARE BOTH EMBRYONIC AND RAPIDLY CHANGING, there are few standardized terms in use today. For example, the term greentech is commonly described with alternatives such as cleantech, alternative energy and sustainable practices.

In order to ensure a common language throughout this report, the Initiative reviewed existing definitions of greentech-related concepts, gathered the views of industry experts and solicited feedback from its partners and advisors. The resulting definitions presented in this chapter are those used by the China Greentech Initiative. Additional definitions can be found in the Glossary.

DEFINITION OF 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 and maximizing the efficient and sustainable use of energy, water and other resources

China Greentech Market Map

A CRITICAL ELEMENT OF DEFINING CHINA'S GREENTECH MARKETS for the purposes of the Initiative was the development of The China Greentech Market Map, presented in Figure 1. The map is comprised of nine broadly-defined market sectors and 40 focused segments across three broad categories – energy supply, resource use and other markets. This map provides a common language to describe greentech markets in China, and a structure that has guided the research process and the organization of this report.

Fig. 1: THE CHINA GREENTECH MARKET MAP

	ENERGY SUPPLY			RESOURCE USE			OTHER MARKETS		
SECTORS	Cleaner Conventional Energy	Renewable Energy	Electric Power Infrastructure	Green Building	Cleaner Transportation	Cleaner Industry	Clean Water	Waste Management	Sustainable Forestry and Agriculture
SEGMENTS	Cleaner Coal	Solar Energy	Transmis-sion	Optimized Design	Cleaner Road	Optimized Design	Water Extraction	Waste Collection	Sustainable Forest Management
	Cleaner Oil	Wind Power	Distribution	Sustainable Materials	Cleaner Rail	Sustainable Materials	Water Treatment	Waste Recycling	Sustainable Land Management
	Cleaner Gas	Bioenergy	Energy Storage	Energy Efficiency	Cleaner Air	Efficient Processing	Water Distribution	Energy from Waste Recovery	Sustainable Farming Communities
	Nuclear Power	Hydropower	Demand Management	Water Efficiency	Cleaner Waterway		Water Use	Waste Treatment	Optimized Crops
		Wave Power	Supply Flexibility				Wastewater Treatment	Sustainable Waste Disposal	
		Geothermal Energy							

LEGEND

- Sectors covered in the report
- Segments covered in the report
- Sectors and segments not covered in the report

THIS REPORT FOCUSES ON SEVEN CHINA GREENTECH MARKET SECTORS:

- **Cleaner Conventional Energy**
- **Renewable Energy**
- **Electric Power Infrastructure**
- **Green Building**
- **Cleaner Transportation**
- **Cleaner Industry**
- **Clean Water**

Within the Renewable Energy and Cleaner Industry sectors a representative range of segments are covered. This choice of focus was made based on input from partners and advisors, an understanding of the market opportunities, and consideration of the Initiative's available time and resources. Sectors and segments not covered in this report should by no means imply a judgment on their environmental or commercial potential.

Greentech Sectors and Segments

DEFINITIONS FOR EACH SECTOR COVERED IN THE CHINA GREENTECH REPORT are presented below. Due to the particularly broad scope of the Cleaner Conventional Energy, Renewable Energy and Cleaner Transportation sectors, definitions for segments within these three sectors are also included. The report has subsequently been organized along these specific segment lines.

CLEANER CONVENTIONAL ENERGY

Cleaner Conventional Energy is defined as energy derived from non-renewable fossil fuel sources (e.g. coal, oil and natural gas) in ways which minimize the negative impact on the natural environment. This sector also includes nuclear power.

- Cleaner coal includes solutions such as Coal Screening and Scrubbing, Integrated Gasification Combined Cycle (IGCC) and Carbon Capture and Sequestration (CCS)
- Cleaner gas consists of solutions such as Capture and Use of Coal Mine Ventillation Air Methane and Natural Gas Combined Cycle (NGCC)
- Cleaner oil is made up of solutions such as Efficient Oil Extraction, Water Reinjection and Optimized Reservoir Management that allows oil to be extracted in ways which minimize negative impact on the natural environment
- Nuclear power is energy derived via controlled nuclear fission of radioactive materials at nuclear power plants

RENEWABLE ENERGY

Renewable Energy is produced from sources that are naturally replenishing, such as Solar Light, Wind, Waves, Underground Heat, Surface Water Flows and Biomass.

- Wind power is defined as electric energy generated from wind using Power Generation Turbines
- Solar energy consists of thermal or electric energy derived from solar light using Photovoltaic Cells, Concentrating Solar Installations or Solar Water Heaters
- Bioenergy is thermal or electric energy produced from biomass, and includes solutions such as Bioethanol, Biodiesel, Biogas and Biomass Combustion

ELECTRIC POWER INFRASTRUCTURE

Electric Power Infrastructure refers to "smart" electric grids and networks, supported by IT applications, which deliver power to users on demand in an efficient and reliable way, from a broad range of generating sources.

GREEN BUILDING

Green Building covers planning, building and operating solutions that are more sustainable, efficient and healthy than conventional solutions for an equivalent level of comfort and service. Solutions include Integrated Design, Sustainable Materials, Energy Efficient Appliances and Building Automation.

CLEANER TRANSPORTATION

Cleaner Transportation is defined as solutions that increase energy efficiency, reduce emissions and improve resource utilization to minimize the negative impact of transportation on the environment.

- Cleaner road transportation includes More Efficient Engines, Cleaner Fuels, Alternative Vehicle Energy Systems, as well as comprehensive road network planning and development
- Cleaner rail transportation refers to Energy Efficient Trains, Electrification of Railways and Optimized Railway Operations Management
- Cleaner air transportation includes Fuel Efficient Aircraft, well planned and constructed airport infrastructure and Optimized Air Traffic Management
- Cleaner waterway transportation covers Fuel Efficient Ships, well planned and constructed waterway infrastructure and Optimized Water Traffic Management

CLEANER INDUSTRY

Cleaner Industry encompasses practices that increase energy efficiency, reduce air and water pollution and decrease the amount of solid waste produced by industrial activities. Solutions include on-site Combined Heat and Power (CHP), Energy Efficient Motors, Flue Gas Desulfurization (FGD) systems and Process Redesign.

CLEAN WATER

Clean Water is defined as the collective sum of activities within the economic water cycle – water extraction, water treatment, water distribution, water use and wastewater treatment. Solutions include Water Treatment Technologies, Water Quality Measurement and Monitoring.

CHINA'S

MARKET CONTEXT

China's three decades of dynamic economic growth have created a colossal and resilient economy at significant cost to the environment. However, as the country increasingly adopts greentech solutions, the signs of a green transformation are beginning to emerge.

THE UNPRECEDENTED SCALE OF CHINA'S ECONOMIC DEVELOPMENT over the past three decades has resulted in both positive and negative consequences. While the living standards of hundreds of millions of people have improved, China's ecosystems have suffered from significant environmental damage. For China to continue on this path of rapid economic growth, it will need to take deliberate steps towards improving the sustainability of its economic activities. There is ample evidence that both national and international stakeholders are rallying to support opportunities for this new transformation to an environmentally sustainable China.

China's Three Decades of Transformation

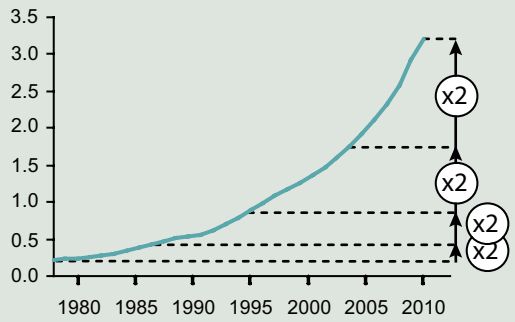
IN JUST A LITTLE OVER 30 YEARS, since the Deng Xiaoping-led government adopted "Reform and Opening Up" policies in December 1978, China has undergone an economic transformation unlike anything the world has seen before. Economic and political developments during this period have solidified China's status as a major world power, particularly in trade and international affairs.

FORMIDABLE ECONOMIC GROWTH

China's economic output (real GDP) has grown on average 10% annually since the late 1970s. This led China to double the size of its economy every seven to eight years and resulted in its current GDP being sixteen times the size it was in 1978. China's economy is currently the world's third largest, behind the U.S. and Japan. Most analysts predict that China will replace Japan as the world's second largest economy (see Figure 1) in the near-term future.

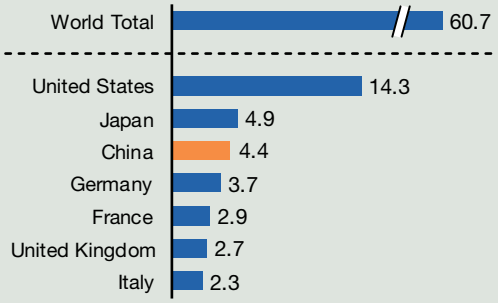
Fig.1: **CHINA'S GROSS DOMESTIC PRODUCT (GDP)**

China Real GDP, 1978-2008
2005 Trillion US$, Official Exchange Rate



Source: *US Department of Agriculture, "International Macroeconomic Data Set"*

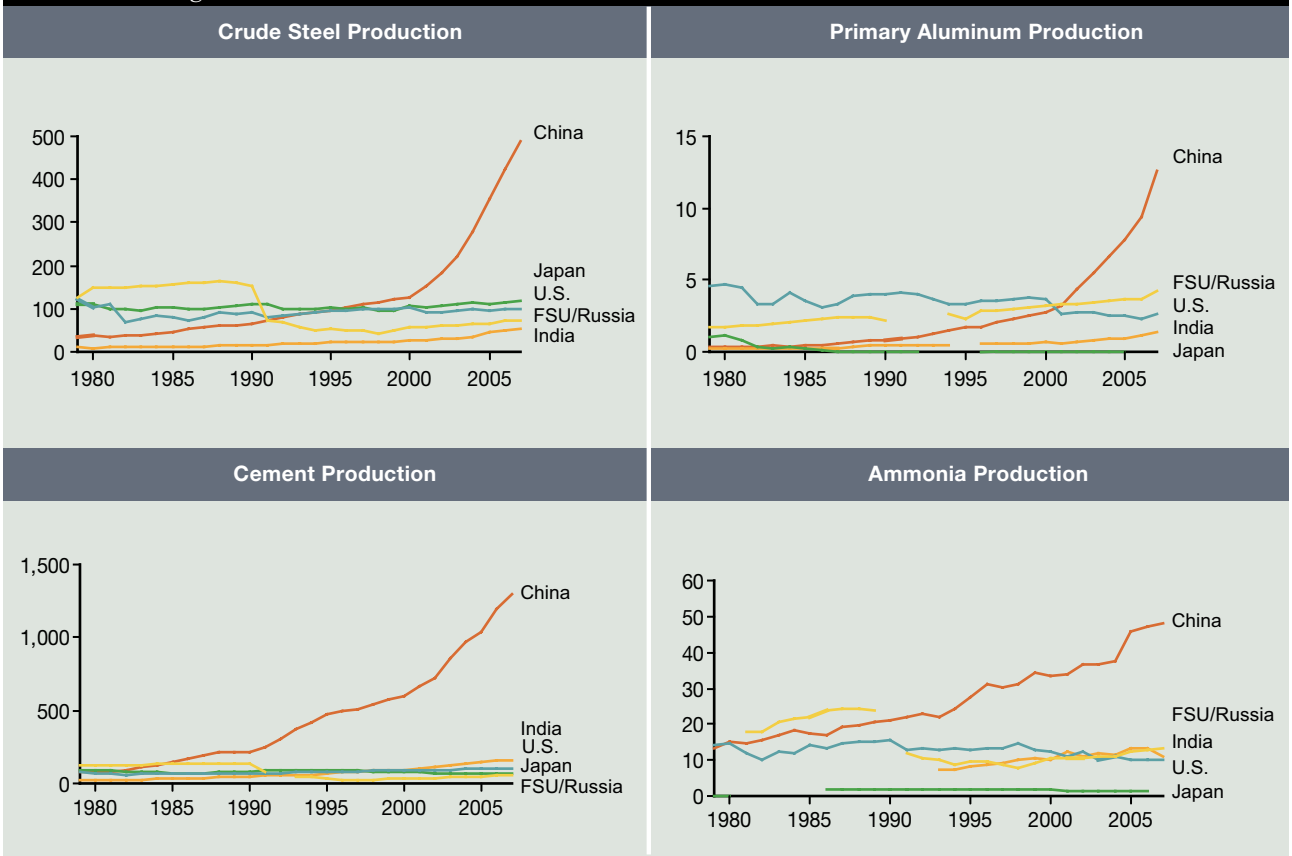
Nominal GDP by Leading Countries, 2008
Trillion US$, Official Exchange Rates



Source: *International Monetary Fund, "World Economic Outlook Database April 2009 Edition"*

The country's rapid economic growth has been led by fast-paced industrialization, starting with light industry (e.g., textiles, clothing and footwear) in the 1980s, and propelled by heavy industry (e.g., metallurgy, chemicals and machinery) over the last decade. The output of China's heavy industry, a significant part of which is exported, has grown particularly fast since 2001, the year China joined the World Trade Organization. This growth has resulted in China becoming the world's leading producer and consumer of a wide range of basic materials and tradable commodities. For example, China produces over half of the world's cement and one-third of the world's steel and aluminum (see Figure 2).[1] In terms of consumption, China is the world's largest consumer of rice, cotton, steel, aluminum, copper, nickel and tin.

Fig .2: **SELECTED INDUSTRIAL PRODUCTION BY CHINA AND LEADING COUNTRIES, 1980-2007,** *Megatons*



Source: *Lawrence Berkeley National Laboratory, "China Energy Databook Version 7.0"*

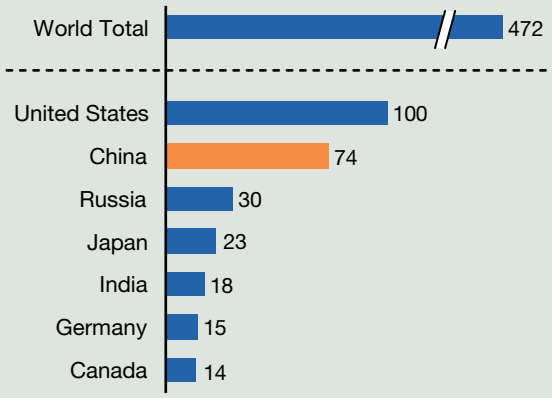
Not surprisingly, China's economic growth has fueled its demand for energy. Between 1978 and 2006, China's primary energy consumption grew an average of 6% per year, compared to the world average of 2%. This growth accelerated after 2000, increasing to over 10% per year and doubling China's primary energy consumption between 2000 and 2006 alone.[2,3] China is now the second largest consumer of energy in the world, behind the U.S. In 2006, it was responsible for 16% of global energy consumption, a figure that continues to grow (see Figure 3). It is the largest consumer of coal and the second largest consumer of crude oil.

RADICAL IMPROVEMENTS TO LIVING STANDARDS

This tremendous economic growth has led to radical improvements in the living standards of Chinese citizens. Given that China's population grew by only 35% in the last three decades while its economy experienced a sixteen-fold increase in overall GDP, per capita income increased ten-fold.

Since the 1980s, poverty in China has been reduced significantly. According to the World Bank, while 84% of China's population lived on less than US$1.25 per day in 1981, this number had fallen to 16% by 2005 (see Figure 4).[4] Hundreds of millions of people have been lifted out of poverty by China's economic development in half a generation.

Fig.3: PRIMARY ENERGY CONSUMPTION BY LEADING COUNTRIES, 2006
Quadrillion BTU



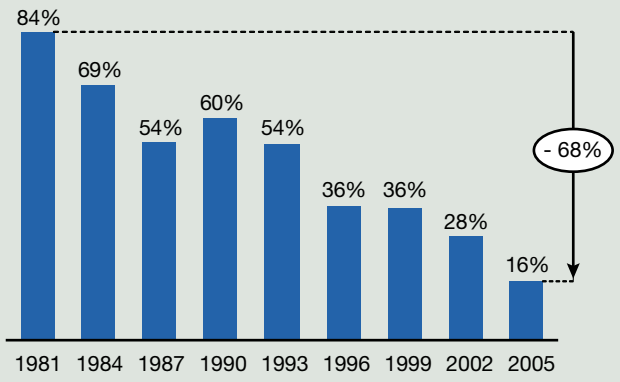
Source: *The World Bank, Poverty Data: A Supplement to World Development Indicators 2008 (Washington DC, U.S.: World Bank, 2008)*

In addition to poverty reduction, overall living standards have improved markedly. China's United Nations Human Development Index (HDI), which is a measure of health, education and income, increased from 0.53 to 0.78 between 1975 and 2005, an improvement of over 47% (see Figure 4). In 1975, this score nearly qualified China for the UN definition of "low human development," assigned to roughly one-third of the world's countries with the lowest scores. In 2005, however, China had come close to the UN's definition of "high human development," assigned to roughly one-third of the world's countries with the highest scores.

Between 1975 and 2005, China's life expectancy at birth increased from 66 to 76 years and from 64 to 72 years, for females and males respectively.[5] Public spending on healthcare increased nearly fourteen-fold (constant dollars) between 1978 and 2006, and access to education (i.e. literacy rates and number of years in school) has improved dramatically.[6] As the United Nations Development Program's China Human Development Report 2007/08 points out, "China's population is wealthier, better educated and healthier than it has ever been."[7]

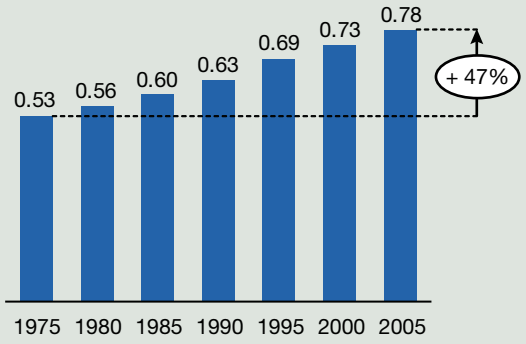
Fig.4: IMPROVEMENT OF LIVING STANDARDS IN CHINA

Share of Population Living on Less than US$1.25 per Day (PPP 2005), 1981-2005, *%*



Source: *The World Bank, Poverty Data: A Supplement to World Development Indicators 2008 (Washington DC, U.S.: World Bank, 2008)*

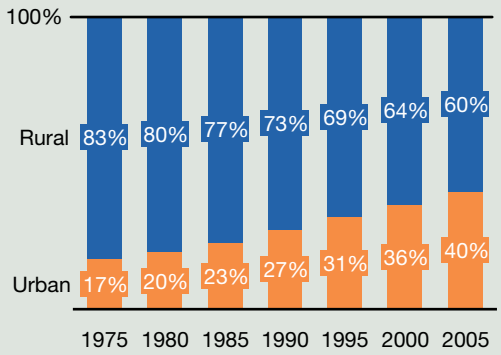
United Nations Human Development Index, 1975-2005
Index



Source: *United Nations Development Programme, Human Development Report 2007/2008 (New York, NY, USA: Palgrave Macmillan), 235*

[1] *Lawrence Berkley National Laboratory, "China Energy Databook Version 7.0" Tables 9B.13-15*
[2] *Energy Information Administration, "International Energy Annual 2006" Table E.1*
[3] *At the time of writing this report, energy data as reported by the Energy Information Administration for 2006 was the latest available, published in 2008; the update was scheduled to be released later in 2009*
[4] *Measured on Purchasing Power Parity basis in 2005 US$*
[5] *Watkins, Kevin, China Human Development Report 2007/08 (Beijing, China: United Nations Development Program and China Translation and Publishing Group Corporation, 2008), 6*

Fig.5: **PROPORTION OF POPULATION IN URBAN AND RURAL AREAS IN CHINA, 1975-2005,** *%*



Source: *United Nations, "World Urbanization Prospects: The 2007 Revision Population Database"*

One key factor driving the improvement of living standards in China has been massive urbanization – the migration of people from rural to urban areas. Between 1975 and 2005, the percentage of the population that live in urban areas rose from 17% to 40% (see Figure 5), expanding the urban population by nearly 400 million.

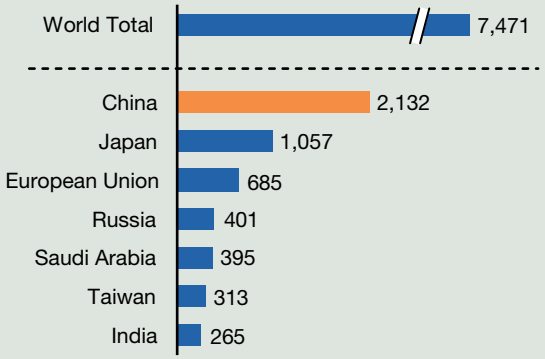
Cumulative household consumption has also grown dramatically across the country, at a pace just under that of GDP growth – over 8% per year on average for 30 years.[8] China is quickly emerging as a major market for home appliances, consumer electronics, mobile telecommunications, internet service, real estate, air travel and private vehicles sales.

■ RESILIENT ECONOMY

Export-led growth and tempered fiscal policies have allowed China to accumulate the largest foreign exchange reserves in the world. As of May 2009, China had over US$2,000 billion in reserves, representing nearly 30% of total foreign exchange reserves held worldwide (see Figure 6). The speed at which China accumulated these reserves is equally astounding, as the total amount stood at less than US$200 billion in 2000, merely one-tenth the present level.[9]

As the global economic crisis became apparent in the fall of 2008, China's government acted quickly, announcing a four trillion yuan (US$586 billion) economic stimulus package in November to be spent over two years. This became the second largest stimulus package in the world, following the US$787 billion American Recovery and Reinvestment Act. As a percentage of GDP though, China's stimulus package was the largest in the world.

Fig.6: **FOREIGN EXCHANGE RESERVES BY LEADING COUNTRIES, MAY 2009,** *Billion US$*

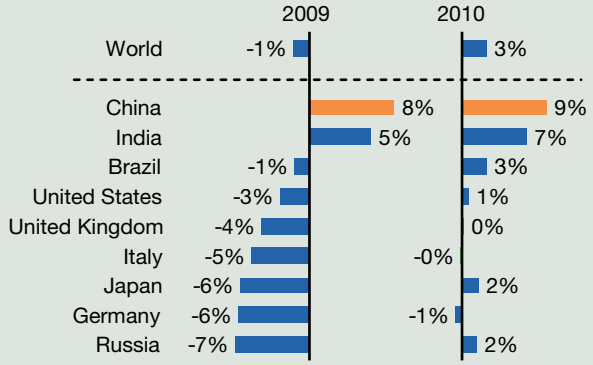


Source: *Wikipedia, "List of Countries by Foreign Exchange Reserves," http://www.wikipedia.com/ (accessed on August 10, 2009)*

[6] *Ibid., 15*
[7] *Ibid., 1*
[8] *National Bureau of Statistics of China, "China Statistical Yearbook 2008," The China Greentech Initiative analysis*
[9] *The People's Bank of China, "Gold and Foreign Exchange Reserves, 2000," http://www.pbc.gov.cn/ (accessed on August 18, 2009)*

A combination of policies aimed at stimulating the economy appears to have helped China maintain fast economic growth this year, outperforming the expectations of many analysts. China announced that the economy grew at 7.1%, year-over-year in the first half 2009.[10] At the time, the International Monetary Fund (IMF) had forecast China's economy to grow 8% in total for 2009, while anticipating a worldwide contraction of 1%. China's growth is projected to reach 9% in 2010 (see Figure 7).

***Fig.7*: REAL GDP GROWTH FORECASTS BY THE INTERNATIONAL MONETARY FUND FOR SELECTED COUNTRIES, 2009-10, %**



Source: *International Monetary Fund, "World Economic Outlook Update, July 2009"*

Environmental Cost of China's Economic Growth

CHINA'S RAPID ECONOMIC DEVELOPMENT has significantly impacted the environment. While this is not dissimilar to what has happened in other countries that have undergone industrialization, the scale and pace at which it has happened in China has caused the rest of the world to take notice. China has the unenviable task of balancing improvements in the welfare and living standards of its people with the need to protect and nurture the natural environment. Key natural resources (e.g. air, water and land) are compromised by pollution and overuse, thereby impacting human health and jeopardizing renewal of resources. These results reveal the unsustainability of former practices and dramatically reinforce the urgent need for rapid change.

■ POLLUTED AIR

As concerns over global climate change have increased, China has become a focal point for leaders in the field of environmental protection. In 2006, far ahead of international forecasts, China emerged as the world's largest emitter of greenhouse gases (GHGs), overtaking the U.S. Although China's per capita GHG emissions are still low relative to most developed countries, in aggregate, China is responsible for over 20% of the total GHGs released into the atmosphere annually (see Figure 9).[11] As international efforts to slow down and eventually reverse GHG emissions increases continue, China is expected to play a central role.

On the surface, the magnitude of China's GHG emissions may seem surprising, particularly given the size of its economy, which is only one-third that of the United States. However, key differences between China and the U.S., such as the role industrial production plays in the economy and energy efficiency levels, explain why. Industrial production, which is inherently more GHG intensive than services or agriculture, accounts for over 50% of China's GDP compared to just 25% in the U.S.[12] This is due in part to China's role as the world's leading producer of manufactured goods, a large proportion of which is exported and consumed overseas. China also has lower energy efficiency than the U.S. across most industrial sectors.

[10] *National Bureau of Statistics of China, "China's Economy Stabilized with a Better Performance Trend While Its Upturn Yet to Consolidate," July 17, 2009, http://www.stats.gov.cn/*
[11] *Xinhua, "China's Installed Power Capacity Increases 10%," January 11, 2009, http://english.people.com.cn/*
[12] *Energy Information Administration, "International Energy Annual 2006" Table 6.4*

CHINA'S COLOSSAL SCALE

It is essential to understand the scale at which China operates

Representing 7% of the world's land mass by area, China is home to nearly one-fifth of the world's population. At just over 1.3 billion people, its population is nearly twice that of the United States and Western Europe combined. Six of China's provinces are home to more than 65 million people each, making them comparable in population to large European countries such as the U.K., France and Italy.

Each year, more than 18 million people migrate from rural to urban areas in China, which is more than the national population of Greece, Belgium or Portugal (see Figure 8).

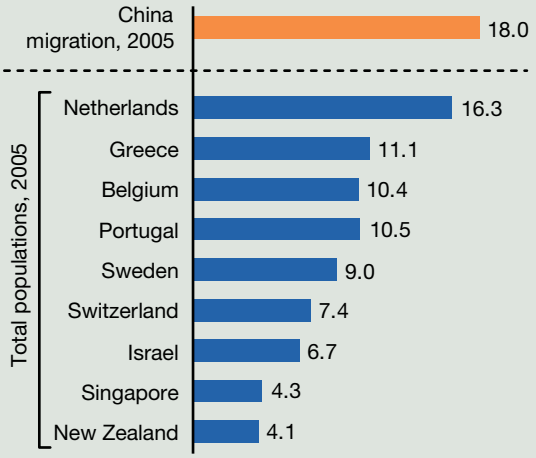
China maintains over 40 billion square meters of residential, commercial and industrial floor space, representing the largest building stock in the world. This is more than twice the floor space found in the U.S.

Economically, the output of just one of China's provinces, Guangdong, is greater than that of Norway, Saudi Arabia or Indonesia.

Each year, China installs electricity generation capacity beyond the total capacity of countries such as the U.K., Italy or South Korea (see Figure 8). In fact, at the present pace of installation, it would take China just three years to build new capacity equivalent to that which currently exists in Japan or Russia, two of the five largest power generating countries in the world.[13,14]

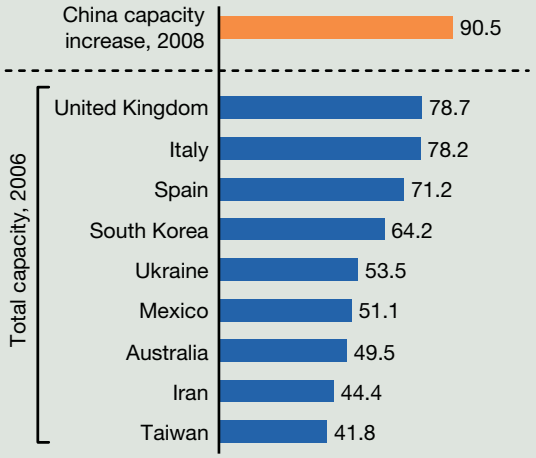
***Fig.8*: CHINA'S COLOSSAL SCALE**

China Yearly Migration Ccompared to Populations of Selected Countries, 2005, *Millions*



Sources:
1. Chan, Kam Wing, Internal Labor Migration in China: Trends, Geographical Distribution and Policies (Seattle, U.S.: University of Washington, 2008)
2. United Nations, "World Urbanization Prospects: The 2007 Revision Population Database"

China Generating Capacity Increase 2008 Compared to Total Capacity of Selected Countries, 2006, *GW*



Sources:
1. Energy Information Administration, "International Energy Statistics" Table 6.4
2. Xinhua, "China's Installed Power Capacity Increase 10%," January 11, 2009, http://english.people.com.cn/

Finally, China relies heavily on coal as its primary energy source. Coal accounts for over 70% of China's primary energy supply, compared to the world average of less than 30% and even less for the U.S. (see Figure 10). China continues to increase its coal-fired power generation capacity by an equivalent of two 500MW plants per week.[15] Coal is a highly GHG intensive fuel source, emitting nearly twice the CO_2 of natural gas and about one-third more than oil in delivering one unit of energy.[16] In fact, over 80% of China's CO_2 emissions from energy use come from burning coal.[17]

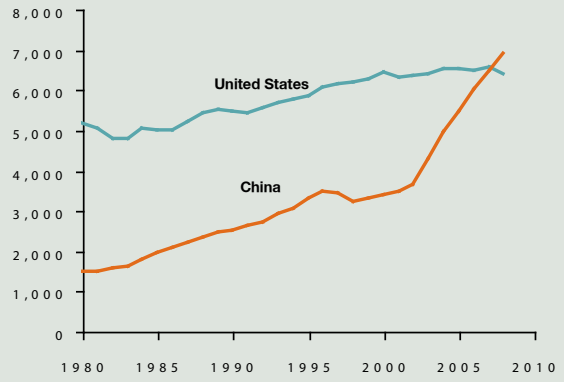
Apart from greenhouse gases, China's air quality suffers from other pollutants that have more immediate effects on human health. According to the World Bank's

[13] *The statistics presented in the Figure accounts for CO_2 emission from consumption of coal, oil and natural gas only and do not include other GHG emissions, such as those from deforestation and industrial processes. This data is often used as proxy to analyze trends and relative emissions between countries due to greater reliability and consistency.*
[14] *Zhou, Nan, Energy Use in China: Sectoral Trends and Future Outlook (Oakland, CA, U.S.: Lawrence Berkeley National Laboratory, 2008), 10, 28*
[15] *Energy Information Administration, "International Energy Annual 2006" Table 6.4t*
[16] *BP, "BP Statistical Review of World Energy June 2009"*
[17] *Ibid; The China Greentech Initiative analysis*

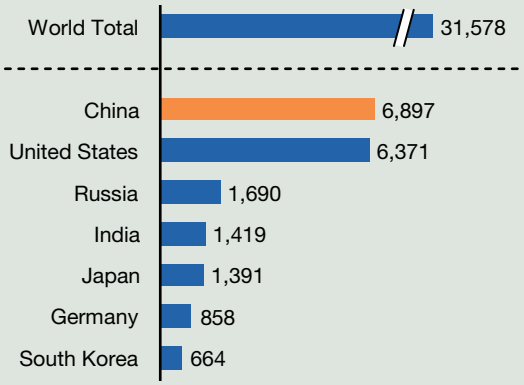
latest ranking of over 100 large cities by particulate matter pollution worldwide, 17 of the 25 most polluted cities in 2004 were located in China. Particulate matter are small particles or liquid droplets suspended in the air, some of which are small enough to pass through the human nose and throat into the lungs, and in large quantities cause serious damage to the heart and lungs. Data in the same study, sourced between 1995 and 2001, revealed that six of the world's seven cities with the highest sulfur dioxide air concentration were located in China. Sulfur dioxide exacerbates human respiratory and heart illnesses and contributes to the formation of acid rain, which can damage crops, buildings, soil and water.[18,19]

Fig.9: **CO_2 EMISSIONS FROM COMSUMPTION OF COAL, OIL AND NATURAL GAS**

China and the U.S., 1980-2008, *Megatons per Year*



Leading Countries, 2008, *Megatons per Year*



Note: *This statistics does not include CO_2 emitted from sources other than coal, oil or natural gas and non-CO_2 greenhouse gases*
Source: *BP, "BP Statistical Review of World Energy June 2009"*

STRAINED WATER RESOURCES

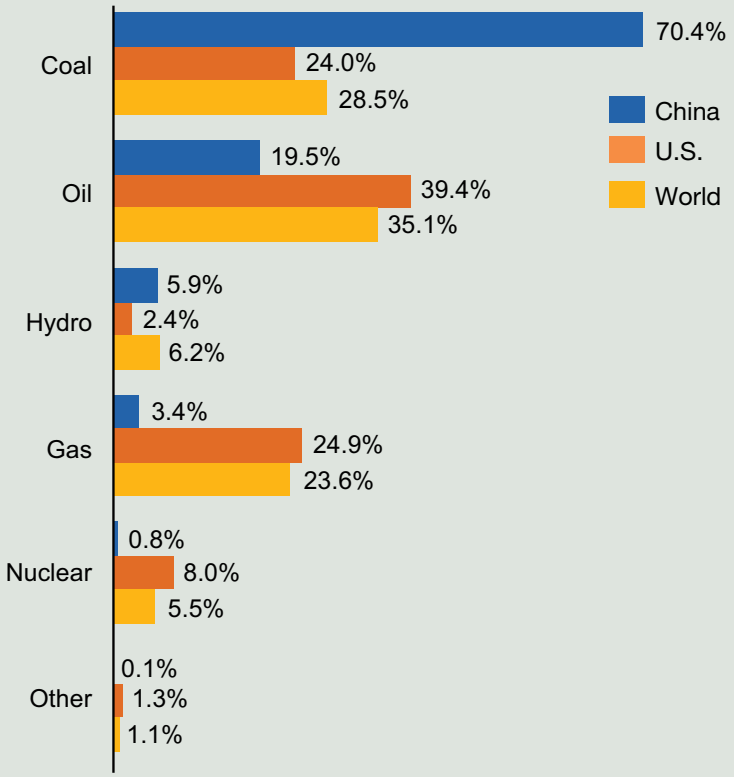
In addition to air pollution, China faces the dual problem of water scarcity and water pollution. China, with 20% of the world's population, has less than 7% of the world's fresh water resources, which come from surface rivers and groundwater sources that are now in decline.[20] Driven predominantly by a large population, it is the second largest water consumer in the world, behind India (see Figure 11). According to China's National Bureau of Statistics, China's water resources fell by as much as 10% between 2000 and 2007 alone (see Figure 12). This is due in part to the increased frequency of severe droughts, which some have attributed to changing climate conditions. During the winter of 2004-2005, Southern China suffered from what local authorities called the worst drought in 50 years.[21] Later, in the winter of 2008-2009, Beijing experienced its longest drought since 1971.[22]

One of the main reasons China experiences such a high water demand is that the country tends to use water resources inefficiently. Nearly two-thirds of all water drawn in China is used in the agricultural sector, which is highly fragmented. In most cases, irrigation systems are very inefficient, with only 45% of the water drawn actually reaching the crops.[23] Industry accounts for one-quarter of China's water withdrawal. Similarly, water productivity in China – which is a measure of the value of output created per one unit of water used – was in 2001 five times lower than that of Germany, and remarkably, nearly 30 times lower than that of Japan or Denmark (see Figure 13). This is due not only to China's lower water recycling rate and overall lower water use efficiency, but also the dominant role of heavy industry.

Furthermore, China faces the difficulty of geographic disparity as nearly 80% of its surface water resources are concentrated in the South. As a result, Northern China is faced with the issue of overexploited groundwater resources.

[18] *World Bank, World Development Indicators 2007 (Washington DC, U.S.: World Bank, 2008), 174-175*
[19] *Environmental Protection Agency, "Six Common Air Pollutants" (accessed on August 18, 2009)*
[20] *China Internet Information Center, "Efforts to Protect and Save Water Resources," March 23, 2009, http://www.china.org.cn/*
[21] *United States Department of Agriculture, "Recent Rain Eases Drought in Southern China," March 10, 2005, http://www.fas.usda.gov/*
[22] *China Economic Net, "No Rain in Beijing for 100 Days," February 4, 2009, http://en.ce.cn/*
[23] *Xie, Jian, Addressing China's Water Scarcity: Recommendations for Selected Water Resource Management Issues (Washington DC: U.S.: The World Bank, 2009)*

Fig.10 **CHINA'S PRIMARY ENERGY MIX COMPARED TO THE U.S. AND WORLD TOTAL, 2007,** *% of Total Energy Consumption*

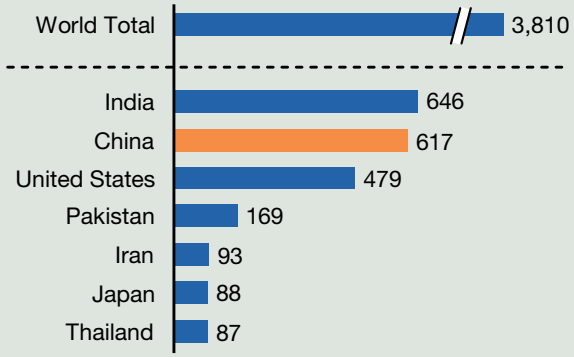


Note: *"Other" includes electric power generated from geothermal, solar, wind, and wood and waste sources*

Sources:

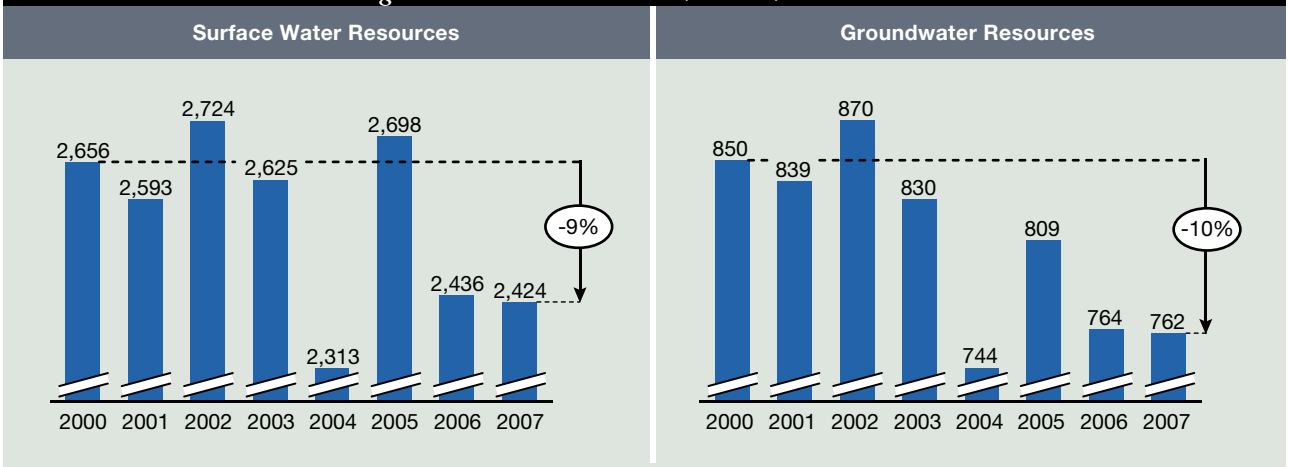
1. BP, "BP Statistical Review of World Energy June 2009"
2. Energy Information Administration, "International Energy Annual 2006" Table F.8
3. The China Greentech Initiative analysis

Fig.11: **TOTAL WATER WITHDRAWAL BY LEADING COUNTRIES, 2000**
Billion Cubic Meters per Year



Source: *Food and Agriculture Organization of the United Nations, "AQUASTAT"*

Fig.12: **CHINA WATER RESOURCES, 2000-07,** *Billion Cubic Meters*



Note: *Duplicated measurement between surface water and groundwater was not accounted for in this analysis*
Source: *National Bureau of Statistics of China, "China Statistical Yearbook 2008" Table 11-17*

Water pollution is an equally large concern. According to Greenpeace, 70% of China's rivers, lakes and reservoirs are seriously impacted by water pollution and are "not safe for humans to use."[24] Pollutants originate from point sources, such as industrial and municipal discharges, as well as non-point sources, such as fertilizers that seep into water reservoirs via the soil. Industrial and domestic water users discharge over 50 billion tons of wastewater annually into China's rivers, lakes and reservoirs.[25] Pollution is a particularly acute problem in China's major rivers in the North, such as the Hai, Huai and Liao rivers, where over one third of the water is so polluted it cannot be used for any purpose, including industrial or agricultural uses (see Figure 14). Studies have shown clear links between China's level of water quality and the incidence of human illness, such as diarrhea, typhoid, and cancer of the stomach, liver and bladder.[26]

■ LAND DEGRADATION

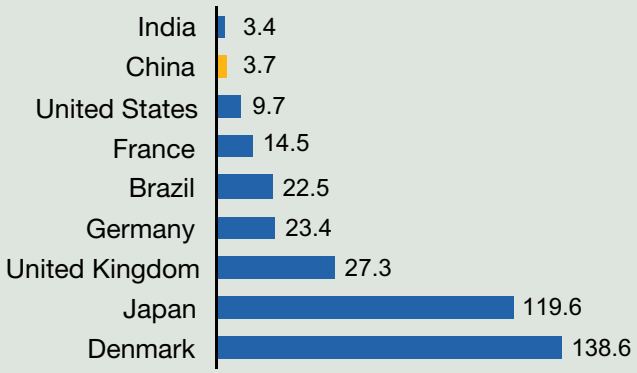
Land degradation and contamination is another environmental issue facing China. Between 1957 and 1990, the area of arable land in China was reduced by 35 million hectares. This is equivalent to the available crop areas of Denmark, France, Germany and The Netherlands combined.[27] Desertification is a major force that continues to threaten arable land in China, particularly in the North, with deserts already accounting for 18% of the country's land area.[28]

Although China has taken sweeping measures to rationalize and control solid waste management, it remains a key issue. Waste landfills are growing at alarming rates, resulting in land contamination and posing risks to human health. It is estimated that 80% of solid waste in China is landfilled.[29] Of nearly 1,000 official landfills that are currently in use or already closed in China, almost half were found to not comply with China's own Environmental Impact Assessment standards.[30] In 2003, researchers at the U.S. Environmental Protection Agency (EPA) estimated that only 5% of China's landfills were sufficiently sanitary to conform to U.S. standards, nearly 40% did not conform to such standards and over 50% were open dumps.[31]

Improperly managed landfills lead to a range of environmental problems. They create groundwater pollution as dissolved solids, nitrate nitrogen, ammonia

[24] *Greenpeace, "China's Water Crisis," http://www.greenpeace.org/ (accessed on August 20, 2009)*
[25] *National Bureau of Statistics of China, "Statistical Yearbook 2008;" The China Greentech Initiative analysis*
[26] *Xie, Jian, Addressing China's Water Scarcity: Recommendations for Selected Water Resource Management Issues (Washington DC, U.S.: The World Bank, 2009), 19*
[27] *Global Environment Facility and International Fund for Agricultural Development, Tackling Land Degradation and Desertification (U.S. and Italy: Global Environment Facility and International Fund for Agricultural Development, 2002), 2*
[28] *The Walrus, "The Chinese Dust Bowl," http://www.walrusmagazine.com/ (accessed on August 15, 2009)*
[29] *Robinson, A. et al., Landfill Data from China: Addressing Information Needs for Methane Recovery (Washington DC, U.S.: Environmental Protection Agency, 2003), 1*
[30] *中国低碳网, "全国仅57%垃圾填埋通过环评," [China Low Emissions Website, "Only 57% of the National Landfill Passed Through Environmental Impact Assessment"], July 3, 2009*
[31] *Robinson, A. et al., Landfill Data from China: Addressing Information Needs for Methane Recovery (Washington DC, U.S.: Environmental Protection Agency, 2003), 1*

***Fig.13*: INDUSTRIAL WATER PRODUCTIVITY, 2001,** *Billion US$ per Cubic Kilometer*

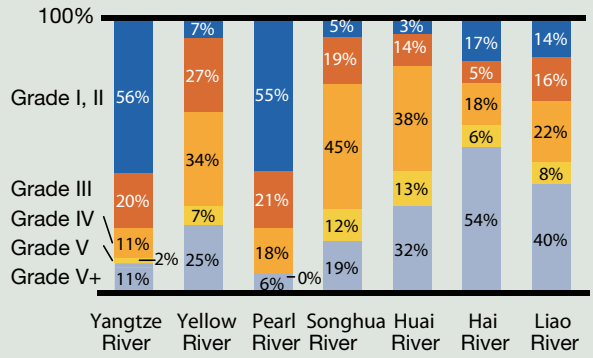


Source: *United Nations Industrial Development Organization, Water: A Shared Responsibility (New York, NY, U.S.: United Nations Industrial Development Organization, 2006)*

nitrogen and other pollutants seep through into aquifers. Methane is released as organic matter decays, which is a potent greenhouse gas that contributes to global warming in addition to endangering inhabitants in the area due to its explosive nature. Landfills also can become breeding grounds for disease vectors, such as rats and flies.

Similarly, hazardous waste management is a concern. Although only 1% of all solid waste generated in China is hazardous,[32] China's government has invested heavily in regulation and management systems due to the significant threats to human and environmental health. While reports vary on the level of compliance and treatment, a number of challenges are consistently recognized. Given that waste generators are required to finance the treatment of the waste themselves, and that the disclosure of the nature of their activities may lead to closer scrutiny in the future, small to medium-sized enterprises tend to avoid using the formal channels of managing hazardous waste.

***Fig.14*: WATER POLLUTION IN CHINA'S RIVER BASINS BY GRADE, 2005,** *%*



Definition of Pollution Grades by Standard Application:

Grade I : Source of water bodies and national nature reserves
Grade II : Protected area for centralized drinking supply (Class A)
Grade III : Protected area for centralized drinking supply (Class B)
Grade IV : Water bodies for general industrial water supply
Grade V : Water bodies for aggricultural water supply
Grade V+ : Cannot be used for any purpose

Sources:
1. Lee, Seungho, China's Water Policy Challenges (Nottingham, U.K.: The University of Nottingham, 2006), 7
2. Boerset, Erik et al., China Water Quality Management-Policy and Institutional Considerations (Washington, DC, U.S.: The World Bank, 2006), 8

[32] 王琪，"工业固体废物处理及回收利用，" *[Qi Wang, "Industrial Solid Waste Processing and Recycling"], (Beijing, China: Environmental Science Publishing House, 2006), 24*

Electronic waste (e-waste) is a case in point. China harbors a booming e-waste recycling industry which is under-regulated and almost entirely outside the control of the central government. An estimated 70% of the world's high-tech waste finds its way to China, through formal and informal channels.[33] The majority of it is processed in backyards and small workshops using manual disassembly, with almost no reliance on advanced technology. After valued components have been extracted, the remains are either disposed of in open fires or dumped. This exposes humans, flora and fauna to heavy metals and other toxins. It is of great concern that China's own sum of discarded electronics and appliances is expected to increase significantly over the coming decades.[34]

Industrialization in China Compared to Other Countries

The environmental issues currently facing China are in many ways similar to those encountered by today's developed nations, on their own paths toward industrialization.

Commencing with the U.K., European countries in the 18th and 19th centuries found themselves having to cope with a myriad of environmental difficulties, including air pollution, water shortages, sanitation issues and resource exhaustion. Air pollution became a persistent problem in the U.K., particularly in London, where it combined with fog to become persistent smog. In Paris, sewage was deposited directly into rivers, causing sanitation issues and having a devastating effect on river ecosystems and water stocks. The build up of sulfur dioxide in the atmosphere, as a result of coal burning, resulted in acid rain, which led to the salinization of soil and underground water sources. Deforestation was a major issue across most of Europe. The U.S. experienced similar challenges on its path to industrialization.

China's situation is unique in three important ways. Firstly, China's pace of industrialization is significantly faster than that experienced by other countries throughout history. As noted in a Pulitzer Prize-winning Wall Street Journal series, China has "condensed an entire Industrial Revolution into the span of a single lifetime."[35] Secondly, the scale of China's industrialization is unprecedented, with a greater proportion of China's 1.3 billion people engaged year after year. Finally, previous national experiences in industrialization have occurred during an era when the world's natural environment was less stressed. There were fewer people, greater per capita resources available, and climate change had not yet become a pressing issue.

While these differences create unique circumstances for China, they also encourage the country to address its environmental difficulties in a more efficient and rapid manner than other countries throughout history.

China's Future Development and the Need for Sustainability

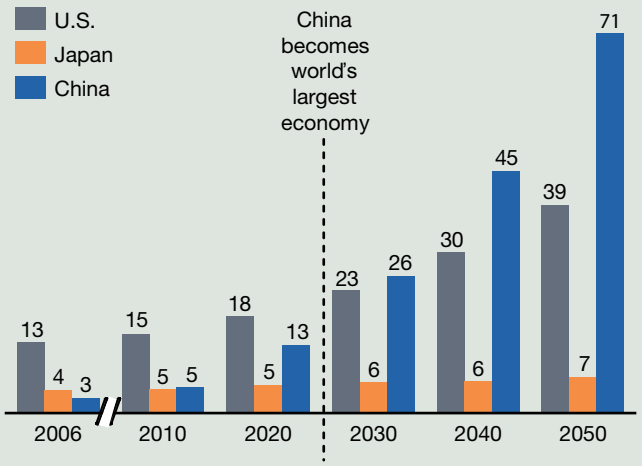
CHINA'S UNTAPPED POTENTIAL, ACCUMULATED MOMENTUM and the determination of its people will ensure that the country continues to develop economically over the coming decades. With environmental difficulties already at hand, China will need to significantly improve the sustainability of its economic activities to maintain its economic growth.

■ ECONOMIC DEVELOPMENT OF EPIC PROPORTIONS

The fundamentals are in place for China to continue its path of rapid economic development, accompanied by large-scale urbanization and the deployment of infrastructure. China's 2008 nominal GDP per capita was just over US$3,000, compared to U.S. GDP per capita of nearly US$47,000 and Japan's of above US$38,000. This difference indicates China's potential to boost the productivity of its labor force through capital investments and education. Indeed, many analysts expect China's economy to continue to grow on average at 8% annually for at least another decade. Economists at Goldman Sachs have forecast that China will overtake the U.S. to become the largest economy in the world sometime before

[33] *World Watch Institute, "China's E-Waste Problem: Facing Up to the Challenge," May 4, 2006, http://www.worldwatch.org/*
[34] *Shen, Xiaoyue et al, "Regional Economic Integration and E-Waste Management in China," Policy Research Center for Environment and Economy (presentation given at the Institute of Global Environmental Strategies, Yokohama Japan, March 26-28, 2008)*
[35] *Steiger, Paul, "China's Naked Capitalism: Raucous Industrial Revolution Echoes Era of America's Robber Barons a Century Ago," Wall Street Journal, 2007*

***Fig.15*: GDP PROJECTIONS FOR SELECTED COUNTRIES,** *2006 Trillion US$*



Source: *Goldman Sachs Economic Research Group, BRICs and Beyond (New York, NY, U.S.: Goldman Sachs, 2007), 149*

2030 (see Figure 15). While other analysts project lower growth rates for China's economy, it is widely acknowledged that China has the potential to become the world's largest economy prior to 2050.

China's urbanization, while on a large scale, is low compared to other countries. In 2005, it reached 40%, while the 2007 world average for urbanization was 50%. China's future urbanization is expected to involve hundreds of millions of people moving from villages to the cities. The United Nations forecasts that by 2050, it will reach the level of today's developed countries, which is approximately 75%.[36] In absolute terms, this implies the expansion of China's urban population by nearly 500 million people over the next 40 years (see Figure 16).

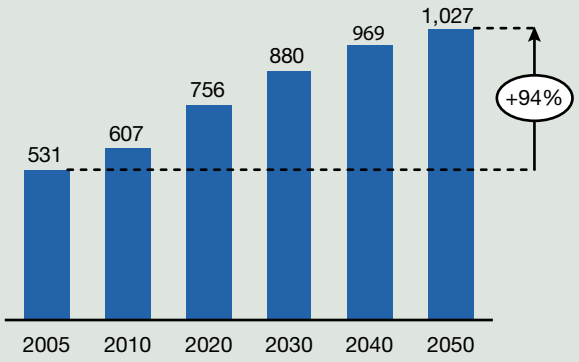
The McKinsey Global Institute estimates that this urban migration will require China to build as much as 40 billion square meters of floor space between 2005 and 2025,[37] nearly doubling the current floor space. In the same study, McKinsey estimates that in 2025 China will have over 200 cities with a population over one million. By comparison, Europe has only 35 such cities today.

This massive urbanization will be accompanied by large scale deployment of infrastructure, such as power generation, water provision, sewage, telecommunications and transportation systems (e.g., road, rail, air and waterway). China is already planning the largest railway expansion in history, which will extend the railway network from 78,000 kilometers to 120,000 kilometers by 2020 at a cost of over one trillion US$.[38]

As individual incomes rise, so will consumption. At the end of 2008, China's civil vehicle fleet stood at over 50 million cars, representing just four vehicles per 100 people.[39] Compared to the U.S., where there are over 80 passenger cars for every 100 people, or Japan with 45 cars per 100 people,[40] China's fleet on a per capita basis is small. The current growth in private car ownership, which has averaged nearly 20% since 2005,[41] will continue through the next several decades, albeit at a slower pace. McKinsey estimates that China could become the nation with the greatest number of vehicles, reaching over 300 million by 2030.[42]

[36] *United Nations, "World Urbanization Prospects: The 2007 Revision Population Database"*
[37] *Woetzel, Jonathan et al., Preparing for China's Urban Billion (New York, NY, U.S.: McKinsey & Company, March 2008), 7*
[38] *Wong, Julian and Andrew Light, China Begins Its Transition to a Clean-Energy Economy (Washington DC, U.S.: Center for American Progress, June 2009), 6*
[39] *National Bureau of Statistics of China, "Statistical Communique of the People's Republic of China on the 2008 National Economic and Social Development," February 26, 2009, http://www.stats.gov.cn/; The China Greentech Initiative analysis*
[40] *United States Bureau of Transportation "Statistics: Table 1-11," http://www.bts.gov/ (accessed on August 23, 2009); The Japan Times, "Households Owning Fewer Cars," August 21, 2007, http://www.japantimes.co.jp/ (accessed on August 23, 2009); United Nations, "World Urbanization Prospects: The 2007 Revision Population Database;" The China Greentech Initiative analysis*
[41] *National Bureau of Statistics of China, "China Statistical Yearbook 2008" Table 15-26*

Fig.16: **CHINA'S URBAN POPULATION, 2005-50,** *Millions*



Source: *United Nations, "World Urbanization Prospects: The 2007 Revision Population Database"*

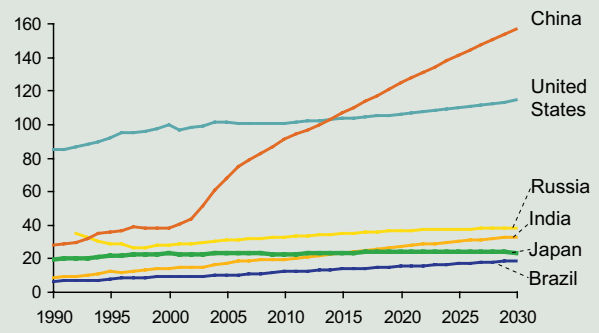
RESULTING SURGE IN RESOURCE DEMAND

This anticipated economic growth will demand increased energy, water and material resources. If China maintains its previous practices, even with ongoing improvements in resource use efficiency, the additional strain on the natural environment will be colossal and in the long-term unsustainable, given the scale of expected economic development.

According to the International Energy Agency (IEA), in the reference case scenario – which essentially assumes no significant policy and technology changes beyond what's already anticipated, and moderate GDP growth – China's energy demand could grow about 3% per year on average between now and 2030 (see Figure 17). At this rate, China would overtake the U.S. as the largest consumer of energy by 2015, and by 2030 would account for close to 25% of the world's total energy demand.[43]

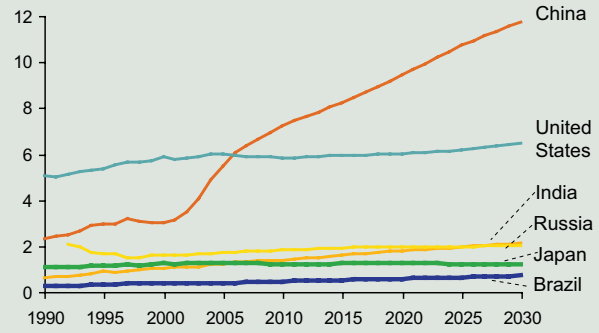
While forecasts for China's future energy mix vary greatly, some trends are clear. China's reliance on coal will persist for the foreseeable future, given the country's large installed coal-fired electricity generation capacity, abundant coal reserves and relatively stable and low coal prices. Oil demand is expected to grow rapidly, driven by the increase in motor vehicles on the road and greater proliferation of air, rail and domestic waterway transport. China's reliance on oil

Fig.17: **HISTORIC AND REFERENCE CASE PROJECTIONS FOR ENERGY CONSUMPTION BY EIA, 1990-2006 ACTUAL, 2007-2030 PROJECTIONS,** *Quadrillion BTU*



Sources:
1. Energy Information Administration, "International Energy Annual 2006" Table E1
2. Energy Information Administration, "Intenrational Energy Outlook 2009" Table A1
3.The China Greentech Initiative analysis

Fig.18: **HISTORIC AND REFERENCE CASE PROJECTIONS BY EIA FOR CO_2 EMISSIONS FROM FOSSIL FUELS, 1990-2006 ACTUAL, 2007-2030 PROJECTIONS,** *Gigatons*



Sources:
1. Energy Information Administration, "International Energy Annual 2006" Table H.1CO2
2. Energy Information Administration, "International Energy Outlook 2009" Table A10
3. The China Greentech Initiative analysis

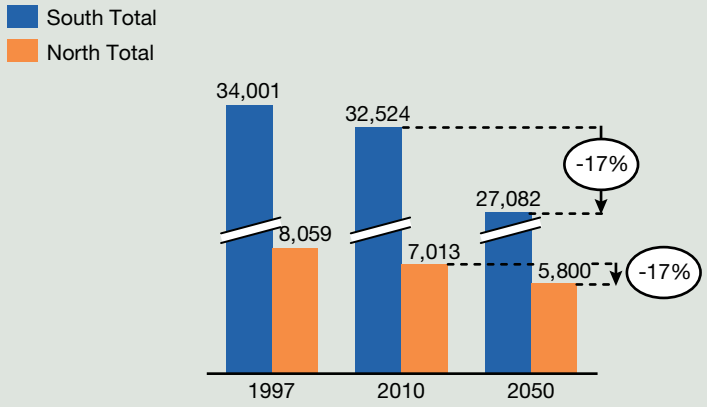
[42] *Joerss, Martin et al., China's Green Opportunity (Beijing, China: McKinsey & Company, May 2009), 5*
[43] *Energy Information Administration, "International Energy Outlook 2009" Table A1*

imports, which is currently close to half of its roughly seven million barrels of daily crude oil consumption, is expected to increase. Forecasts for contributions from hydroelectric power, natural gas, nuclear power and renewable energy sources, such as wind and solar, vary greatly, and depend on the view of individual forecasters. One certainty is that contributions from renewable energy sources, other than hydroelectricity, will remain low as a percent of total energy consumed unless China actively drives the adoption and use of these technologies.

Given the uncertainty associated with China's long-term energy mix, it is equally difficult to forecast China's GHG emissions. Nevertheless, according to the IEA's reference case scenario, China's CO_2 emissions from fossil fuel burning could grow on average at 3% annually until 2030, reaching 12 gigatons, which by that time would represent nearly 30% of the world's total GHG emissions (see Figure 18). [44]

If China indeed were to develop in line with the reference case scenario, international concerns over global warming would increasingly be directed towards China. The pace and scale of the rise of GHG emissions in this scenario could reduce the incentives for other countries to curtail their emissions. The

Fig.19: **RIVER BASINS WATER AVAILABILITY PER CAPITA PROJECTIONS, 1997-2050,** m^3



Source: *The World Bank, China: Water Quality Management – Policy and Institutional Considerations (Washington, DC, U.S.: The World Bank, 2006)*

China Greentech Initiative actually expects China to do more to reduce its GHG emissions than is projected in the reference case scenario, and explores this throughout the rest of the report.

In addition to energy, water is a major resource that China will require to sustain its growth. As discussed earlier, China's water resources are not only scarce and unevenly distributed across the country, but a large proportion is significantly polluted. The World Bank forecasts that water resources per capita across China's both southern and northern river basins will decline by as much as 17% between 2010 and 2050 (Figure 19). Given that the population is expected to grow by only 4% over the same period,[45] this forecasted decline is due mostly to the decline in actual water resources.

Economic growth also will demand increased material resources, such as metals (e.g. steel and aluminum), cement, wood, textiles (e.g. cotton) and food (e.g. sugar and rice). If unmediated, China's soaring demand for these commodities may put undue pressure on available supplies and further heighten international competition for these resources.

[44] *Ibid, Table A10*
[45] *United Nations, "World Urbanization Prospects: The 2007 Revision Population Database"*

A VISION FOR SUSTAINABILITY

The China Greentech Initiative believes that for China to continue its rapid economic development, it cannot afford to maintain the status quo or proceed along the reference scenario presented above. In fact, for China, embracing new approaches to clean energy generation, stepping up its pollution mitigation efforts and promoting resource use efficiency are optimal ways to preserve the health of its citizens, conserve the natural environment for future generations, solidify its international status as a leading player and continue its stellar economic growth.

China's future vision, therefore, must be one in which new technologies focused on environmental sustainability must be developed and deployed, new business models and modes of cooperation between consumers, businesses and the government established, and compliance with government regulations brought up to a high level. This will enable China to succeed on a broad range of interconnected objectives:

- Develop and deploy a wide range of alternative forms of energy, as well as cleaner ways to use conventional energy sources, in order to meet its voracious energy appetite sustainably
- Curtail the growth in GHG emissions to slow global climate change, helping to minimize the risks of significant adverse impact on China and the rest of the world, such as rising sea levels, desertification, extreme weather and disruptions in water supply
- Reduce air and water pollution to improve health, quality of life and attractiveness of the country as a business and tourist destination
- Improve water use efficiency, step up conservation efforts and further rationalize the administration of water resources to mitigate water shortages
- Address solid waste issues, including hazardous waste, and manage the waste to increase recycling and reuse and to decrease the adverse impact of waste treatment on the environment

While China faces significant environmental sustainability hurdles as it continues to develop economically, the China Greentech Initiative believes that China has the potential to innovate and lead the transformations required. The country's stable macroeconomic environment, systematic government planning, growing pool of engineering and managerial talent, increasing investment in research, and dynamic business environment are positioning China for cleaner and more sustainable growth. Fortunately, the initial signs of a green China have already emerged, indicating what the future may hold and how quickly it may arrive.

Promising Signs of China's Greentech Future

REALIZING BOTH THE BENEFITS OF EMBRACING A CLEANER AND MORE SUSTAINABLE FUTURE and the dangers of failing to do so, China is addressing a range of key areas simultaneously. The nation has already achieved impressive growth across a number of renewable energy and resource efficiency areas, using an approach that combines government policy, private entrepreneurship and best practice transfer that incorporates indigenous technological and commercial innovation.

While these efforts are still dwarfed by the magnitude of the issues faced, it is important to remember that China is experiencing a situation unique to the modern era – it must balance economic development with the need to protect and sustain natural resources at an unprecedented scale. Today's developed countries did not have global environmental sustainability issues to contend with in the Industrial Age. This situation presents a unique set of challenges, but also opportunities for collaboration and action by businesses, regulators, consumers and other stakeholders.

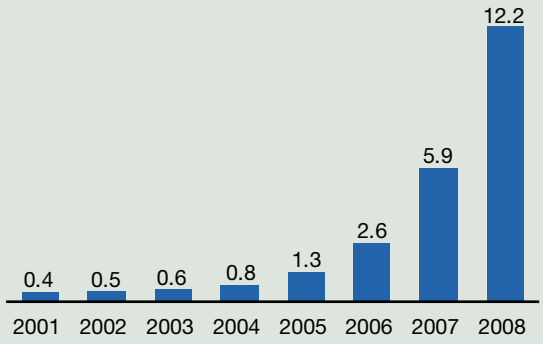
LAYING THE FOUNDATION

China has made impressive progress in laying a foundation for the future growth of green technologies and has rapidly emerged as one of the world's leading providers and consumers of renewable energy and cleaner modes of transportation. It is also taking significant steps to use energy resources more efficiently.

China's wind power market has been growing particularly fast, doubling the installed capacity for four consecutive years, reaching 12 GW in 2008 (see Figure 20). In fact, China reached the original 2010 target of 5 GW, established in 2005, three years ahead of schedule. This allowed the National Development and Reform Commission (NDRC) to upgrade the target to 10 GW, which has also been achieved ahead of schedule. Today, China ranks fourth in the world, behind the U.S., Germany and Spain, in terms of total installed wind capacity, accounting for 10% of the world's total.[46] Recently, China has begun to explore the country's offshore wind resource potential, which is estimated to be three times greater than onshore resources.[47]

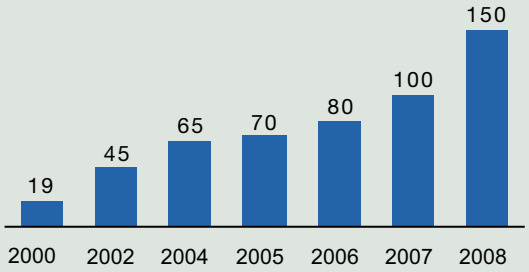
Fig.20: **CUMULATIVE INSTALLED WIND AND SOLAR CAPACITIES IN CHINA, 2000-2008**

Wind Capacity, *Gigawatts*



Source: *Pullen, Angelika et al., Global Wind 2008 Report (Brussels, Belgium: Global Wind Energy Council, 2009), 25*

Solar Photovoltaic Capacity, *Megawatts*



Sources:
1. Li, Junfeng et al., China Wind Power Report (Beijing, China: China Environmental Science Press, 2007)
2. Renewable Energy World, "China's New Focus on Solar," May 22, 2009, http://www.renewableenergyworld.com/

Fig.21: **CHINA RENEWABLE ENERGY CAPACITY TARGETS**

TYPE	2005 ACTUAL	2010 TARGET	2020 TARGET
Energy from renewable sources	7%	10%	20%(15%)
Hydropower	117 GW	190 GW	300 GW
Wind power	1.3 GW	10 GW (5 GW)	100 GW (30 GW)
Solar PV	0.07 GW	0.3 GW	20 GW (1.8 GW)
Solar water heating capacity	80 million m^2	150 million m^2	300 million m^2
Biomass power (agriculture/forestry)	2 GW	5.5 GW	30 GW
Bioethanol	1 million tons	3 million tons	10 million tons
Biodiesel	0.05 million tons	0.2 million tons	2 million tons

Sources:
1. National Development and Reform Commission, Medium and Long Term Development Plan for Renewable Energy in China (Beijing, China: NDRC, September 2007)
2. The China Greentech Initiative analysis

[46] *Pullen, Angelika et al., Global Wind 2008 Report (Brussels, Belgium: Global Wind Energy Council, 2009), 9*
[47] *China Internet Information Center, "Nation Eyes Offshore Wind Power," December 10, 2007, http://www.china.org.cn/*

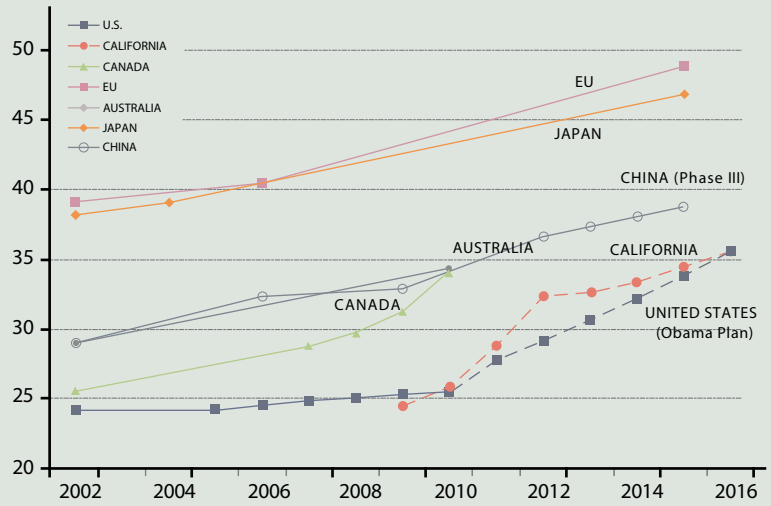
Solar photovoltaic (PV) capacity has also been growing steadily, although at a significantly lower pace, reaching 150 MW in 2008 (see Figure 20). This is widely expected to change with recently introduced government subsidies for building-integrated photovoltaic and utility-scale solar power projects.[48] In contrast to the currently low photovoltaic capacity, which represents only 1% of the world's total, China is a leader in the manufacturing of photovoltaic cells. In 2007, China accounted for nearly 30% of all PV cells manufactured in the world, led by large local companies such as Suntech Power Holdings, Yingli Green Energy Holdings and Trina Solar. Over 95% of the manufactured cells produced in 2008 were exported.

Recent success in the development of the renewable energy industry and heightened concerns about the reliance on fossil fuel have prompted China's regulators to upgrade the country's 2020 targets for renewable energy. In the most recent announcement, China plans to generate 20% of its electricity from renewable energy sources by 2020, including large scale hydropower. The most recent targets include 100 GW for wind generating capacity, and 20 GW for solar photovoltaic capacity both of which represent significant increases from the earlier 30 GW and 1.8 GW targets respectively that were in place at the beginning of 2009 (see Figure 21).

In addition, China plans to double its existing power generating hydroelectric capacity from about 150 GW to 300 GW by 2020 and to develop power-generating capacity from biomass combustion to 30 GW. Furthermore, it has defined targets for bioethanol and biodiesel production that will help offset China's reliance on imported crude oil.

One area of renewable energy in which China has emerged as an unchallenged leader is solar water heating. Currently, China boasts the world's largest installed base of solar water heaters, over 125 millions square meters, with one in ten families having adopted the technology.[49,50] Analysts estimate that over 95% of core solar water heating technology is held by Chinese firms, such as Himin Solar Energy Group. China's annual production of solar water heaters in 2007 reached 40 million square meters, accounting for two thirds of global output.[51]

Fig .22: **STANDARDIZED COMPARISON OF INTERNATIONAL FUEL ECONOMY STANDARDS,** *Miles per Gallon*



Note: *Values are for CAFE test cycle; dotted lines represent proposed standards*
Source: *Feng An, Revised Charts for World Standards, 2009*

[48] *Reuters, "China Offers Big Solar Subsidy," July 21, 2009, http://www.reuters.com/*
[49] *People's Daily, "China Promotes New Energy," April 15, 2009, http://english.peopledaily.com.cn/*
[50] *Li, Junfeng et al., China: Prospect for Renewable Energy Development (London, U.K.: The Treasury of United Kingdom, 2006), 6*
[51] *People's Daily, "New Energy Vehicle Pilot Programs Promoted in 13 Chinese Cities," February 2, 2009, http://english.peopledaily.com.cn/*

Industry analysts expect that China will continue to support clean energy development, as the government continues to roll out subsidies and incentive packages to accelerate the adoption of new technologies. Recent announcements indicate that China is planning an unprecedented package worth three trillion yuan (US$444 billion) over multiple years focused on renewable energy alone, in addition to the four trillion yuan (US$586 billion) stimulus package announced in 2008.[52]

In the road transportation segment, China has been progressively adopting stricter fuel economy and pollution emission standards, and is emerging as a leader in new energy vehicles. China has increased its fuel economy standards on several occasions since 2000, bringing the overall average up to 32 miles per gallon in 2008 and has announced plans to upgrade it further to nearly 40 miles per gallon by 2015. This makes China's fuel efficiency standards significantly stricter than those used in the U.S., Canada or Australia (see Figure 22).

In 2000, China adopted its first vehicle emission control standard, equivalent to the Euro 1 standard used in the European Union, and since then has been upgrading it one level roughly every three years. Currently, China is implementing the Euro 3 equivalent standard nationwide. Following implementation in Beijing in 2008, regulators are targeting to roll out Euro 4 equivalent standard nationwide in 2010.[53,54]

Furthermore, China has strongly supported the electric vehicle (EV) concept. Recognizing the benefits that EVs offer – such as alleviating local pollution, mitigating the demand for oil, and the potential to reduce CO_2 and other emissions associated with fossil fuel burning – China's government has announced pilot programs in a number of major cities and plans to subsidize the adoption of electric vehicles.[55]

Many analysts have observed that China is establishing itself as a potential world leader in the production and adoption of new energy vehicles. In December 2008, BYD Auto, a Chinese manufacturer based in Shenzhen, launched the world's first mass-produced plug-in hybrid, the F3DM sedan.[56] Other local manufacturers, such as Chery, Geely and Foton, are developing their own models and have announced plans to enter the market. China aims to increase its annual production of hybrid and electric vehicles to half a million by 2011, roughly 5% of total new vehicle sales.[57] The China State Grid has also announced plans to deploy networks of charging stations for electric vehicles in major cities like Beijing and Shanghai.[58]

One early success in the adoption of battery technology for transportation is the abundance of electric scooters and bicycles in China, currently estimated at 65 million – greater than the number of passenger vehicles on the road. China's yearly production has soared to over 22 million units from fewer than 200,000 eight years ago.[59] These electric two wheelers are usually powered by a 250-watt motor and use a Lead-Acid battery that provides a driving range of 25-100 kilometers between charges at speeds of up to 30 kilometers per hour.[60] China accounts for over 90% of worldwide electric scooter and bicycle sales and the average selling price is significantly lower than in developed countries.

On the industrial front, China has been consistently increasing its energy productivity. Since 1980, China's energy intensity of GDP – the amount of energy required to produce one unit of GDP – has fallen sharply, by roughly 70% (see Figure 23). No other major nation has achieved such a steep decline in such a short timeframe. On average, energy intensity declined at nearly 5% per year between 1980 and 2000, and apart from a notable increase in 2002 and 2003

[52] *Sina English, "China Plans 440 Billion Dollars Stimulus for Green Energy," May 24, 2009, http://english.sina.com/*
[53] *"Euro" in this context refers to mandatory non-CO_2 fuel emission standards used in the European Union for new passenger vehicles. The standard was introduced in 1997 and since then has been updated three times (Euro 1 through Euro 4), with two more updates (Euro 5 and Euro 6) planned – one in fall of 2009 and one in fall 2010*
[54] *Clean Air Initiative, "Emissions Standard for New Light-Duty Vehicles, 2009," http://www.cleanairnet.org/ (accessed on August 20, 2009)*
[55] *People's Daily, "New Energy Vehicle Pilot Programs Promoted in 13 Chinese Cities," February 2, 2009, http://english.peopledaily.com.cn/*
[56] *Bloomberg, "BYD Adds Plug-In as China Gets Edge on Toyota, GM," December 15, 2008, http://www.bloomberg.com/*
[57] *Xinhua, "China Aims to be World Pacemaker of New Energy Auto Production," September 17, 2008, http://news.xinhuanet.com/*
[58] *China Daily, "Electric Vehicles Drive Closer to Reality," September 17,2009, http://www.chinadaily.com.cn/*
[59] *MSNBC, "China Drives Electric Bike, Scooter Boom," July 27, 2009, http://www.msnbc.msn.com/*
[60] *Parkash, Manmohan, Promoting Environmentally Sustainable Transport (Manila, Philippines: Asia Development Bank, 2008), 27*

(due to the rapid growth of heavy industry output in those years), has been on a downward trajectory over the last three decades.

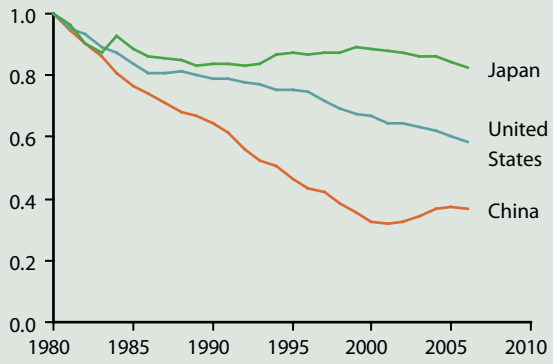
In the 11th Five-Year Guidelines,[61] China established a target of reducing the energy intensity of GDP by an additional 20% between 2005 and 2010. According to a recent statement made by Sun Qin, the Deputy Director of the National Energy Administration, GDP energy intensity posted a decline of 10.1% in the implementation of the first three year plan, between 2005 and 2008.[62]

China managed to achieve these reductions in part through centrally administered programs. The major initiative in the current Five-Year Guidelines has been the Top-1000 Energy-Consuming Enterprises Program, which was launched by Wen Jiabao, Premier of China, in July 2006. It focused on raising energy efficiency across the 1000 largest industrial energy consumers which cumulatively account for 33% of China's energy consumption and 43% of China's CO^2 emissions.[63] This program is modeled on voluntary agreements used in some European countries and Japan, and establishes energy efficiency benchmarks for enterprises to achieve. The success of this program will be influenced by an incentive scheme which connects political promotion for enterprise and local government leaders to the achievement of these benchmarks.[64]

Additionally, China's government has pursued a strategy of shutting down smaller – less efficient and more polluting – power generation plants. Deputy Director Sun Qin has confirmed that as of June 30, 2009, China had already closed 7,467 small scale generating units with total capacity of over 54 GW.

China has also been developing new energy efficiency standards for buildings and major appliances, in addition to revising those already existing. Building codes have been updated and the government is stepping up promulgation and enforcement. China recently launced its own building rating system titled the "Green Building Label" and a first batch of projects have already been approved.[65]

Fig .24: **ENERGY INTENSITY OF GDP HISTORIC TRENDS FOR SELECTED COUNTRIES, 1980-2006,** *Index 1980=1*

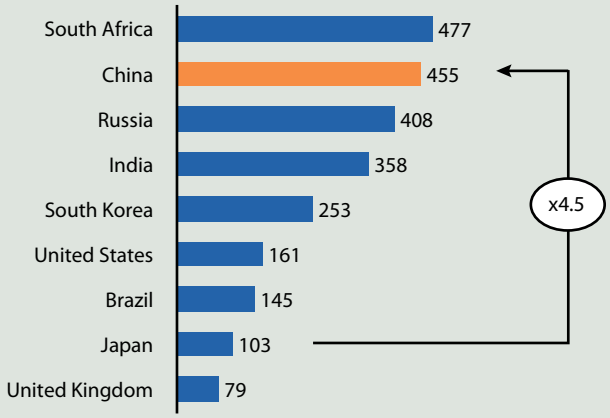


Source: *Energy Information Administration, "International Energy Annual 2006" Table E.1g*

A new minimum energy performance standard (MEPS) has been developed for over 40 different appliances, predominantly for residential and commercial use. Initial analysis has shown that these measures are helping China reduce the growth of consumer energy demand.[66]

[61] *Five-Year Guidelines are China's development blueprints that set targets for a range of economic and other parameters for a five-year period and are approved by the National People's Congress. 11th Five-Year Guidelines cover the time period of 2005-2010. A more detailed discussion of Five-Year Guidelines can be found in the "China's Regulatory Response" chapter of this report.*
[62] 北青网, "国家能源局副局长孙勤:'我国将在年内出台新兴能源发展规划'," *2009年8月10日［YNet, SunQin, Deputy Director of National Energy Administration, "New Energy Development Plan Will Be Launched this Year," Aug 10, 2009], http://dycj.ynet.com/*
[63] *Price, Lynn et al., China's Top-1000 Energy-Consuming Enterprises Program: Reducing Energy Consumption of the 1000 Largest Industrial Enterprises in China (Berkeley, CA, U.S.: Berkeley National Laboratory, 2008), 18*
[64] *The Top-1000 Energy-Consuming Enterprises Program is discussed further in the China's Regulatory Response chapter*
[65] 中国住房和城乡建设部, "关于公布2008年度第一批'绿色建筑设计评价标识'项目名单的公告," 2008年7月16日［*Ministry of Housing and Urban-Rural Development, "Announcement of 'Green Building Label' Project Names," July 16, 2008], http://www.mohurd.gov.cn/*

Fig.23: **ACTUAL ENERGY INTENSITIES OF GDP, 2008,**
Tons of Oil Equivalent per US$1 million



Sources:
1. BP, "BP Statistical Review of World Energy June 2009"
2. International Monetary Fund, "World Economic Outlook Database April 2009"
3. The China Greentech Initiative analysis

UNTAPPED POTENTIAL

The achievements and progress made by China in improving the sustainability of its economic activities are remarkable. While the sustainability of China's ecological system is a larger challenge, there are significant areas of untapped potential, such as renewable energy generation, new modes of transportation and green building.

Regarding power supply, even if China were to achieve its target of deriving 20% of energy from renewable sources by 2020, most of the non-renewable energy would still be derived from coal. Given that the overall capacity for electricity generation will potentially double between 2008 and 2020, greenhouse gas emissions will most likely continue to increase. Air pollutants such as SO_x and NO_x, will continue to pose a danger to human health and the natural environment unless their removal is enforced more strictly. For this reason, there is great potential to expand the role of renewable sources beyond the current targets and further improve the sustainability of conventional energy.

China's energy intensity of GDP, while having declined significantly over the past thirty years, remains one of the highest in the world. In fact, China's energy intensity is nearly three times that of the U.S. and more than four times that of Japan (see Figure 24).[67] The improvement of energy efficiency will remain a key focus of future development. Despite the development of a range of new hybrid and fully electric vehicles, few have been embraced by the local market, which is expected to purchase 10 million new gasoline and diesel vehicles this year alone.[68] The market for EVs is largely untapped and the future of the transportation industry is yet to be defined.

In regards to green buildings, estimates suggest that that only a tiny fraction, less than 1%, of all floor space expected to be built in 2009 will be certified as green by any certification standard, whether national or international. Therefore, the potential for new design and planning approaches, optimized construction techniques, sustainable materials and efficient appliances is vast, particularly considering the size of China's plans for continued urbanization.

[66] *Fridley, David et al., Impacts of China's Current Appliance Standards and Labeling Program to 2020 (Berkeley, CA, U.S.: Lawrence Berkeley National Laboratory, 2007), 1*
[67] *BP, "BP Statistical Review of World Energy June 2009;" International Monetary Fund, "World Economic Outlook Update, July 2009;" China Greentech Initiative analysis*
[68] *Gasgoo, "China Ups 2009 Vehicle Sales Target to 10.2 Million," May 11, 2009, http://autonews.gasgoo.com/*

A UNIQUE MOMENT IN TIME

The fundamentals are largely in place to drive China's economic development for decades to come and the importance of increased environmental sustainability is becoming more widely recognized. The first signs of transformation are promising, as the government, private business and average citizens are motivated by the vision of a China that is both economically and ecologically sustainable.

China's government has already established policies and provided incentives to stimulate green development. Businesses are adapting to the new operating environment and are beginning to explore opportunities by developing new technologies, products and business models. A broad spectrum of adopters, from individual consumers to large industrial players, are becoming increasingly aware of the benefits of green technologies – to the environment, business sector and society. While the path to sustainable development will not be easy, it will be a journey encouraged by international support and guided by strong government leadership.

CHINA'S

REGULATORY RESPONSE

China's array of national and local regulators has initiated a wide range of policies and regulations to address environmental issues and promote greentech markets. This policy environment is further influenced by international policy principles, agreements and relationships. While clear progress has already been made, policy challenges remain.

CHINESE REGULATORS HAVE ALREADY TAKEN MANY CONCRETE STEPS to address environmental issues and support the development of greentech markets. In fact, when compared to other countries, both developing and developed, China appears to be on the path of becoming a global greentech leader. Given the magnitude and pace of environmental change, however, there are still many important regulatory challenges that must be addressed.

The China Greentech Initiative, taking into account the critical role of government in China, investigated four key questions related to the regulatory environment:

- Which key Chinese regulatory agencies exert influence over China's greentech markets?
- What principles guide their policies?
- What specific actions have they taken to support environmental sustainability and greentech markets in China?
- How has the international policy environment influenced and impacted China's greentech markets?

This chapter explores these questions at a high level. More sector-specific details on the regulatory environment are provided in the sector chapters included in the full version of the report.

China's Policy Environment

CHINA'S POLICY ENVIRONMENT IS COMPLEX with a large number of entities exerting control at national and local levels.

CHINA'S CENTRAL GOVERNMENT

China's national government, which develops targets, guidelines and regulations concerning environmental, sustainability and greentech issues in China, encompasses many different types of policy bodies.

The country's highest legislative body is the National People's Congress (NPC), responsible for formulating China's laws as well as approving and tracking implementation of China's Five Year Guidelines for Economic and Social Development.

The State Council, China's highest executive body, takes direction from the National People's Congress. Its role is to enact regulations that achieve the government's key development objectives and coordinate the activities of China's various ministries. For particularly important cross-sector issues, China's Central government sometimes establishes Leadership Groups directly under the State Council to guide policies and principles across the rest of the government. For example, in June 2007, the Leading Group for National Response to Climate Change, Energy Conservation and Emission Reduction was established to coordinate state efforts, with Premier Wen Jiabao as the group leader, and members including a Vice Premier, the Secretary-General of the State Council and heads of 27 central government ministries.

The China Greentech Initiative identified 19 different national government agencies under the State Council with responsibilities related to greentech markets. A summary of these is presented in Figure 1.

Due to the complexity of China's political environment, multiple government authorities oversee different aspects of China's greentech markets. In some sectors,

Fig.1 : CHINA'S CENTRAL GOVERNMENT GREENTECH REGULATORS

GOVERNMENT ENTITY	GREENTECH RESPONSIBILITIES
National People's Congress (NPC)	■ Highest national legislative body in China; enacts basic environment and energy laws ■ Examines, approves and tracks the implementation of the Five-Year Guidelines for national economic and social development
State Council (SC)	■ Chief administrative authority; top executive apparatus; coordinates activities of ministries ■ Enacts regulations to achieve the goals set in China's Five-Year Guidelines and laws
Administration of Quality Supervision, Inspection, and Quarantine (AQSIQ)	■ Ministerial-level organ in charge of administering China's technical, product quality, environmental, product safety and other standards, as well as managing China's accreditation and certification activities
China Meteorological Administration (CMA)	■ Responsible for organization and management of China's national meteorological work, including monitoring and assessment of atmospheric signs of climate change
Ministry of Agriculture (MOA)	■ In charge of agriculture and rural economic development including long-term development planning, regulation and policy implementation
Ministry of Commerce (MOFCOM)	■ Responsible for formulating policy on foreign trade, export and import regulations, foreign direct investments, consumer protection and market competition
Ministry of Environment Protection (MEP)	■ Responsible for China's overall environmental management ■ Sets pollution as well as energy and resource efficiency standards
Ministry of Finance (MOF)	■ Monitors fiscal policies; enacts, finances, distributes and tracks subsidies ■ Controls interest rates and the flow of capital in China's economy
Ministry of Housing and Urban-Rural Development (MOHURD)	■ Responsible for infrastructure development, including wastewater treatment and solid waste management ■ Drafts building codes and enforces compliance, including oversight of China's "Green Building Label" standard
Ministry of Industry and Information Technology (MIIT)	■ Responsible for all industry project approval functions as well as regulation and development of information and communications technology regulations
Ministry of Land and Resources (MOLR)	■ Responsible for the planning, administration, and protection of land, mineral and marine resources ■ Certifies land appraisal agencies, confirms land-use prices, examines applications for land use
Ministry of Railway (MOR)	■ Drafts and supervises the execution of development strategies, standards, regulations and policies governing China's railway industry
Ministry of Science and Technology (MOST)	■ Formulates polices and measures on science and technology development ■ Develops, promotes and supervises national basic research and high tech R&D programs
Ministry of Transportation (MOT)	■ Develops and organizes the implementation of planning, policies and standards for waterway, road and air transportation, and promotes convergence of the various modes of transport
Ministry of Water Resources (MWR)	■ Responsible for overall water resource management, soil and water conservation and flood control ■ Grants licenses for water extraction and water use
National Bureau of Statistics (NBS)	■ In charge of statistics and economic accounting in China including collection and publication of pollution, energy consumption and energy intensity statistics at national and local levels
National Development and Reform Commission (NDRC)	■ Most powerful ministry-level body under the State Council; plays a key role in developing and implementing Five-Year Guidelines ■ Oversees National Energy Administration (NEA) and related policy functions
State Administration of Taxation (SAT)	■ Drafts tax laws and regulations; formulates implementation rules ■ Responsible for organizing collection and administration for central taxes
State-owned Assets Supervision and Administration Commission (SASAC)	■ Responsible for managing China's state-owned enterprises, including appointing top executives and approving any mergers or sales of stock or assets, as well as drafting laws related to state-owned enterprises
State Electricity Regulatory Commission (SERC)	■ Responsible for regulation of the power sector ■ Develops and implements key regulations, establishes rules for electricity market operations and issues business licenses
State Forestry Administration (SFA)	■ Responsible for the management of national forests and ecological construction projects ■ Organizes, coordinates, guides and supervises the work of national afforestation, wetland protection, desertification control and terrestrial wildlife resource protection

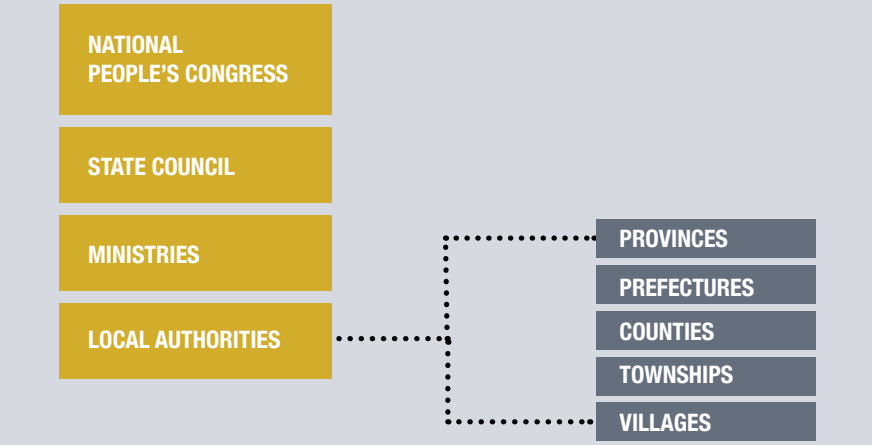
such as railway regulation, individual agencies like the Ministry of Railways have relatively independent authority over defined policy areas. In other areas, a number of entities share regulatory responsibility. For example, the National Development and Reform Commission (NDRC), National Energy Administration (NEA), Ministry of Science and Technology (MOST), State Electricity Regulatory Commission (SERC) and others all have responsibilities related to different aspects of energy policy.

LOCAL CHINESE POLICYMAKERS

Provincial and other local governments also play an important role in regulating China's greentech markets, making it important to understand the often complex relationships between national and local policymakers.Immediately below the national-level agencies is the provincial level, which includes the provinces, four province-level municipalities (Beijing, Chongqing, Shanghai and Tianjin), five autonomous regions such as Tibet and Inner Mongolia and the special administrative regions of Hong Kong and Macau. Most central government agencies have corresponding bodies at local levels that are commonly tasked with implementing the policies of the central regulators, yet are often influenced by both central government agencies as well as entities within the provincial and other local administrations.

Beneath the provinces, China is subdivided into prefectures that are in turn usually subdivided into counties composed of multiple townships. This structure is outlined in Figure 2.

Fig. 2: CHINA'S ADMINISTRATIVE STRUCTURE



A Number of Key Policy Principles Guide China's Greentech Policies

CHINA'S DOMESTIC POLICY PRINCIPLES PLAY AN IMPORTANT ROLE in driving sustainability, climate change and greentech markets policies and regulations. The China Greentech Initiative identified eight key principles that drive the development of China's greentech markets, as shown in Figure 3.

Fig. 3: KEY PRINCIPLES UNDERLYING CHINA'S SUSTAINABILITY, CLIMATE CHANGE AND GREENTECH POLICIES

- **Scientific Approach to Development**
- **Harmonious Society**
- **Equal Emphasis on Mitigation and Adaptation**
- **Efficiency Improvement and Conservation**
- **Energy Structure Optimization**
- **Ecological Preservation and Construction**
- **Agriculture Productivity Enhancement**
- **Indigenous Innovation**

SCIENTIFIC APPROACH TO DEVELOPMENT

First brought forward by China's President Hu Jintao in 2004, this principle calls for "people-centered development, which is comprehensive, coordinated and sustainable, for the promotion of overall harmonic development of the economy, society and human beings." It also stresses "coordinated development between urban and rural areas, among different regions and between economic and social development, harmony between human beings and nature and coordination of domestic development and opening to the outside world" as means of pushing forward reform and progress.[1] The principle of a Scientific Approach to Development was incorporated as an amendment to the Constitution of the Communist Party of China (CPC) in October 2007.[2]

HARMONIOUS SOCIETY

Built on the foundations of the Scientific Approach to Development (see above), and included in the October 2007 amendment to the CPC Constitution, this principle marks a transition from an overall national focus on economic growth to a broader focus on greater social harmony and balance. This incorporates the creation of an ecological civilization that will benefit from environmental protection, economic growth and social development.[3,4]

EQUAL EMPHASIS ON MITIGATION AND ADAPTATION

China's National Climate Change Program highlights the principle of placing equal emphasis on mitigating and adapting to climate change. This means that while energy efficiency and a reduction in greenhouse gas emissions continues to be a focus of China's mitigation efforts, measures such as ecosystem protection, natural disaster prevention and infrastructure development will determine China's experience of adapting to climate change.[5]

ENERGY EFFICIENCY IMPROVEMENT AND CONSERVATION

Promoting energy efficiency and energy conservation has been a key driver of environmental policy from as early as the 1997 promulgation of China's Energy Conservation Law. Industrial and building energy efficiency are two key areas of focus.[6]

ENERGY STRUCTURE OPTIMIZATION

Together with energy conservation, energy structure optimization has been a key principle underlying China's climate change mitigation policies. The core aim of this policy principle is to increase the percentage of renewable energy and cleaner conventional energy in China's fuel mix.[7]

ECOLOGICAL PRESERVATION AND CONSTRUCTION

This guiding principle is leading to important policies that support forestation and grassland rehabilitation as well as driving the effort to minimize or even reverse the desertification of arable or habitable land from overuse and changing climate conditions.[8] As an example, China's water usage statistics reflect not only agricultural, domestic and industrial water use, but since 2003 they illustrate an increasing trend of water being used for ecological protection and the reconstruction or rehabilitation of natural water resources and wetlands.[9]

AGRICULTURAL PRODUCTIVITY ENHANCEMENT

Focused on increasing agricultural productivity, this principle has guided a number of policies that support the modernization of China's agricultural sector. These efforts encourage increased mechanization and efficient irrigation, decrease pollution caused by fertilizer and pesticide runoff and support agricultural greenhouse gas capture.[10]

INDIGENOUS INNOVATIION

The Fifth Plenary Session of the 16th CPC National Congress (2005) proposed that strengthening indigenous innovation is a key foundation for promoting China's scientific development.[11] This principle supports policies that target domestic development of greentech solutions, including building China's capacity in basic research and original innovation.

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[1] People's Daily Online, "Scientific Concept of Development Crucial to China's Future Growth: Premier," March 1, 2009, http://english.peopledaily.com.cn/

[2] Xinhua News Agency, "Major Previous Amendments to CPC Constitution," October 21, 2007, http://news.xinhuanet.com/

[3] China Council for International Cooperation on Environment and Development (CCICED), "Environment and Development for a Harmonious Society," (Beijing, China: CCICED, 2008)

[4] A variety of definitions have been used for the term "social development." In China, achievements classified as "social development" under the Program of Action for Sustainable Development in the early 21st Century (2007) include that "the trend of excessive population growth has been checked; science, technology and education have made positive headway; and remarkable progress has also been made in social security, poverty eradication, disaster relief and prevention, medical care, and narrowing the regional gap in development." National Development and Reform Commission (NDRC), Program of Action for Sustainable Development in the early 21st Century, (Beijing, China: NDRC, February 5, 2007), http://en.ndrc.gov.cn/

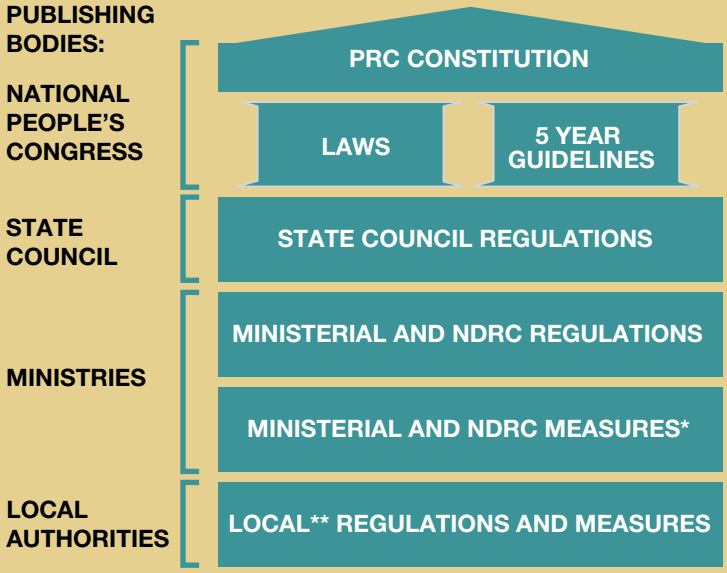
[5] National Development and Reform Commission (NDRC), National Climate Change Program, (Beijing, China: NDRC, June 2007)

[6] Ibid

Greentech-Related Policies and Regulations

CHINA'S GOVERNMENT HAS MADE SIGNIFICANT STEPS in understanding the key environmental issues facing the country and responding with greentech-related policies. China's enormous geographic and population scale is fundamental to the challenge of developing and implementing a coordinated set of central policies while addressing the needs of local market conditions. As a result, China's policy environment represents a complex array of policy instruments. Among these are national plans, programs, laws, standards, industry promotion policies and market price controls – all key tools used by China's government to enable and drive China's greentech markets. Figure 4 provides an overview of the different levels of policies influencing China's greentech markets.

Fig.4: SCHEMATIC OVERVIEW OF CHINA'S KEY REGULATORY INSTRUMENTS



Note: **Ministerial measures include standards, circulars, implementation guidelines, interpretations, rules, orders, ordinance, proposals, etc.*
*** Local includes provincial, municipal, city, prefecture/county levels*

CHINA'S POLICYMAKING PRACTICES

Before investigating what policies China's government has put in place to guide the country's greentech market development, it is important to briefly outline some of the practices policymakers use to develop these policies.

As draft bills are developed, China's legislators, under the National People's Conference (NPC), take into account legal practices of various legal systems around the world. Once a bill is drafted and put on the NPC's legislative agenda, there are complex procedures for deliberation of the draft bill that can include, for example, review in special committees under the NPC, expert round tables or public hearings. Revised versions of draft bills can be voted into law by a simple majority among a plenary session of the NPC.[12] If a bill passes, China's president issues a presidential order to promulgate the law.[13]

The procedures used for drafting and implementing issue-specific regulations and directives at the State Council and ministry level and below bear many similarities to those used in the legislative process. A ministry or other sponsoring regulatory agency commonly develops a draft regulation after considering

[7] *Ibid*
[8] *Ibid*
[9] *National Bureau of Statistics of China, "China Statistical Yearbook 2008"*
[10] *National Development and Reform Commission, National Climate Change Programme (Beijing, China: NDRC, June 2007), 45*
[11] *National Natural Science Foundation of China, Guide to Programmes 2006 (Beijing, China: NSFC, November 20, 2005)*
[12] *There is a second option for China's legislative process, often utilized between plenary sessions of the NPC, whereby draft bills are submitted to, deliberated under, and voted on, by the Standing Committee of the NPC, a permanent committee with legislative powers under the NPC.*
[13] *Chenfeng Cai, Chunhua Li, The Legislative Process in China (Ontario, Canada: The Parliamentary Centre of Canada, 2006),5*

international regulatory precedents, then invites feedback on the draft regulation through a variety of channels. If the regulation addresses issues that cut across separate ministerial mandates or involve fundamental issues, such as how a piece of legislation is to be implemented, the State Council (or perhaps a group of ministries) will issue the regulation. If it involves the jurisdiction of only one ministry, that ministry alone may issue the regulation.

For both legal and regulatory matters, greentech market stakeholders have opportunities to directly input feedback to the draft policies before they are eventually adopted. As China's policymakers continue to refine methods through which they are able to incorporate public input into their new policies, market stakeholders should have opportunities to influence China's greentech policy development.

CHINA'S PLANS AND PROGRAMS

China's government makes substantial use of national planning activities and programs to provide appropriate frameworks for China's response to environmental issues and to generate development targets. A summary listing of several key ongoing and future greentech-relevant plans is contained in Figure 5.

Fig.5: SUMMARY OF ISSUING AGENCIES AND TIME FRAMES OF SELECTED CHINESE GOVERNMENT PLANS IMPACTING GREENTECH SECTORS

PLAN	ISSUING AGENCY	TIME FRAME
11th Five Year Guidelines for Economic and Social Development	NPC	2006-2010
12th Five Year Guidelines for Economic and Social Development	NPC	2011-2015
Five Year Plan for Energy Development	NDRC	2006-2010
Five Year Plan for Coal Industry Development	NDRC	2006-2010
Five Year Plan for Railway Development	MOR	2006-2010
Five Year Plan for the Development and Utilization of Coal Bed Methane and Coal Mine Methane	NDRC	2006-2010
Five Year Plan for Sulfur Dioxide Treatment in Existing Coal-Fired Power Plants	NDRC, MEP	2006-2010
Five Year Plan for Acid Rain and Sulfur Dioxide Pollution Control	NDRC, MEP	2006-2010
Five Year Plan for Ecological Protection	MEP	2006-2010
Medium and Long Term Science and Technology Development Plan	State Council	2000-2020
Medium and Long Term Energy Development Plan	State Council	2004-2020
Medium and Long Term Plan for the Oil Refining Industry	State Council	2005-2020
Medium and Long Term Energy Conservation Plan	NDRC	2006-2020
Medium and Long Term Plan for Renewable Energy Development	NDRC	2007-2020
Medium and Long Term Rail Network Development Plan	NDRC	2008-2020
Shipping Revitalization Plan	State Council	2009-2011
Logistics Industry Revitalization Plan	State Council	2009-2011
Equipment Manufacturing Revitalization Plan	State Council	2009-2011

Every five years, China's National People's Congress votes to endorse new Five-Year Guidelines for Economic and Social Development. The 11th Five-Year Guidelines[14] (2006-2010) represented a dramatic shift from previous plans both in their new focus on sustainable development, and in the importance they placed on a harmonious society and several of China's other key environmental and climate change principles.[15] This latest set of Guidelines contains key targets to decrease China's energy intensity per unit of GDP by 20% between 2005 and 2010. While specifics have not yet been published, some market experts suggest that the 12th Five-Year Guidelines (2011-2015) will put even greater emphasis on environmental and sustainability issues, and may even contain a national target for carbon emissions intensity.[16]

[14] *Note: After the 10th Five-Year Plan (2001-2005), subsequent five year plans have been renamed "Five Year Guidelines"*
[15] *Chinese Government's Official Web Portal, "NPC Endorses 11th Five-Year Plan," March 14, 2006, http://www.gov.cn/*
[16] *Financial Times, "Chinese Group Buys Voluntary Carbon Credits," August 6, 2009, http://www.ft.com/*

To support the Five-Year Guidelines for Economic and Social Development, the NDRC and other key ministries release detailed plans to guide the development of specific parts of the economy over the same five year periods. The Five-Year Energy Plan,[17] the Five-Year Plan for Coal Industry Development,[18] and the Five-Year Plan for the Development and Utilization of Coal Bed Methane and Coal Mine Methane[19] are three examples of supporting five year plans during the 11th five-year period (2006-2010) with relevance for China's greentech markets.

"Medium and Long-Term Plans" are other policy planning tools used by China's greentech regulators, providing cross-ministry policy guidance for 10-20 year periods and complementing the more detailed five-year plans. Recent greentech-relevant Medium and Long-Term Plans have been created for Energy Development (2004-2020),[20] Renewable Energy Development (2007-2020),[21] Energy Conservation (2006-2020),[22] Science and Technology Development (1992-2020),[23] and Rail Network Development (2008-2010).[24]

Many Medium and Long-Term plans themselves contain national-level projects with important greentech implications. The Medium and Long-Term Energy Conservation Plan (2006-2020), for example, lays out a program of 10 key energy conservation projects which should collectively lead to energy conservation equivalent to 240 million tons of coal. A listing of these 10 key energy conservation projects can be found in Figure 6.[25]

Fig.6: THE TEN KEY ENERGY CONSERVATION PROJECTS IN CHINA'S MEDIUM AND LONG TERM ENERGY CONSERVATION PLAN (2006-2020)

- **Coal-fired industrial boiler retrofit**
- **District heating and power cogeneration**
- **Residual heat and pressure utilization**
- **Petroleum saving and substituting**
- **Motor system energy saving**
- **Energy system optimization**
- **Building energy conservation**
- **Green lighting projects**
- **Government agency energy conservation**
- **Energy saving monitoring and testing, and technology service system building**

Whereas Medium and Long-Term plans commonly focus on individual policy topics, industry revitalization plans are targeted at individual industries. China's government has released a number of greentech-relevant industry revitalization plans for industries such as new energy, shipping, logistics and equipment manufacturing. Among the 10 key projects for revitalizing China's equipment manufacturing industry in the Restructuring and Revitalization Plan for the Equipment Manufacturing Industry (2009), for example, Clean and Efficient Power Generation Equipment, Ultra-high voltage (UHV) Power Transmission Equipment, Electric Locomotives, Sludge Processing Equipment, and Flue Gas Desulfurization and Denitration Equipment are some of the many greentech areas highlighted as national priorities.[26]

[17] 中华人民共和国国家发展和改革委员会, 能源发展. "十一五." 规划, *2007*年*4*月, *[Beijing China: NDRC, "11th Five Year Energy Plan," April, 2007]*
[18] 中华人民共和国国家发展和改革委员会, 煤炭工业发展"十一五"规划, *2007*年*1*月, *[Beijing China, NDRC: "11th Five Year Plan for Coal Industry Development," January, 2007]*
[19] 中华人民共和国国家发展和改革委员会, "煤层气(煤矿瓦斯)开发利用"十一五"规划," *2007*年*4*□*[NDRC, "11th Five-Year Plan for the Development and Utilization of Coal Bed Methane and Coal Mine Methane," April 2007]*
[20] 中华人民共和国国务院办公厅,"国务院常务会议原则通过'能源中长期发展规划纲要'（草案）," *2006*年*6*月*30*日 *[State Council General Office, "On Issuing Medium and Long-Term Plan for Energy Development (2004-2020), (Draft)," June 30, 2006] http://202.123.110.3/*
[21] 中华人民共和国国家发展和改革委员会,可再生能源中长期发展规划, *2007*年*8*月, *[China Climate Change Info-Net, "Medium and Long-Term Plan for Renewable Energy Development (2007-2020), August 2007], (Beijing, China: National Development and Reform Commission, August 2007)*
[22] 中华人民共和国国家发展和改革委员会,"节能中长期专项规划," *2004*年*11*月*25*日, *[National Development and Reform Commission, "Medium and Long-Term Plan for Energy Conservation," November 25, 2004], http://www.sdpc.gov.cn/*
[23] 南阳市科技信息网, "国家中长期科学技术发展纲领," *1992*年*3*月*8*日, *[NanYang Science and Information Website, "Medium and Long-Term Plan for Science and Technology Development," March 3, 1992], http://www.nysti.ha.cn/*
[24] 中华人民共和国国家发展和改革委员会,"国家发展改革委批准中长期铁路网规划，*<2008*年调整*>*," *2008*年*10*月, *[National Development and Reform Commission, "On issuing Medium and Long-Term Plan for Rail Network Development, '2008 revision'," October 2008], http://www.ndrc.gov.cn/ (accessed on May 30, 2009)*
[25] 中华人民共和国国家发展和改革委员会,"节能中长期专项规划," *2004*年*11*月*25*日, *[National Development and Reform Commission, "Medium and Long-Term Plan for Energy Conservation," November 25, 2004] http://www.sdpc.gov.cn/ (accessed on June 16, 2009)*
[26] 中华人民共和国国务院, "装备制造业调整和振兴规划," *2009*年*05*月*12*日, *[State Council, "Restructuring and Revitalization Plan for the Equipment Manufacturing Industry," May 12, 2009] http://www.gov.cn/*

In addition to all of these plans, China's policymakers also make substantial use of national programs, which provide policy direction or specific regulations across a range of implementing agencies. One of the most significant greentech-related programs in recent years is the National Climate Change Program released by the National Development and Reform Commission in 2007. The National Climate Change Program formally incorporates a number of China's environmental policy principles and additionally lays out a broad range of specific policy objectives to be carried out by stakeholders across China's regulatory landscape. With respect to emissions tracking, for example, the program calls for "the establishment of statistical systems catering to the compilation of emission inventory, collection of testing and monitoring data for emission factors, methodologies for inventory quality control, assessment of climate change impact and adaptation, projection of future emissions, and the development and management of national greenhouse gas emission database."[27]

China's Top-1000 Energy-Consuming Enterprises Program (2006-2010) is another national program with a substantial impact on the development of China's greentech markets. This joint program, involving the National Development and Reform Commission, the National Bureau of Statistics, the state-owned Assets Supervision and Administration Commission plus the General Administration of Quality Supervision, Inspection and Quarantine, was launched in April 2006. The enterprises included in the program represent nine major energy-consuming industries: iron and steel, petroleum and petrochemicals, chemicals, electric power generation, non-ferrous metals, coal mining, construction materials, textile and pulp and paper.

By establishing energy conservation targets for China's highest energy consuming enterprises, the program aims to reduce total energy consumption by the equivalent of 100 million tons of coal by 2010.[28]

In the context of the global economic downturn of 2008 and 2009, it is important to note China's announcement in November 2008 of a 4 trillion yuan (US$586 billion) economic stimulus plan. While only 210 billion yuan (US$31 billion) is directly earmarked for green investments, a further 370 billion yuan (US$55 billion) will be channelled into technology upgrades and industrial restructuring in China's energy-intensive factories, bringing the total portion of the stimulus used for cutting carbon emissions up to 15%.[29] The Hongkong and Shanghai Banking Corporation (HSBC) estimates that US$221 billion of the overall plan, including grid, water and rail infrastructure investments, is greentech-related, making it the largest such stimulus package in the world, followed by the American Recovery and Reinvestment Plan's US$112 billion (out of a total US$787 billion) allocated to green areas in the U.S.[30]

LAWS AND STANDARDS

While principles, programs and development plans guide policies across a range of regulatory agencies, China's laws and standards are the formal requirements that companies and individuals are legally obliged to follow. Specific fines for non-compliance are commonly included in the law or standard itself.

Over recent years, China's government has passed a range of laws that has affected the development of the nation's greentech markets. The Renewable Energy Law (2005) and Circular Economy Law (2008), for example, contain notable provisions for the promotion of renewable power generation to meet energy security and environmental objectives, and for the development of recycling and pollution reduction activities, respectively. Figure 7 contains an overview of several important greentech-related laws introduced over the last two decades.

Standards are another important component of China's greentech policy environment. China's Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) is responsible for administering technical, product quality, environment and product safety standards, in addition to managing China's accreditation and certification activities.

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[27] National Development and Reform Commission, National Climate Change Program, (Beijing, China: NDRC, June 2007),62
[28] Price, Lynn et al., China's Top-1000 Energy-Consuming Enterprises Program, Reducing Energy Consumption of the 1000 Largest Industrial Enterprises in China (Berkeley, CA, U.S.: Lawrence Berkeley National Laboratory, June 2008), 6
[29] China Daily, "Billions from Stimulus Tagged to Cut Emissions," August 6, 2009, http://www.chinadaily.com.cn/
[30] HSBC Bank plc, A Climate for Recovery: The Colour of Stimulus Goes Green (London, United Kindom: HSBC Bank plc, February 25, 2009), 3

Fig. 7: SELECTED CHINA GREENTECH LAWS

LAW	PROVISIONS
Circular Economy Promotion Law (2008)	■ Defines circular economy as referring to the reduction, reuse and recycling of resources in production, circulation and consumption ■ Establishes systems for recycling, planning, resource management, emissions control and environmental monitoring and auditing
Water Pollution Control Law (2008)	■ Emphasizes accountability of local governments and enterprises for pollutant over-discharge; increases penalties, removes penalty limits ■ Requires local governments to establish centralized municipal wastewater treatment facilities
Energy Conservation Law (Revised 2008)	■ Confirms energy conservation as a guiding state policy ■ Lays out preference for energy efficient equipment and products in public procurement ■ Emphasizes responsibilities for high energy consuming entities
Urban-Rural Planning Law (2007)	■ Objective to strengthen the administration of city, town and township planning ■ Specifies compulsory elements of urban and rural plans including electricity, water, transportation and communications infrastructure ■ Contains requirements for plans to address environmental and ecological protection
Renewable Energy Law (2005)	■ Objectives include promoting energy security and protecting China's ecological environment ■ Includes provisions on public funding for renewable energy development, discounted lending and tax preferences and connection of renewable generation to China's electricity grid
Law on Prevention and Control of Environmental Pollution Caused by Solid Waste (Revised 2005)	■ Lays out guidelines on the prevention, supervision and administration of household and industrial solid waste ■ Special provisions on the importation of solid waste and on hazardous waste management ■ Includes a detailed schedule of penalties up to one million yuan for non-compliance
Cleaner Production Promotion Law (2003)	■ Objective to decrease negative impact of manufacturing on health and the environment ■ Lays out objectives, implementation guidelines and funding plans for Cleaner Production ■ Emphasis includes management improvement, clean energy use and pollution reduction
Water Law (Revised 2002)	■ Amends 1988 Water Law to include greater emphasis on water-saving measures and technology and on balancing the water needs of municipal, agricultural and domestic users ■ Specifies ministries' and provincial governments' water resource management responsibilities
Environmental Impact Assessment Law (2002)	■ Outlines necessary environmental impact assessments to be provided to the Ministry of Environmental Protection before project construction ■ Provides for legal liability up to 500,000 yuan for non-compliance
Law on Prevention and Control of Atmospheric Pollution (Revised 2000)	■ Emphasizes protection of the atmospheric environment as a compulsory element of government planning at all levels ■ Sets up total emissions control, polluter registration/licensing and discharge fee systems ■ Details treatment of emissions from coal combustion and motor vehicles
Environmental Protection Law (Revised 1989)	■ Sets up systems for environmental standard development and monitoring, environmental protection and pollution control management ■ Imposes three types of non-compliance penalties: administrative sanctions, civil liability and criminal liability

Many of China's greentech solutions, such as water pipe materials and industrial manufacturing equipment, are subject to international standards under the International Standards Organization (ISO) or the International Electrotechnical Commission (IEC). Both these bodies are represented in China by a body under the AQSIQ called the Standardization Administration of China (SAC).

Domestic standards, for the most part, are developed by the SAC in coordination with a number of affiliated organizations and industry-specific technical committees at the national level. The SAC is also responsible for the examination and approval of products subject to the national standards. More detail on sector-specific standards is included in the sector chapters of the full version of this report.

■ FISCAL INCENTIVES AND SUBSIDIES

Aside from the laws and standards outlined above, China also uses an array of fiscal and policy instruments to promote domestic greentech markets.

As in other countries, tax benefits for solution providers and adopters are a key aspect of China's greentech promotion policies. Although China has no stand-alone environmental tax regime, multiple tax exemptions, consumption-related taxes, natural resource-related taxes and other tax benefits embedded in the existing fiscal system aim to promote environmental and greentech activity.

One notable area where these tax benefits have been applied is in China's corporate income tax (CIT) policies. Revenue earned from certain types of Clean Development Mechanism (CDM), environmental protection, energy conservation and water saving conservation projects, for example, is eligible for a three-year exemption and three-year 50% reduction of corporate income taxes.[31]

Tax credits are a second approach used to support greentech in China's CIT rules. Greentech adopters making investments in qualified equipment used for environmental protection, energy or water conservation may be eligible for a CIT credit equal to 10% of the investment value.[32]

Finally, there are several provisions in the CIT regime that, while not being specific to the greentech sector, are favorable to greentech solution providers. One example of this type of rule is the High and New Technology Enterprises (HNTE) provisions, whereby qualifying companies that meet a variety of criteria including spending a minimum percentage of their revenue on R&D for technologies selected by the government as being in priority areas, can be granted a reduction in corporate income tax liability.[33]

Value-added taxes (VAT) refunds and exemptions are another key taxation tool used to support greentech in China. For example, since December 2008 there has been VAT exclusion for products or services making a comprehensive utilization of resources – for example, making use of energy-efficient processing or utilizing waste heat, wastewater or different types of solid wastes as production inputs. Greentech solutions specifically eligible for this benefit include building materials with at least 30% recycled content, Reclaimed Wastewater, Combined Heat and Power solutions, Shale Oil and other products.[34] Another important area where VAT-based tax policy has spurred China's greentech development has been China's wind power sector, where importers of Wind Turbine Components and domestic Wind Power Equipment manufacturers both receive significant VAT benefits.[35]

As a final example, China uses extraction and natural resource taxes to manage many upstream activities like mining, oil and gas exploitation, and water extraction and waste-related charges to control downstream waste and pollution management. Adjusting the fee levels for the various activities can have significant impacts on greentech companies involved in those areas.

Aside from tax incentives, China's government also directly subsidizes providers and adopters of several strategic greentech technologies, perhaps more than any other country. Several important recent greentech subsidies are listed in Figure 8. An example of China's greentech subsidization is seen in the transportation sector, where the Ministry of Science and Technology set out new subsidies for the adoption of Hybrid Vehicles, Electric Vehicles and Fuel Cell-based Vehicles in February 2009.[36] Additionally in Green Building, the Ministry of Housing and Urban-Rural Development laid out in March 2009 a plan for direct subsidization of the installation of Building-Integrated Photovoltaic installations.[37]

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[31] 中华人民共和国财政部, "国家税务总局关于中国清洁发展机制基金及清洁发展机制项目实施企业有关企业所得税政策问题的通知," *2009年03月23日, [Ministry of Finance, "Tax Notice on China's Clean Development Mechanism Fund and the Implementation of CDM project-related Corporate Income Tax Policy Issues," March 23, 2009],http://www.js-n-tax.gov.cn/*

[32] 中国人民共和国国务院办公厅, "中华人民共和国国务院令第512号," *2007年12月6日 [General Office of the State Council,"State Council Circular 512," December 6, 2007] http://www.gov.cn/*

[33] *Ministry of Science and Technology, "Circular on Printing and Issuing of the Guidelines for the Administration of the Recognition of Hi-tech Enterprises," August, 12, 2008, http://english.mofcom.gov.cn/*

[34] *[1]*中华人民共和国财政部, "国家税务总局关于资源综合利用及其他产品增值税政策的通知," *2008年12月09日[Ministry of Finance and State Administration of Taxation, "Tax Policy on the Comprehensive Utilization of Resource and Other Products," December 9, 2008] http://www.js-n-tax.gov.cn/*

[35] *Renewable Energy World, "China's Wind Power Industry: Localizing Equipment Manufacturing," July 18, 2009 http://www.renewableenergyworld.com/*

[36] 中华人民共和国科学技术部, "关于开展节能与新能源汽车示范推广试点工作的通知", *2009年2月11日 [Ministry of Science and Technology, Provisional Measure on the Management of Government Subsidies for Energy-Saving and New Energy Vehicles, February 11, 2009] http://www.most.gov.cn/*

[37] 中国人民共和国住房和城市建设部,"建筑节能：科技创新是重中之重," *2008年3月17日[Ministry of Housing and Urban-Rural Development,"Building Energy: Technology innovation is the most important," March 17, 2008,] http://www.mohurd.gov.cn/*

Fig.8: SUMMARY OF SELECTED GREENTECH SUBSIDIES IN CHINA

SUBSIDY	ANNOUNCEMENT DATE	AMOUNT OF SUBSIDY	DESCRIPTION OF ELIGIBILITY
GOLDEN SUN	July 2009	• 50% of grid-connected solar investment • 70% of off-grid PV power investment	• 300 kW min capacity • 1-year max construction period • 20+ year operations requirement
SOLAR ROOFS	March 2009	• 15-20 yuan per watt of capacity	• Targets new construction • Minimum efficiency guidelines • 50 kW min installation
PHEV/EV/FC*	January 2009	• 28K-600K yuan per vehicle	• Minimum fuel saving 5% for passenger and light commercial vehicles • Minimum fuel saving 10% for busses
WIND TURBINE	August 2008	• 600 yuan per kW for the first 50 units	• Only Chinese turbine manufacturers • 50/50 split between component suppliers and turbine manufacturers • 1 MW minimum capacity
BIOMASS POWER GENERATION	July 2008	• Temporary electricity tariff increase by 0.1 yuan/kWh	• Certain types of feedstock only (forest, firedamp and straw)
COAL BED METHANE MINING	April 2007	• 0.2 yuan per cubic meter	• Methane for consumer or chemical industry sale only, not power generation

Source: China Greentech Initiative analysis

Regulators have been particularly active in the subsidization of renewable energy. Domestic wind turbine manufacturers and wind turbine component manufacturers both have access to subsidies from the Ministry of Finance.[38] Biomass power generation and bioethanol production are subsidized in China's bioenergy sector.[39] In addition to the building-integrated solar subsidy announced in March 2009, a second major subsidy program — the Golden Sun program, for utility-scale solar installations - was announced by the National Development and Reform Commission in July 2009.[40]

While the above discussion focuses on China's central government, it is important to note that provincial and regional governments also have significant policy levers they can use to support greentech development in their jurisdictions. The Yixing Industrial Park in the city of Wuxi, in Jiangsu province, for example, offers both tax holidays and significant tax reductions for up to five years for greentech and other high-tech companies setting up business there.[41] Other policies used by China's local regulators to entice greentech businesses to set up in their jurisdictions include discounted office rates, direct financing, assistance with preparations for initial public offerings (IPOs), reimbursements for employee training and other benefits.

[38] *CMS Cameron McKenna, "Renewable Energy Project Subsidies: What Has China To Offer?" http://www.mondaq.com/ (accessed on August 5, 2009)*
[39] *Institutue of Science in Society,"Biogas China," http://www.i-sis.org.uk/ (accessed on April 28, 2009)*
[40] *中华人民共和国财政部, "关于实施金太阳示范工程的通知", 2009年07月16日 [Ministry of Finance, "Regarding the Golden Sun Policy," July 16, 2009] http://www.mof.gov.cn/*
[41] *China Yixing Industrial Park for Environmental Science and Technology, "Policies and Regulations," http://hky.gov.cn/ (accessed August 14, 2009)*

INDUSTRIAL PROMOTION POLICIES

Whereas tax incentives and subsidies promote greentech in China by directly influencing relationships between companies and the government, China's policymakers also support greentech through industrial promotion policies leveraging financial intermediaries.

For instance, regulators often direct favorable investment financing to greentech sectors via China's three policy banks (Agricultural Development Bank of China, China Development Bank and Import-Export Bank of China) and the four largest state-owned banks (Agricultural Bank of China, Bank of China, China Construction Bank and Industrial and Commercial Bank of China). For example, by the end of 2007, China Development Bank had more than 119 billion yuan (US$17.6 billion) in loans outstanding for environmental protection, energy conservation and emissions reduction projects.

Also in the financial sector, China's policymakers have used a variety of regulations to promote sustainability and the development of greentech markets. As an example, China's Green Credit policy (2007) requires commercial banks to incorporate environmental performance criteria into their lending decisions. Further, China's Green Securities policy (2008) requires environmental and energy disclosures from heavy industry companies seeking to list on domestic stock markets. Both these and other examples illustrate how China's regulators are using access to finance and capital as tools to promote environmental awareness and greentech adoption.

In addition to the many tax benefits, subsidies and favorable loans that China promotes to develop its greentech industries, there is also significant support for infrastructure construction. As noted earlier with respect to the economic stimulus plan, electric power infrastructure and railway network development are two key priorities of the government. Aside from these initiatives, China continues to develop

Fig. 9 : COMPARISON OF SELECTED PRICES BETWEEN CHINA AND THE UNITED STATES

CATEGORY	CHINA AVERAGE PRICE 2008-09	UNITED STATES AVERAGE PRICE 2008-09
NATURAL GAS[1,2]	US$ 192.30 per thousand cubic meters	US$ 455.70 per thousand cubic meters
COAL[3,4]	US$ 91.85 per ton	US$ 121.33 per ton
ELECTRICITY[5,6]	US$ 82.96 per MWh	US$ 115.56 per MWh
WATER[7]	US$0.31 per ton	US$ 0.74 per ton

Sources:
1. *Ningbo Municipal People's Government, China, "Natural Gas Price To Be Line With That in International Market," March 15, 2009 / http://english.ningbo.gov.cn*
2. *Energy Information Administration, "Natural Gas Prices," http://tonto.eia.doe.gov/ (accessed on Aug 15, 2009)*
3. *China Coal Resource, "Coal Prices Database" http://en.sxcoal.com/ (accessed on Aug 15, 2009)*
4. *Energy Information Administration, "Coal Prices," April 14, 2009, http://www.eia.doe.gov/*
5. *中国电力, "电监会：2008年居民电价广东最高 青海最低", 2009 年4月24 [China Power, "State Electricity Regulatory Commission: Residential Electricity Price in 2008 is the Highest in Guangdong, the Lowest in Qinghai," April 24, 2009] http://www.chinapower.com.cn/*
6. *Energy Information Administration, US Government, "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State," http://www.eia.doe.gov/ (accessed on Aug 15, 2009)*
7. *The Wall Street Journal, "China Cities Raise Water Price in Bid to Conserve", http://online.wsj.com/ (accessed on August 15, 2009)*

[42] *China Development Bank, "Overview of Operations," http://www.cdb.com.cn/ (accessed on August 14, 2009)*
[43] *Ministry of Environmental Protection (MEP), "Blacklist of Polluters Distributed," August 6, 2007, http://english.sepa.gov.cn/*
[44] *中华人民共和国环境保护部, "国家环境保护总局办公厅文件," 2007年8月30日, [Ministry of Environmental Protection (MEP), "Circular on Environmental Protection Verification of Highly Polluting Industries to Further Standardize the Production and Management of Companies Applying for Public Listing or Refinancing," September 30, 2007], http://www.mep.gov.cn/ (accessed on August 14, 2009*

other multi-province infrastructure initiatives which can incorporate anything from pipelines for liquefied natural gas and coal bed methane to massive water diversion projects. As many green technologies focus on making infrastructure 'smarter' and more efficient, these continued infrastructure plans should provide significant opportunities for greentech solution providers.

As above in the discussion of local tax and other fiscal incentives used to support China's greentech development, local infrastructure investment can also play a significant role. Local regulators can and do incorporate environmental considerations into their planning processes for public works infrastructure, and in some areas like the Sino-Singapore Tianjin Eco-city, they are showing signs of making such considerations an important part of their urban planning processes.

PRICING MANAGEMENT

Another important regulatory instrument that influences the development of China's greentech markets is pricing controls. As China's economy has liberalized over the past 30 years, a number of goods and services, previously subject to pricing controls, have been permitted to fluctuate with market forces.

The low cost of converting natural resources into useable enery in China compared to in other countries is a key factor enabling lower end-user costs. The government continues to exert control over the prices of electricity, gas, district heating and water utilities, in addition to commodities such as gasoline, to enable the affordability of these goods for China's low-income households. Figure 9 gives some examples of the price differentials on these basic goods and service between China and the U.S.

While less visible to end-users, upstream prices such as the feed-in tariffs for the connection of renewable energy to China's electric power grids or pre-treatment water resource costs are also controlled by China's regulators, partly through the taxation mechanisms described above, but also using other policy tools.

China's government has been increasing the flexibility of natural resource and utility prices to fluctuate with market forces, allowing providers some influence in setting feed-in prices in some cases. But power, pricing is a complex issue and these moves have been subject to much debate, so few nationwide pricing plans have been unveiled.

As a notable exception, the NDRC in July 2009 released a national feed-in tariff for wind power, giving it a significant premium over the typical feed-in price for coal power.[45] Besides the new national wind power pricing scheme, there are a number of pilot pricing programs in place in cities around China experimenting with new models to raise prices in other greentech sectors while continuing to protect low-income consumers. Relevant challenges and opportunities related to these new pricing schemes are discussed in more detail in later sections.

The International Policy Environment

INTERNATIONAL POLICY CONTEXT

While the Chinese government has the most influence and control over China's environmental sustainability issues, many international organizations and regulatory bodies also impact the development of China's greentech markets.

The United Nations (UN), through its variety of specialized agencies that sponsor international policy discussions related to the environment and climate change, provides a global context to China's sustainability and climate change policies. Two key UN agencies addressing sustainability, climate change and greentech issues are the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP). Established by the World Meteorological

[45]中华人民共和国国家发展和改革委员会, "关于完善风力发电上网电价政策的通知," *2009年7月24日, [National Development and Reform Commission, Notice on Improvements to the Wind Power Feed-In Pricing Policy, July 24, 2009]*

Organization (WMO) and UNEP, the Intergovernmental Panel on Climate Change (IPCC) is tasked with evaluating the risks of climate change caused by human activity. Finally, other UN agencies, such as the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), are more accurately international regulators, setting standards and playing policy roles in specific greentech sectors.

The World Trade Organization (WTO), International Monetary Fund (IMF), World Bank and Asian Development Bank (ADB) are other international organizations which exert influence over the development of China's greentech markets, via their role in guiding trade relations between individual countries, managing the global economy and promoting economic development.

Since green technologies can often help support the development objectives of international financial institutions, soft loans[46] are often available from the World Bank, Asian Development Bank and other development agencies. The World Bank has at least four funds that direct financing to greentech projects—the Clean Technology Fund, the Strategic Climate Fund, the Carbon Partnership Fund and the Forest Carbon Partnership Facility.[47]

INTERNATIONAL POLICY PRINCIPLES

As China's economy has grown, so too has its role in international policy circles. In addition to the Chinese policy principles discussed above, a number of international policy principles also exert influence on the development of China's greentech markets. Perhaps the most important of these is the concept of *sustainable development*. Sustainable development is commonly defined as development "meeting the needs of the present without compromising the ability of future generations to meet their own needs."[48] China's government's "Agenda 21 – White Paper on China's Population, Environment and Development in the 21st Century" laid out China's sustainable development principles, and more recently its 2007 "Program of Action for Sustainable Development in China in the Early 21st Century" is also among the many references to the principle of sustainable development in Chinese policies.[49,50]

As climate change becomes an increasingly important international policy area, other principles have emerged to help guide countries in collectively addressing this issue. These principles play significant roles in ongoing international climate change negotiations. An important principle frequently referred to by China's policymakers is *Common but Differentiated Responsibilities and Respective Capabilities* (CbDR/RC). The underlying concept is that all countries, while sharing a common responsibility to mitigate the impact of climate change, have unique capabilities to do so that are directly related to their level of socioeconomic development. Accordingly, the actions taken by each country, for example reducing greenhouse gas emissions, should correlate with their individual capabilities as determined by their unique socioeconomic conditions. China's National Climate Change Programme explicitly notes that according to CbDR/RC: "developed countries should take the lead in reducing greenhouse gas emissions as well as providing financial and technical support to developing countries. The first and overriding priorities of developing countries are sustainable development and poverty eradication."[51]

Another key principle in international climate change negotiations relates to Measurable, Reportable and Verifiable (MRV) actions. The Bali Road Map, generated as a result of the December 2007 Bali climate change negotiations, called for "measurable, reportable and verifiable policies and actions" from developing countries, and a strong commitment to reducing emissions from developed countries. The plan also required developed countries to assess,

[46] *Soft loans are commonly loans provided at interest rates below market levels or with other concessionary terms*
[47] *World Bank, The World Bank and Climate Change: An Operational Update (Beijing, China: World Bank, November 2008.)*
[48] *United Nations, "General Assembly: Report of the World Commission on Environment and Development," December 11th, 1987, http://www.un.org/*
[49] *The Administrative Center for China's Agenda 21, "White Paper on China's Population, Environment, and Development in the 21st Century," http://www.acca21.org.cn/ (accessed on August 14, 2009)*
[50] *People's Daily, "Program of Action for Sustainable Development in China in the Early 21st Century," July 16, 2003 //english.peopledaily.com.cn/*
[51] *National Development and Reform Commission,National Climate Change Program,(Beijing,China: NDRC, June 2007),3*

report and verify a range of support measures for developing countries, including financing, technology and adaptation assistance.[52]

INTERNATIONAL AGREEMENTS

Going beyond these principles, certain international agreements commit China to specific policy actions and place China's policies in the context of international environmental efforts.

The 1989 Montreal Protocol on Substances That Deplete the Ozone Layer is often highlighted as an example of a successful international climate change agreement. It was ratified by China and all other members of the United Nations, except East Timor, and has led to substantial reductions in levels of ozone-damaging hydrocarbons in the global atmosphere.[53,54] Fulfilling China's commitments under the Montreal Protocol has driven greentech innovation in the development of new refrigerator and air conditioner technologies which are not reliant on ozone depleting chemicals.[55]

Three years after the signing of the Montreal Protocol, the 1992 UN Earth Summit in Rio de Janeiro produced the United Nations Framework Convention on Climate Change (UNFCCC) with an objective to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[56] China's development of its Agenda 21 sustainable development strategy was another outcome of the Rio Conference.

In 1997, the parties to the UNFCCC established the Kyoto Protocol to require binding commitments for the reduction of greenhouse gases from industrialized nations and other climate change-related commitments for all member countries. One hundred eighty four countries had signed and ratified the Kyoto Protocol by July 2009.[57] Over 45% of the certified emission reduction certificates (CERs) registered under the Kyoto Protocol by August 2009 were generated from renewable energy and other emissions reduction projects in China.[58]

The Kyoto Protocol targets for emissions reductions will expire in 2012. Through a series of international meetings, including notably the 13th and 14th United Nations Climate Change Conferences (Bali, Indonesia - December 2007 and Pozna, Poland - December 2008, respectively), the parties to the UNFCCC are currently involved in a series of high-level negotiations. They hope to come to accord on a successor agreement to the Kyoto Protocol at the 15th United Nations Climate Change Conference scheduled for December 2009 in Copenhagen, Denmark.

While China's official position on issues surrounding climate change is continually being refined, Premier Wen Jiabao provided a concise summation of China's approach to international climate change issues in a speech. In a November 2008 speech:

> *First, climate change must be tackled through international cooperation… Second, climate change must be tackled under the framework of sustainable development… Third, the principle of "common but differentiated responsibilities" must be followed… Fourth, the UN Millennium Development Goals must be upheld… Fifth, climate change must be tackled by relying on technological progress.*[59]

China has actively been preparing for the Copenhagen meetings, engaging in multiple high-level talks on the issue with other countries. In many public

[52] *World Resources Institute, Comment on the Chinese National Program and its Potential Connection to an MRV Approach in Comments on China's Policies and Actions Addressing Climate Change, 2009-03, (Beijing,China: Global Environmental Institute, 2009), 22*
[53] *United National Environment Programme Ozone Secretariat, "Status of Ratification," http://ozone.unep.org/ (Accessed on August 5, 2009)*
[54] *Earth System Research Laboratory,"Twenty Questions and Answers About the Ozone Layer: 2006 Update," http://www.esrl.noaa.gov/ (accessed on August 16, 2009)*
[55] *United Nations Environment Programme, "China Closes Ozone Depleting Chemical Plants," July 1, 2007, http://www.unep.org/*
[56] *United Nations Framework Convention on Climate Change, "Full text of the Convention, Article 2," http://unfccc.int/ (accessed on July 26, 2009)*
[57] *United Nations Framework Convention on Climate Change, Kyoto Protocol Status of Ratification (Bonn, Germany: UNFCCC, July 08,2009)*
[58] *Original Source: United Nations Framework Convention on Climate Change, "CDM: Issuance," http://cdm.unfccc.int/ (accessed on August 11, 2009)*
[59] *Wen Jiabao, Strengthen International Technology Cooperation and Address Climate Change Actively, (Speech given at the Beijing High-level Conference on Climate Change: Technology Development and Technology Transfer, Beijing, China, 7 November,2009)*

statements issued by key policymakers, China has reinforced its commitment to the principle of Common but Differentiated Responsibilities outlined above.

While it is too early to speculate on the details of any agreement that might come out of the Copenhagen meetings, it seems likely that all possibilities will stress the importance of reducing global greenhouse gas emissions. In doing so, it will present opportunities for continued greentech development both in China and in other countries.

BILATERAL RELATIONSHIPS

Aside from the actions of international organizations, treaties and conventions, direct relationships with other countries and economic blocs also impact China's greentech markets. Regulators from key trading partners, such as the U.S., the European Union and Japan, have frequent dialogues with China's policymakers on greentech-relevant policy issues. For instance, China and the U.S. are engaged in a formal program called the China-U.S. Strategic and Economic Dialogue (S&ED). The program, designed to strengthen bilateral ties and expand cooperation on major international issues and shared global challenges, has placed significant emphasis on combating global climate change, developing clean and efficient energy, environmental protection and energy security.[60]

Another good example of a Sino-American agreement is the China-U.S. Science and Technology Agreement, the first accord signed between China and the U.S. after the normalization of relations in 1979.[61] Under the framework set up by the agreement, the U.S. Department of Energy (DOE) currently manages 12 individual agreements with China on issues including building and industrial energy efficiency, clean vehicles, renewable energy, nuclear energy and science as well as biological and environmental research.

One of these agreements, is a memorandum of understanding (MoU) on cooperation in industrial energy efficiency. Among the multiple cooperative actions outlined in this MoU, one program would select 8-12 enterprises from the Top-1000 Energy-Consuming Enterprises Program (2006-2010) and for each enterprise have a joint NDRC-DOE team carry out an energy audit and highlight opportunities for improvements. Building on this experience, the NDRC would then be in a stronger position to replicate best practices across other large companies in the Top-1000 program.[62]

Cooperation and agreements between China and the European Union and between China and Japan have also been key drivers of China's greentech market development. Individual agreements such as the EU-China Energy and Environment Programme and the EU-China Dialogue on Energy and Transport Strategies have supported successful collaboration on greentech issues.[63] Sino-Japanese greentech relations, such as cooperation in energy conservation and environmental protection technologies and equipment, are a significant component of the 2005-2010 Long-Term Trade Agreement between China and Japan.[64]

In addition, environmental regulations in other countries can also impact China's greentech markets, either directly or indirectly. For example, the EU regulation on the safe use of chemicals (Regulation Concerning the Registration, Evaluation, Authorisation and Restriction of Chemical Substances - REACH), requires China's chemical companies to conduct detailed environmental, health and safety assessments of their products for export to Europe.[65]

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[60] *Washington Foreign Press Center, "Foreign Press Center Briefing with Senior Administration Officials: Preview of the First Joint-Meeting of the U.S.-China Strategic and Economic Dialogue" July 23, 2009, http://beijing.usembassy-china.org.cn/ (accessed on August 14, 2009)*

[61] *US Department of Energy, "US-China Clean Energy Research Center Announced," July 15, 2009 http://www.energy.gov/*

[62] *US Department of Energy, Memorandum of Understanding between the US DOE and the PRC NDRC Concerning Industrial Energy Efficiency Cooperation (Washington D.C., U.S.: United States Department of Energy, 2007), 2*

[63] *European Commission, "Environment-Climate Change-China," http://ec.europa.eu/ (accessed on July 26, 2009)*

[64] *British Broadcasting Corporation, "China, Japan Sign 2005-2010 Long-Term Trade Agreement," December 12, 2005, http://www.nautilus.org/ (accessed on August 14, 2009)*

[65] *The European Parliament and The Council of the European Union, "Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)"*

Regulatory Challenges Still Hamper the Full Potential of Greentech in China

RECOGNIZING CHINA'S NATURAL RESOURCE LIMITATIONS, increasingly pressing environmental issues and vulnerability to the impacts of climate change, Chinese and international policymakers have innovated a variety of approaches to support the development of healthy Chinese greentech markets.

However, the ongoing challenge remains of having to develop and implement effective policies across China's vast land area, diverse climate zones and large population, all the while continuing to support social stability and ongoing economic development.

Specific regulatory challenges examined later in this report include those related to:

- Coordinating the complex array of stakeholders and policies exerting influence on the greentech sector
- Achieving uniform compliance with existing policies across geographies and different types of market participants
- Providing sufficient transparency in the timing and specifics of new policies in order for participants to effectively build regulatory considerations into their business models and respond to regulatory drivers

There is no defined pathway to meet the scale, complexity and urgency of China's challenges; greentech market stakeholders are working to surmount the challenges and thereby alleviate China's environmental issues.

The following chapters of this report look at the approaches commercial companies are taking to respond to China's sustainability and climate change issues. They highlight the different challenges that are impeding progress and identify opportunities all market stakeholders have in overcoming these hurdles and in contributing to the acceleration of greentech in China.

EXISTING AND

EMERGING SOLUTIONS

Businesses are delivering hundreds of existing and emerging greentech solutions to China markets, providing the potential for significant positive impact on the environment. While these solutions are often already attractive to adopters and represent tremendous market opportunities, some areas are closed to foreign and private entities.

CHINA'S TRANSFORMATION TO ENVIRONMENTAL SUSTAINABILITY requires solutions that do not contribute to climate change, do not pollute the atmosphere or water and do not rely on finite resources such as coal and oil. It also requires technologies that enable the efficient delivery and use of energy. Water shortages and pollution, land degradation, and the proliferation of hazardous and other waste all require solutions as well. Fortunately, an extensive number of existing and emerging green technologies are being applied in China to address these challenges.

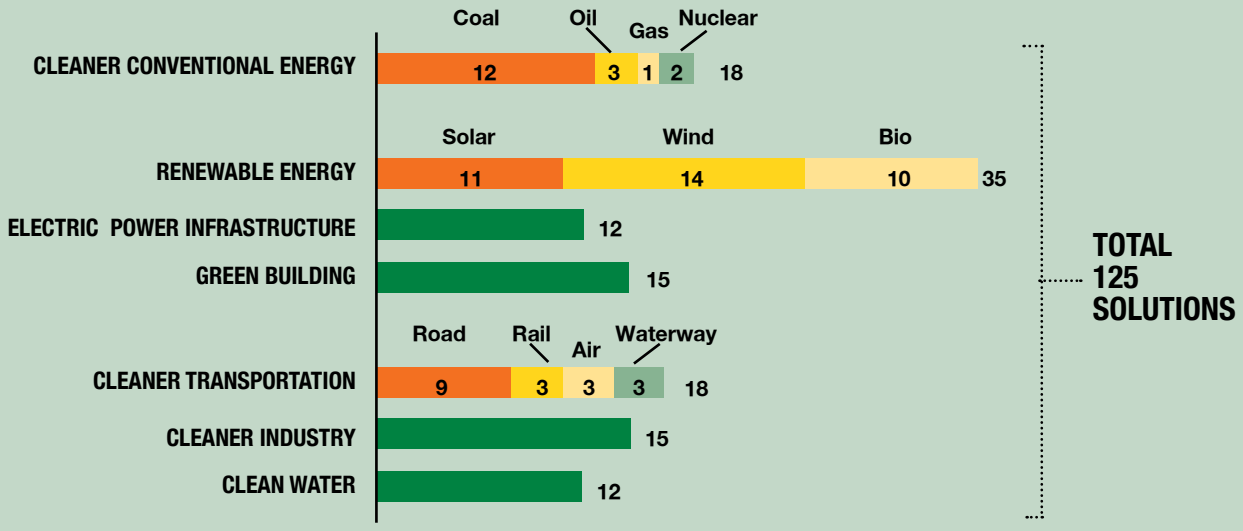
A key objective of the China Greentech Initiative was to understand which greentech solutions are likely to play key roles in the short to medium term as China addresses the sustainability of its growth, and the relative advantages and disadvantages of each.

The analysis carried out by the Initiative suggests:

- A great number of greentech solutions in China have the potential for significant positive impact on the environment
- While a number of solutions are still in development, many are already commercially available in China and are attractive to adopters
- China is generally an attractive market for the application of greentech solutions, given its large size and rapid growth; However, some markets are closed to private and foreign participants

This chapter presents the approach the Initiative has taken to identify and evaluate greentech solutions in China, defines prioritized solutions by sector and provides key findings from the assessment.

Fig.1: PRIORITIZED GREENTECH SOLUTIONS EVALUATED BY THE CHINA GREENTECH INITIATIVE



Note: *The number of solutions prioritized within each sector does not imply judgement on the environmental or commercial potential of the sector*

Fig.2 DEFINITION OF CRITERIA IN THE SOLUTION EVALUATION FRAMEWORK

UNIT ENVIRONMENTAL IMPACT POTENTIAL

- Potential of the solution to **abate negative impact** on **the natural environment** while delivering benefits similar to or greater than the conventional solution
- Focuses on **one target metric** of negative impact (e.g. SO_x emission, water use, electricity use) of the conventional solution abated to the largest degree
- Is **measured in percent on unit basis** – i.e. the potential to abate negative impact in delivery of one unit of benefit (e.g. miles driven, Kwh produced)

VALUE	DEFINITION
●	**Very high:** ■ Potential to decrease impact on the environment of the target metric by **over 40%**
◕	**High:** ■ Potential to decrease impact on the environment of the target metric by **30%-40%**
◑	**Medium:** ■ Potential to decrease impact on the environment of the target metric by **20%-30%**
◔	**Incremental-medium:** ■ Potential to decrease impact on the environment of the target metric by **10%-20%**
○	**Incremental:** ■ Potential to decrease impact on the environment of the target metric by under **10%**

SOLUTION ATTRACTIVENESS

- **Economic attractiveness** of the solution to adopters – i.e. ability to deliver expected benefit at competitive cost is measured on life basis driven or influenced by:
  - **Lifecycle unit cost** against the alternative
  - **Policies** encouraging the adoption
  - **Risk** of not becoming industry standard in China
- All solutions **mandated by the regulation** are considered *advantaged,* regardless of actual penetration

VALUE	DEFINITION
●	**Advantaged:** ■ Lower cost than conventional alternatives Is the industry standard ■ Is regarded as the industry standard
◕	**Attractive:** ■ Cost on par with conventional alternatives ■ On way to become industry standard in China
◑	**Emerging:** ■ More expensive but cost declining ■ Active competition from other technologies
◔	**Disadvantaged:** ■ Significantly more expensive than alternative ■ No indication of becoming major industry force
○	**Unavailable:** ■ Still a concept or in early research phase ■ High risk of pursuing the technology

ADDRESSABLE MARKET SIZE

- Annual **sales of the solution** if it were purchased by 100% of potential adopters that year
- **Adopters are organizations and individuals that purchase solutions** (either conventional or greentech solution under evaluation) to achieve certain benefits
- Is measured in US$ billion (billion yuan) per year and mathematically is a product of:
  - Total **number of potential adopters** that year
  - **Price of current "standard"** substitute

VALUE	DEFINITION
●	**Very large:** ■ Over US$50 billion (350 billion yuan) per year
◕	**Large:** ■ Between US$10 and US$50 billion (70 and 350 billion yuan) per year
◑	**Medium:** ■ Between US$3 and US$10 billion (20 and 70 billion yuan) per year
◔	**Limited-medium:** ■ Between US$0.5 and US$3 billion (3 and 20 billion yuan) USD per year
○	**Limited:** ■ Under US$0.5 billion (3 billion yuan) per year

MARKET ACCESSIBILITY

- **Degree** of market accessibility for private/foreign players
- Is driven or influenced by:
  - Degree of **direct state influence** over the sector
  - **Openness** to foreign capital and ownership
  - **Preferential treatment** of SOEs or local players
- Where accessibility for private is different than for foreign players, the more restricted value is used
- In cases where 3-tier evaluation is used, terms applied are shown in parenthesis

VALUE	DEFINITION
●	**Fully open (Mostly open):** ■ Low to no state control of the sector ■ Fully open to private/foreign capital/ownership
◕	**Open with restrictions (Mostly open):** ■ Generally open, but restrictions on the degree of private/foreign ownership apply
◑	**Partially limited (Limited):** ■ Some parts of the sector are open while others are restricted to private/foreign ownership
◔	**Limited (Limited):** ■ Generally strong state control of the sector ■ In exceptions, private/foreign ownership allowed
○	**Restricted (Restricted):** ■ Full state control of the sector ■ Private or foreign ownership is not allowed

Evaluation Approach

The China Greentech Initiative developed an initial set of over 300 greentech solutions across seven sectors, which were then prioritized into a list of 125 solutions (see Figure 1) based on environmental impact and commercialization potential. Each prioritized solution was then evaluated, using the Solution Evaluation Framework developed by the Initiative.

The Solution Evaluation Framework (SEF) was developed to assess solutions in a comprehensive, consistent, rigorous and flexible manner. The SEF provides a structure in which to capture relevant available qualitative and quantitative information, apply judgment in a structured way and compare results both within and across sectors.

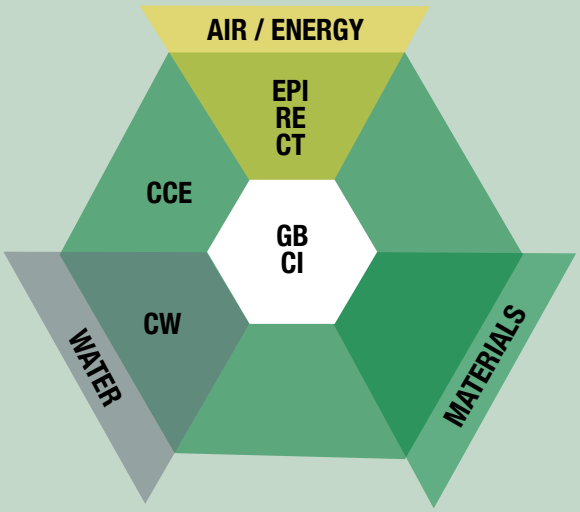
The SEF evaluates solutions across four dimensions: *unit environmental impact potential, solution attractiveness, addressable market size* and *market accessibility.* The last three criteria collectively represent the overall commercial potential of the solution in China. As described in Figure 2, each dimension may take on one of five distinct values. Visually, a Harvey Ball is used to express the rating, with an empty ball representing the lowest and a full ball representing the highest value. Solutions were evaluated according to three time periods: Short (under one year), Medium (1-5 years) and Long (5-10 years). The analysis in this chapter focuses on the Medium term evaluations.

Due to the nature of the SEF, the Initiative partners and advisors sometimes had different views on how to evaluate given solutions. Significant attempts were made to validate and reconcile differing perspectives; however, ultimately the Initiative research team used its judgment to determine the value for each criterion. Given that the SEF is only a tool meant to facilitate the evaluation of greentech solutions, as with any framework, it has limitations and its results should be interpreted accordingly.

UNIT ENVIRONMENT IMPACT POTENTIAL

Unit environmental impact potential (environmental impact) expresses the ability of one unit of technology (e.g. one solar panel, one flue gas desulphurization system or one water treatment system) to abate a particular pollutant (e.g. sulfur dioxide, ammonia or solid waste) or increase efficiency of a particular resource (e.g. energy, water or material feedstock) compared to the conventional solution used or no solution at all. The metric used is a percentage which reflects the proportion of pollution abated or efficiency gained by using a particular solution. This consistent metric makes it possible to compare greentech solutions based on their environmental impact within and across segments and sectors.

Fig.3: DISTRIBUTION OF SECTORS BY ENVIRONMENTAL DIMENSIONS TARGETED BY PRIORITIZED SOLUTIONS



SECTOR NAME ABBREVIATIONS LEGEND:

CCE - Cleaner Conventional Energy

RE - Renewable Energy

EPI - Electric Power Infrastructure

GB - Green Building

CT - Cleaner Transportation

CI - Cleaner Industry

CW - Clean Water

Figure 3 demonstrates the distribution of China's greentech sectors among three dimensions of environmental impact abatement: Air/Energy, Water and Materials. Air and energy are combined into one dimension because the majority of air pollution and CO_2 emissions in China comes from fossil fuels, which can be abated through improved energy efficiency and increased use of renewable energy sources. For each prioritized greentech solution, the dimension on which the greatest unit environment impact abatement could be delivered was chosen.

This graphic shows that the Renewable Energy, Electric Power Infrastructure and Cleaner Transportation sectors primarily impact the environment by reducing atmospheric emissions, including CO_2, and improving energy efficiency. Clean Water solutions focus on addressing challenges associated with the shortage and pollution of water. Cleaner Conventional Energy solutions abate environmental impact on both air and water. Green Building and Cleaner Industry include solutions that address all three environmental dimensions.

Unit environmental impact potential, as defined by the Solution Evaluation Framework, does not represent the potential of a solution to abate a specific pollutant or increase resource use efficiency for a particular resource for China as a whole. The consideration of the scale of impact is included under the addressable market size dimension.

SOLUTION ATTRACTIVENESS

Solution attractiveness aims to capture the value of adopting a greentech solution compared to alternatives, focusing on the ability of the solution to deliver benefits to adopters at costs equal to or lower than substitutes on a life cycle basis (e.g., energy savings from the use of a Combined Heat and Power (CHP) system or an Energy Efficient Motor).

Cost competitiveness generally is correlated with technological maturity. For instance, the cost of electricity generated using solar photovoltaic (PV) technology is currently much higher than that of electricity generated using thermal coal fired power plants. Due to these higher costs, the SEF does not qualify Solar PV for a rating of *attractive*, but rather *emerging*. This rating reflects the fact that solar PV technology is currently under rapid development and as technology matures, it will likely achieve cost parity with conventional energy sources like coal, at which time it would be rated *attractive*.

Solutions that are mandated in China, such as Flue Gas Desulphurization (De-SOx) and Flue Gas Denitration (De-NOx) systems are rated as *advantaged*. This assumes that non-compliance among solution adopters with China's regulation is a short-term phenomenon, and that in the long run it will be an exception.

ADDRESSABLE MARKET SIZE

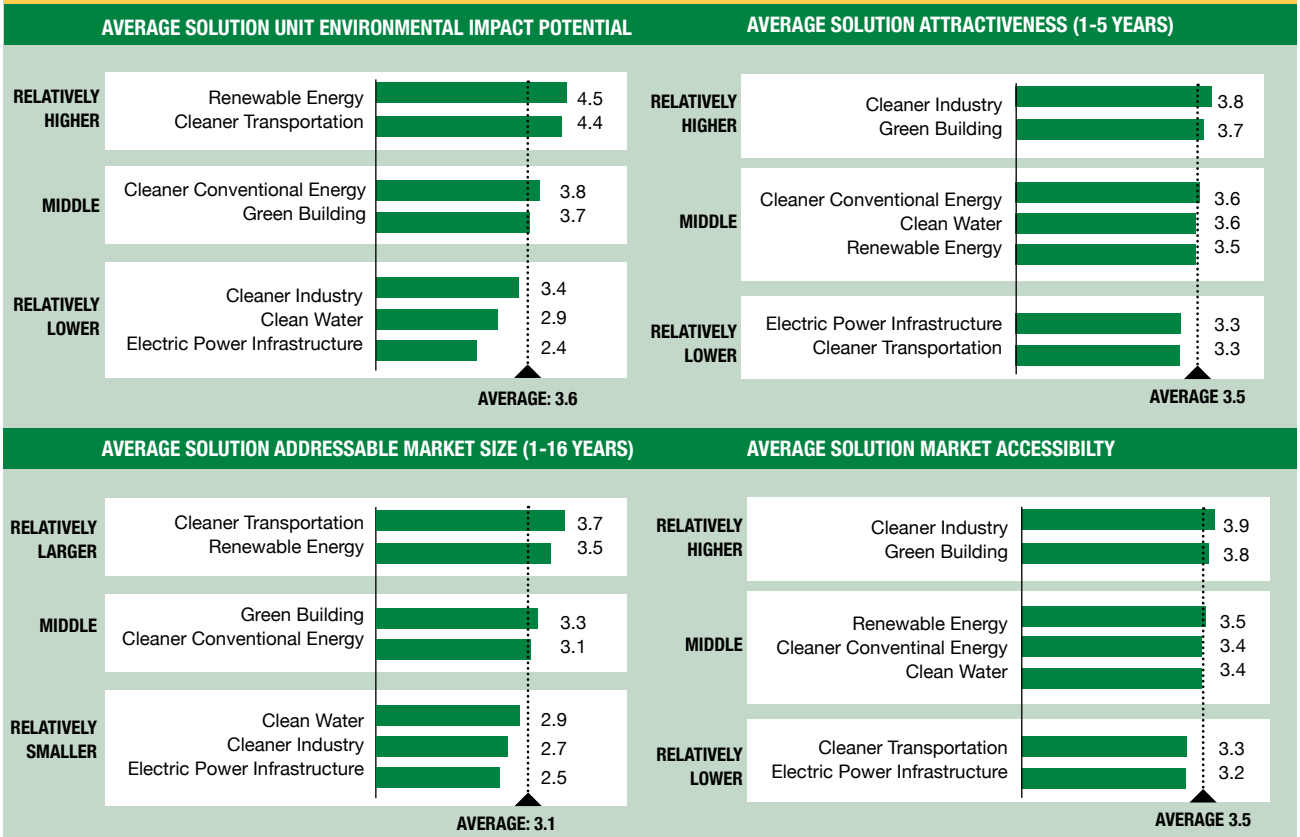
Addressable market size identifies the potential scale at which a particular solution could be applied in China. It is an estimate of the total revenues a particular solution (expressed in US$ or yuan) could achieve if it were *advantaged* in terms of solution attractiveness today. This is a hypothetical number meant to differentiate technologies, rather than forecast market trends. In other words, addressable market size helps differentiate between power plants, turbines used in power plants and blades used in turbines, as the latter are components of the former and therefore have smaller addressable market size by definition.

Values were estimated by the China Greentech Initiative, relying on information gathered by the research team and feedback from partners and advisors.

MARKET ACCESSIBILITY

The objective of the market accessibility criteria is to differntiate between markets to which foreign and private players have access and those that are restricted due to regulations or other barriers. *Mostly open* markets are not specifically restricted by the Chinese government. Examples of *mostly open* markets include home appliances, machinery equipment and components, and select technologies that China is interested in developing. *Limited* access markets are those that China controls and allows partial access to, such as construction design, wind power

Fig. 4: SECTOR EVALUATION BY CRITERIA



Note: Three tiers of sectors on each dimension and tier labels are used to facilitate discussion about relative position of the sector and not absolute.

development and conventional power generation. *Restricted* markets are those that China normally does not allow foreign and/or private players to participate in, such as air traffic control and the construction and operation of electrical grid networks.

Cross-Sector Findings

Figure 4 shows the average values given to solutions within each of the seven greentech sectors across the four evaluation dimensions introduced above. The sectors are ranked from highest to lowest solution average on each dimension and categorized into three tiers. The labels used to describe the tiers provide a relative assessment of sectors in comparison to the other sectors. For example, the *relatively higher* label applied to the Renewable Energy and Cleaner Transportation sectors on the "Average Solution Unit Environmental Impact Potential" dimension reflects that solutions in these two sectors, on average, have higher unit environmental impact than solutions in the other five.

UNIT ENVIRONMENTAL IMPACT POTENTIAL

As highlighted above, Renewable Energy and Cleaner Transportation solutions on average have *relatively higher* environmental impact compared to other sectors. This is because many of these solutions, such as solar photovoltaics, wind turbines and new energy vehicles, have the potential, on a per unit basis, to abate up to 100% of the emissions associated with fossil fuel burning.

Cleaner Industry, Clean Water and Electric Power Infrastructure solutions have, on average, *relatively lower* unit environmental impact compared to other sectors. This is mainly due to the incremental improvement in efficiency and abatement that many of these modular solutions offer.

The average of solutions in the Cleaner Conventional Energy and Green Building sectors falls in the *middle* tier. This is driven by a combination of solutions with *high* and v*ery high* environmental impact in each sector, such as Carbon Capture and Sequestration (CCS) and De-SOx in Cleaner Conventional Energy, with solutions that deliver *incremental* to *medium* environmental impact.

SOLUTION ATTRACTIVENESS

Cleaner Industry and Green Building have *relatively higher* average solution attractiveness to adopters. Many solutions in these sectors focus on energy efficiency and are already economically feasible on a life cycle basis today. Cleaner Industry also includes solutions, such as De-SOx and De-NOx, which are mandated by regulation in certain industries.

Electric Power Infrastructure and Cleaner Transportation solutions are ranked *relatively lower*, due to the fact that many of these solutions are in the early stages of technological maturity (e.g. Composite Material Cables and Advanced Metering Infrastructure in the former and Battery Electric Vehicles and Cleaner Aircraft Fuels in the latter).

Cleaner Conventional Energy, Clean Water and Renewable Energy solutions place in the *middle* category, driven by a large number of solutions that technologically are relatively mature or rapidly emerging, but not yet economically competitive in China.

ADDRESSABLE MARKET SIZE

Solutions in Cleaner Transportation and Renewable Energy on average received the highest evaluations. These sectors include many solutions with *large* to very *large* addressable market sizes, such as New Energy Vehicles and Advanced Aircraft in Cleaner Transportation and Solar Photovoltaic, Concentrating Solar and Biomass Combustion Solutions in Renewable Energy.

Clean Water, Cleaner Industry and Electric Power Infrastructure ranked lowest, due to the fact that solutions in these sectors are more specialized and are often individual components of larger systems.

Green Building and Cleaner Conventional Energy solutions are positioned in the *middle* of the ranking. In fact, a number of solutions in these sectors were evaluated to have large and *very large* addressable market size, but fewer than those in the top two sectors.

MARKET ACCESSIBILITY

Market accessibility for solutions in Cleaner Industry and Green Building segments is on average *relatively higher* compared to solutions in other sectors. Many of these solutions are modular by nature with a large number of private business providers (both domestic and foreign) already operating in China.

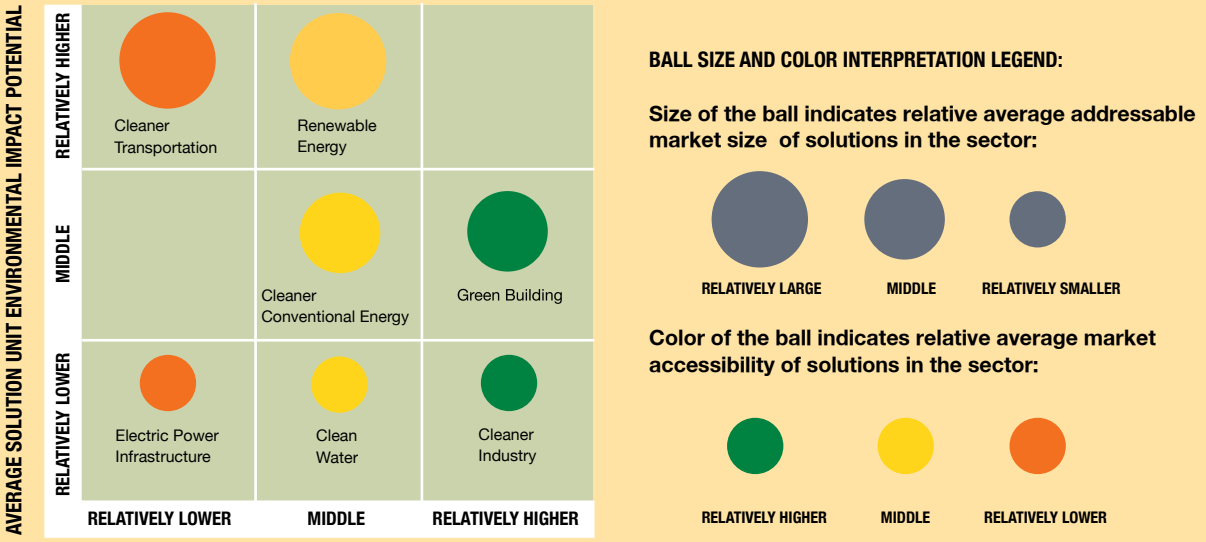
Cleaner Transportation and Electric Power Infrastructure are markets with *relatively lower* accessibility in China. Cleaner Transportation includes solutions in the railway and air transport segments, where access to many value chain elements is *restricted*. The Electric Power Infrastructure market is a regionalized monopoly controlled by the government. While exceptions exist, solution procurement generally favors local state-owned enterprises.

Renewable Energy, Cleaner Conventional Energy, and Clean Water solutions place in the *middle*. Although markets for a number of solutions in these sectors are *mostly open*, a large number of solutions are applicable to markets that have *limited* accessibility, and in some cases, markets that are *restricted*, which is the case with Underground Coal Gasification Combined Cycle in Cleaner Conventional Energy and Extraction Solutions in Clean Water.

CROSS-SECTOR AVERAGE SOLUTION EVALUATION MATRIX

Figure 5 presents average sector findings in a matrix format, using two axes and the size and color of the ball to incorporate relative evaluation of sectors on all four criteria for the medium term time frame of 1-5 years. Based on this analysis, four groups of sectors emerge:

Fig.5: CROSS-SECTOR AVERAGE SOLUTION EVALUATION MATRIX



■ **Cleaner Transportation and Renewable Energy -** sectors in which solutions on average have *relatively higher* environmental impact, *relatively larger* addressable market size, while being in the *relatively lower* or in the middle category in terms of solution attractiveness to adopters and functioning in markets that rank *relatively lower* or in the *middle* on accessibility, compared to other sectors

■ **Green Building and Cleaner Industry** - solutions on average have *relatively higher* attractiveness to adopters, with *relatively higher* market accessibility, while offering environmental impact that ranks *relatively lower* or in the middle and addressable market size that ranks in the *middle* or in the *relatively smaller* category, compared to solutions in other sectors

■ **Cleaner Conventional Energy and Clean Water** - solutions rank in the *middle* in terms of relative attractiveness to adopters and market accessibility, present environmental impact that ranks in the *relatively lower* or the *middle* categories and addressable market size that ranks in the *middle* or the *relatively smaller* tiers, compared to other sectors

■ **Electric Power infrastructure** - solutions on average have *relatively lower* environmental impact, *relatively lower* attractiveness to adopters, and *relatively smaller* addressable market size with *relatively lower* accessibility, compared to other sectors

TWO DISTINCT INSIGHTS RESULT FROM THIS ANALYSIS:

■ **Correlation of solution attractiveness with market accessibility:** Sectors with more attractive solutions generally exist in markets that are more open (in the medium term 1-5 year timeframe). The two sectors with solutions that on average are found to have *relatively higher* attractiveness to adopters (Green Building and Cleaner Industry) appear to have markets with *relatively higher* accessibility than other sectors. On the other hand, the two sectors with solutions that on average have *relatively lower* attractiveness (Cleaner Transportation and Electric Power Infrastructure) tend to have markets that rank *relatively lower* on accessibility.

■ **Correlation of solution unit environmental impact potential with addressable market size:** Sectors which contain solutions with higher average environmental impact also have greater average addressable market size. For instance, the two sectors that fall into *relatively higher* tier on unit environmental impact potential (Clean Transportation and Renewable Energy) also have *relatively larger* addressable market size compared to other sectors. This is partially due to the concentrated nature of solutions in these sectors, such as vehicles, aircraft, locomotives and Solar Photovoltaics, rather than modular or component-oriented solutions, as is the case in other sectors.

KEY FINDINGS FROM THE CLEANER CONVENTIONAL ENERGY SOLUTION EVALUATION ANALYSIS INCLUDE:

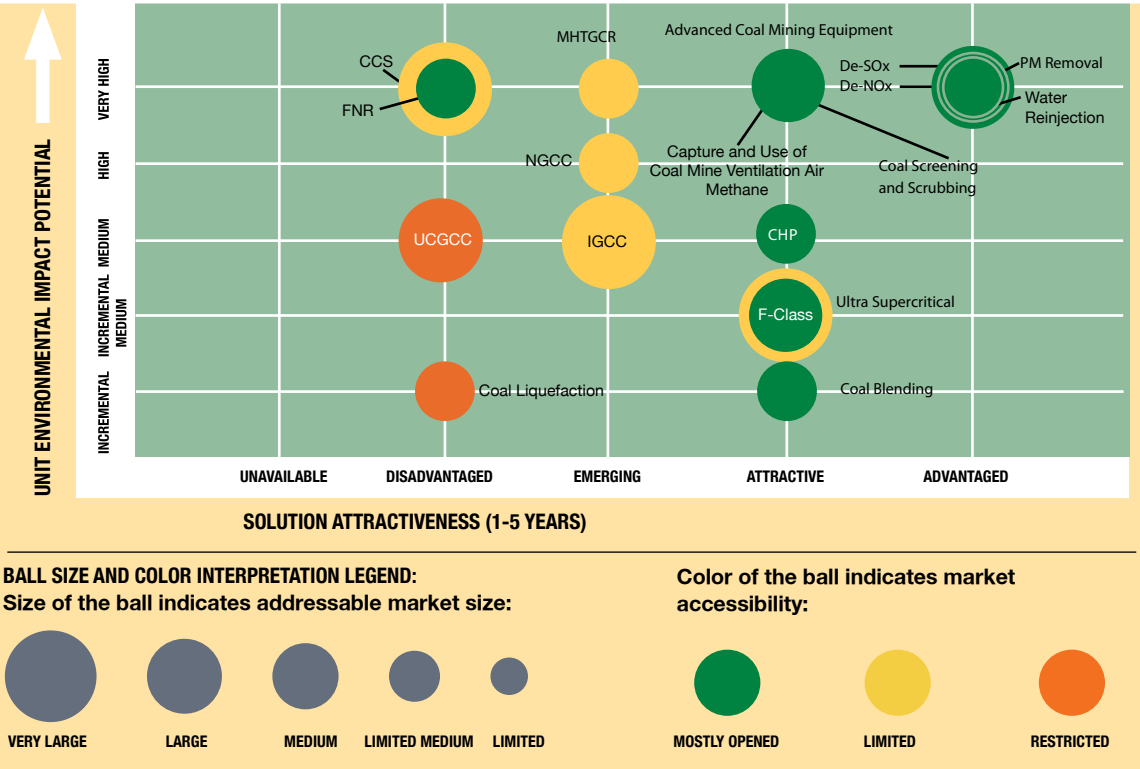
■ **OVER HALF OF ALL SOLUTIONS HAVE *VERY HIGH* UNIT ENVIRONMENTAL IMPACT POTENTIAL.**
This includes all coal post-combustion solutions – Flue Gas Desulfurization (De-SOx), Flue Gas Denitration (De-NOx), Particulate Matter (PM) Removal and Carbon Capture and Sequestration (CCS) solutions. Each of these is able to capture and abate up to 90% of the targeted air pollutant. Additionally, cleaner oil and nuclear power solutions offer *very high* environmental impact. Nearly all other solutions offer lower, though significant, environmental impact. An exception is Coal Liquefaction, which does not present abatement potential due to the high energy intensity of the liquefaction process, but is considered for its strategic energy security benefits.

■ **A MAJORITY OF SOLUTIONS ARE CONSIDERED TO BE *ATTRACTIVE* OR *ADVANTAGED* TO ADOPTERS.**
These solutions are either mandated by regulation, such as De-SOx, De-NOx and PM Removal systems, or are economically feasible on a life cycle basis, mostly due to the energy efficiency gains they offer, such as Coal Blending, Combined Heat and Power (CHP), Ultra Supercritical Power Generation (USPG) and F-class Gas Turbine. Carbon Capture and Sequestration (CCS), Underground Coal Gasification Combine Cycle (UCGCC) and Fast Neutron Reactor are currently under development, and given the costs and risks involved, are yet *disadvantaged* in terms of attractiveness to adopters. Coal Liquefaction is *disadvantaged* due to its high operating costs.

■ **WHILE MOST PRIORITIZED SOLUTIONS OFFER *LIMITED-MEDIUM* TO *MEDIUM* ADDRESSABLE MARKET SIZE, A NUMBER OF SOLUTIONS HAVE *LARGE* TO *VERY LARGE* ADDRESSABLE MARKETS.**
Three technologies have *very large* addressable markets – Integrated Gasification Combined Cycle (IGCC), USPG and CCS. This evaluation is driven by the current market size of China's new coal thermal capacity, which is estimated at over US$50 billion (350 billion yuan) annually. UCGCC, De-SOx and De-NOx solutions are viewed to have *large* addressable market size. Nearly all solutions in Cleaner Gas and Nuclear Power segments have smaller addressable market size, mainly due to the limited capacity of gas fired and nuclear power plants brought online every year, especially when compared to China's coal capacity.

■ **WHILE SOME MARKETS ARE *RESTRICTED*, OVER HALF OF THE ANALYZED SOLUTIONS HAVE MARKETS THAT ARE *MOSTLY OPEN*.**
Coal Liquefaction and UCGCC markets are *restricted* to foreign and private investors and predominantly driven by SOEs. Markets for some key solutions, such as CCS, IGCC, NGCC and USPG are seen as *limited* due to the generally high degree of control exercised by the government. However, markets for many other solutions are *mostly open*, in part driven by China's interest in international collaboration on developing them. These include Fast Neutron Reactor, F-class Gas Turbine and Capture and Use of Coal Mine Ventilation Air Methane.

Fig.6: CLEANER CONVENTIONAL ENERGY SECTOR SOLUTION EVALUATION MATRIX (1-5 Years)



Cleaner Conventional Energy Solutions

THE CHINA GREENTECH INITIATIVE PRIORITIZED 18 CLEANER CONVENTIONAL ENERGY SOLUTIONS for detailed evaluation from 30 that were originally identified as a result of research and partner feedback. Solutions were chosen from across four segments: Cleaner Coal, Cleaner Gas, Cleaner Oil and Nuclear Power.

The primary focus was on cleaner coal solutions due to China's heavy reliance on coal as a primary energy source. 12 cleaner coal solutions were organized into three categories: Pre-Combustion, Conversion and Combustion, Post-Combustion solutions.

CLEANER COAL - PRE-COMBUSTION

- **Advanced Coal Mining Equipment** – Coal mining equipment that is more energy efficient and enables higher extraction rates than conventional equipment
- **Coal Blending** – Process of combining various types of pulverized coal to take advantage of their different combustion and emission properties
- **Coal Screening and Scrubbing** – Processes that reduce impuritities, such as ash and sulfur, contained in coal prior to burning, normally carried out at or close to the coal mine

CLEANER COAL - CONVERSION AND COMBUSTION

- **Coal Liquefaction** – Process that converts coal into liquid fuels
- **F-Class Gas Turbine** – Advanced technology gas turbine, which is a rotary engine that extracts energy from a flow of combustion gas at thermal power plants
- **Integrated Gasification Combined Cycle (IGCC)** – System that turns coal into synthesis gas which is then combusted in gas turbines to generate electricity; the waste heat is captured and passed to a steam turbine system for energy recovery
- **Ultra Supercritical Power Generation (USPG)** – Coal-fired power plant that operates at very high temperatures and uses advanced steam cycles that result in higher heat efficiencies and less emissions than conventional coal power plants
- **Underground Coal Gasification Combined Cycle (UCGCC)** – Process by which coal is converted into a product gas underground and then combusted aboveground to generate electricity in combustion systems that capture and utilize waste heat

CLEANER COAL - POST-COMBUSTION

- **Carbon Capture and Sequestration (CCS)** – System that captures carbon dioxide from fossil fuel, either prior to or after combustion, and sequesters it for long term storage underground
- **Flue Gas Denitration (De-NOx)** – System that removes nitrogen oxides from flue gas
- **Flue Gas Desulfurization (De-SOx)** – System that removes sulfur oxides from flue gas
- **Particulate Matter (PM) Removal** – System that removes particulate matter – harmful fine parttcles – from flue gas

CLEANER GAS

- **Capture and Use of Coal Mine Ventilation Air Methane** – Capture and use of methane contained in the exhaust air from underground coal mines
- **Combined Heat and Power (CHP)** – System that simultaneously generates electricity and usable heat by capturing heat that would normally be lost
- **Natural Gas Combined Cycle (NGCC)** – System that generates electricity using gas turbines, and then captures waste heat to generate steam and additional electricity using a steam turbine

CLEANER OIL

- **Water Reinjection** – Reinjection of water recovered at Gas Oil Separation Plants (GOSPs) back into oil reservoirs as a method of Enhanced Oil Recovery (EOR)

NUCLEAR POWER

- **Fast Neutron Reactor (FNR)** – Type of nuclear reactor that can utilize nuclear waste from conventional nuclear reactors as feedstock and operate at higher efficiencies
- **Modular High-Temperature Gas-Cooled Reactor (MHTGCR)** – Type of nuclear reactor that is safer and has higher efficiency compared to conventional nuclear reactors

Renewable Energy Solutions

THE CHINA GREENTECH INITIATIVE EVALUATED 35 RENEWABLE ENERGY SOLUTIONS. These solutions are split nearly equally across three segments: Solar, Wind and Bioenergy. While the Renewable Energy sector is defined to include hydroelectricity, wave and geothermal segments, these solutions are not covered in this report.

Due to the abundance of solutions in this sector, they have been grouped into ten areas to facilitate analysis. The Solar segment includes three solution areas: Photovoltaic, Concentrating and Water Heaters. Wind Power encompasses four areas: Turbines, Development, Maintenance and Energy storage. The three Bioenergy solution areas are: Electricity, Heat and Fuels.

Unlike other sectors discussed in this chapter, the values shown on the Renewable Energy evaluation matrix represent the average values for the solution areas defined above, not invidual solutions. This is due to the number of solutions analyzed.

KEY FINDINGS FROM THE RENEWABLE SOLUTIONS EVALUATION ANALYSIS INCLUDE:

■ **NEARLY ALL AREAS HAVE *VERY HIGH* AVERAGE SOLUTION UNIT ENVIRONMENTAL IMPACT POTENTIAL.** This is based mainly on the ability of renewable energy sources, particularly Solar and Wind, to completely abate CO_2 and other air emissions associated with fossil fuel combustion in generating electricity. The two exceptions are within the wind segment and include Wind–Development and Wind–Maintenance areas, which have *incremental-medium* to *medium* potential. These two areas focus on discrete parts of the wind value chain and offer efficiency gain improvements rather than direct emissions abatement. Bioenergy-Electricity has high environmental impact, or more than 40% abatement. This is significant because this area includes Biomass Co-Firing solution that normally abates less than 40% of CO_2 emissions due to the fact that biomass is normally Co-Fired with coal.

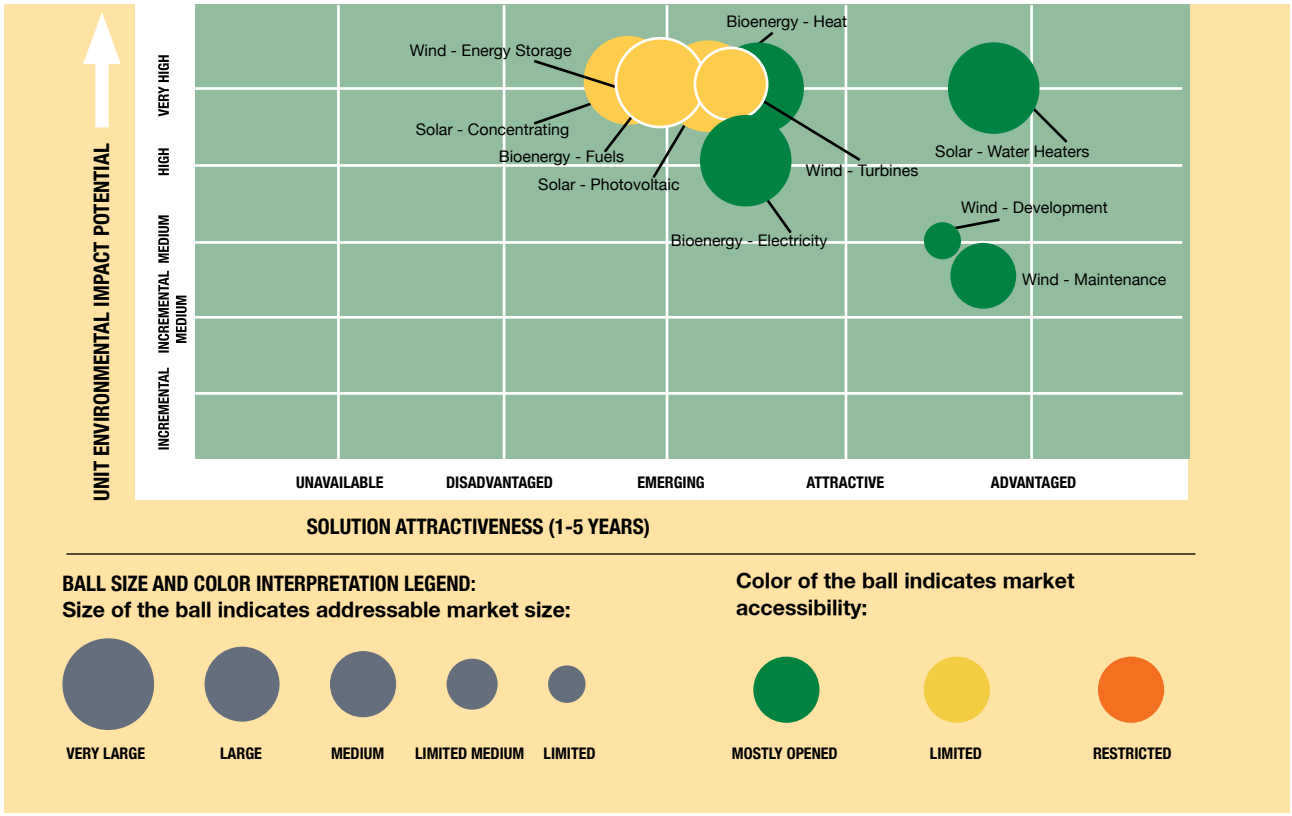
■ **WHILE SOLAR–WATER HEATERS ALREADY ARE *ADVANTAGED* FROM THE ADOPTER PERSPECTIVE, SOLUTIONS IN MOST AREAS ON AVERAGE ARE BETWEEN *EMERGING* AND *ATTRACTIVE*.** Wind–Development and Wind–Maintenance areas include solutions that are either *attractive* or *advantaged* which determined their position between the two evaluations. Bioenergy-Electricity and Bioenergy-Heat both rely on biomass combustion and are found to be between *emerging* and *attractive*. The analysis suggests that among Solar, Wind Power and Biofuels solutions, most attractive are Wind-Turbines solutions, followed by Solar-Photovoltaic, and then by Bioenergy-Fuels solutions. This ranking parallels the technological maturity of solutions within these segments. Wind Power is approaching cost parity with electricity generated using conventional sources, such as coal and natural gas, while generating power using Solar-Photovoltaic solutions is still considerably more expensive. Although a number of Bioenergy-Fuels solutions are technologically mature, the unreliability of feedstock supply significantly decreases their attractiveness to adopters.

■ **THE ADDRESSABLE MARKET SIZE IS ESTIMATED TO BE LARGEST FOR SOLUTIONS IN SOLAR–PHOTOVOLTAIC AND SOLAR–CONCENTRATING AREAS.** This is a reflection of the ability of solutions in these areas to compete for a share of China's forecasted increase in power generation capacity against conventional power sources, especially coal-fired capacity, assuming they reach technological maturity and cost-parity over the medium term timeframe. A number of other solution areas have *large* addressable market sizes, such as Wind–Energy Storage, Solar-Water Heater and all three Bioenergy areas. Apart from two off-grid solutions included in the Wind-Turbines area, solutions there also have *large* addressable market sizes. Solutions in Wind-Maintenance and Wind-Development areas on average offer relatively smaller market sizes, mainly due to how specialized these solutions are.

■ **ON MARKET ACCESSIBILITY, SOLUTION AREAS ARE SPLIT HALFWAY BETWEEN *MOSTLY OPEN* AND *LIMITED*.** Notably, the five solution areas that rank lower on solution attractiveness are seen as *limited* in terms of market accessibility due to both formal and informal restrictions. These areas include Wind-Turbines, Solar-Photovoltaic, Bioenergy-Fuels, Wind–Energy Storage and Solar–Concentrating. A number of areas, however, contain solutions that on average have markets that are *mostly open*, such as Solar-Water Heaters, Wind-Maintenance, Wind-Development, Bioenergy-Electricity, and Bioenergy-Heat.

A more detailed analysis of each individual solution can be found in the Renewable Energy chapter in the full version of The China Greentech Report

Fig.7: RENEWABLE ENERGY SECTOR SOLUTION AREAS EVALUATION MATRIX (1-5 Years)



SOLAR - PHOTOVALTAIC

- **Amorphous Silicon Thin Film Photovoltaic Cell (a-Si PV)** – Type of thin film solar cell based on amorphous silicon chemical compound
- **Building Integrated Photovoltaic (BIPV)** – Application of solar photovoltaic materials, whether crystalline or thin film, into actual building structures, normally replacing conventional building materials in parts of the building envelope such as the roof, skylights or facades
- **Cadmium Telluride Thin Film Photovoltaic Cell (CdTe PV)** – Type of thin film solar cell based on cadmium telluride chemical compound
- **CIGS Thin Film Photovoltaic Cell (CIGS PV)** – Type of thin film solar cell based on copper iridium gallium selenide chemical compound
- **Crystalline Silicon Photovoltaic Cell (cSi PV)** – Type of solar cell made from a single crystal or a polycrystalline slice of silicon that was the first type to be widely commercialized

SOLAR - CONCENTRATING

- **Concentrating Photovoltaic (CPV)** - Device that concentrates sunlight onto photovoltaic surfaces to produce electricity
- **Fresnel Mirror** – Solar thermal energy collector that consists of a series of long, narrow, slightly curved mirrors that focus the light onto linear receivers positioned above the mirrors to be eventually converted into electricity
- **Parabolic Dish Stirling Engine** – Device that concentrates sunlight at a single focal point via a parabolic dish to produce electricity and that can track the sun along two axes by automatically adjusting the direction of the dish
- **Parabolic Trough** – Solar thermal energy collector that consists of a long parabolic mirror and a Dewar tube running its length at the focal point that absorbs energy from the sunlight whicswh is converted into electricity
- **Power Towers** – Type of solar power plant that uses a tower and a high heat capacity component to receive the sunlight focused by an array of flat movable mirrors and convert it into electricity

SOLAR - WATER HEATERS

- **Solar Water Heater (SWH)** – System that heats water by absorbing energy from sunlight, normally consisting of solar thermal collectors, fluid systems to transport the heat and a water tank where water is heated and stored

WIND - TURBINES

- **Offgrid / <1 MW / Horizontal** – Horizontal wind turbine with under 1 MW capacity that generates electricity to be used locally and does not require connection to the power grid

WIND -TURBINES

- **Offgrid / <1 MW / Vertical** – Vertical wind turbine with under 1 MW capacity that generates electricity to be used locally and does not require connection to the power grid
- **Ongrid / 1-3 MW / Onshore** – Horizontal wind turbine with capacity between 1 and 3 MW that is located onshore and feeds the generated electricity onto the power grid
- **Ongrid / >3 MW / Onshore** – Horizontal wind turbine with capacity over 3 MW that is located onshore and feeds the generated electricity onto the power grid
- **Ongrid / >3 MW / Offshore** – Horizontal wind turbine with capacity over 3 MW that is located offshore and feeds the generated electricity onto the power grid

WIND DEVELOPMENT

- **Micrositing** – Consideration of an array of factors related to wind flow, terrain, local power demand, environmental and land-use issues carried out during site selection for wind turbines to maximize wind farm's operational efficiency and economics
- **Wind Assessment** – Process of assessing the quality of wind at a particular location for the purpose of estimating future potential energy production of a wind farm if it were to be installed at that location

WIND MAINTENANCE

- **Control System** – System that monitors and controls the behavior of other devices or systems to ensure optimal operation of the wind turbine
- **Conversion Technology** – Device that converts electricity received from a set of wind turbines to the standard required by the power grid before feeding the electricity onto the grid
- **Maintenance** – Set of inspections, repairs or modifications of individual wind turbines or wind farms to ensure optimal operation
- **Standard Operating Procedures (SOPs)** – Set of prescriptions for employees, often mandated, on how to execute specific tasks or to react to circumstances in the most efficient and effective ways

WIND ENERGY STORAGE

- **Battery Storage** – Electrochemical cells that can be used to store energy and be charged using electricity and discharged to produce electricity
- **Compressed Air Energy Storage (CAES**) – System that can store energy by compressing air in a compartment, such as airtight undeground cavern, and then generate electricity by releasing the air from storage through a combustion turbine
- **Pumped Hydro Storage** – Method under which energy can be stored by pumping the water to a high reservoir and then released back into a lower reservoir to generate electricity when passing through power generating turbines

BIOENERGY - ELECTRICITY

- **Biomass Co-Firing** – Combining biomass with coal to be burned to generate electricity at a power plant
- **Biomass Combustion** – Burning of biomass to generate electricity at a power plant

BIOENERGY - HEAT

- **Civil Heat** – Burning of biomass to generate heat to be used for civil purposes
- **Industrial Heat** – Burning of biomass to generate heat to be used for industrial purposes

BIOENERGY - FUELS

- **Cassava Bioethanol** – Bioethanol produced from cassava crop
- **Cellulosic Bioethanol** – Bioethanol produced from wood, grasses or other plants
- **Jatropha Diesel** – Biodiesel produced from jatropha crop
- **Mircoalgae Diesel** – Diesel produced from microalgae, which are photosynthetic organisms that can be farmed in water
- **Sweet Sorghum Bioethanol** – Bioethanol produced from sweet sorgum crop
- **Waste Vegetable Oil Biodiesel** – Biodiesel produced from waste vegetable oil

Electric Power Infrastructure Solutions

THE CHINA GREENTECH INITIATIVE PRIORITIZED 12 ELECTRIC POWER INFRASTRUCTURE SOLUTIONS for detailed evaluation from an original set of 20. These solutions are organized in four areas: Loss Reduction, Smart Grid, Energy Storage and Grid Access solutions.

KEY FINDINGS FROM THE ELECTRIC POWER INFRASTRUCTURE SOLUTIONS EVALUATION ANALYSIS INCLUDE:

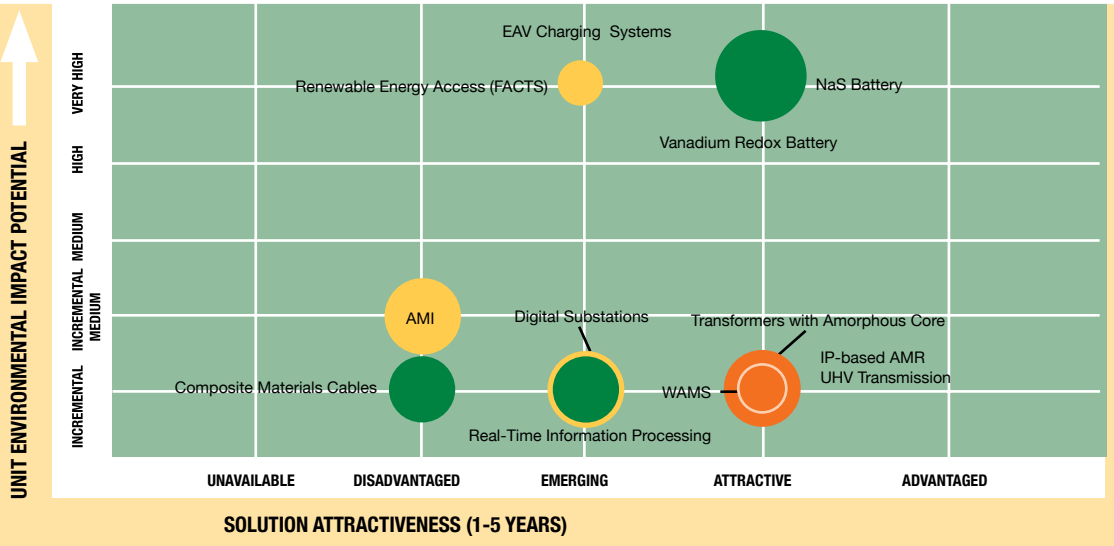
■ **TWO-THIRDS OF ANALYZED SOLUTIONS OFFER *INCREMENTAL* UNIT ENVIRONMENTAL IMPACT POTENTIAL.** This is due to the focus of these solutions, such as Digital Substations, Composite Materials Cables and Wide Area Management System (WAMS), on transmission and distribution loss reduction, which represents less than 10% of today's overall electricity generation in China. The benefit these solutions deliver in improving the reliability of the network is not captured in this evaluation. However, the two energy storage and two grid access solutions represent *very high* environmental impact. This means they are able to abate over 40% of negative environmental impact, which in this case are CO_2 emissions from power generation utilizing China's current fuel mix. Rather than delivering direct impact, these solutions enable the collective system, which is comprised of power generation, storage, transmission, distribution and application, to achieve 40% abatement.

■ **HALF OF THE SOLUTIONS ARE STILL *DISADVANTAGED* OR *EMERGING*, WHILE HALF ARE ALREADY *ATTRACTIVE*.** From the adopter perspective, many solutions are still *disadvantaged* or *emerging*, such as Composite Materials Cables, Advanced Metering Infrastructure (AMI) and Electric Auto Vehicle (EAV) Charging System. Although all of these technologies hold great promise, currently, they are in relatively early stages of technological maturity. In comparison, Ultra High Voltage (UHV) Transmission and the two energy storage solutions were evaluated as *attractive*. Particularly in the area of UHV Transmission China has invested heavily in building strong domestic expertise and today posesses world class technology.

■ **ALL SOLUTIONS, WITH THE EXCEPTION OF ENERGY STORAGE, HAVE *LIMITED* TO *MEDIUM* ADDRESSABLE MARKET SIZE.** This is driven, in part, by the nature of solutions that were prioritized, which represent individual grid components, rather than comprehensive systems. Especially in cases such as Digital Substation and WAMS, these solutions have very narrow application and once installed have long lifespans, not requiring replacements. This constrains the yearly addressable market size of these technologies. The two energy storage solutions, however, NaS Battery and Vanadium Redox Battery, have *large* addressable market size, as they could be deployed to store electricity generated during non-peak times, in place of incremental peak power generating capacity, and used to mitigate power supply and demand fluctuation. UHV Transmission is estimated to have medium addressable market size, driven by China's ongoing investment in the sector.

■ **THE MAJORITY OF MARKETS HAVE EITHER *LIMITED* OR *RESTRICTED* ACCESS.** In the case of UHV Transmission and WAMS, China has made significant investment in these solutions and the government is focusing on deploying them independently. For other technologies – such as AMI, IP-Based Automatic Meter Reading (AMR) and EAV Charging System – markets are viewed to be relatively more open, albeit still *limited*, due to the government-owned regionalized monopoly responsible for the construction and management of China's electric grid.

Fig.8: ELECTRIC POWER INFRASTRUCTURE SECTOR SOLUTION EVALUATION MATRIX (1-5 Years)



BALL SIZE AND COLOR INTERPRETATION LEGEND:
Size of the ball indicates addressable market size:

Color of the ball indicates market accessibility:

LOSS REDUCTION

- **Composite Materials Cables –** Transmission and distribution line cables made from compostive materials that are specifically engineered to reduce losses
- **Transformers with Amorphous Core –** Altnernative transformers that are more energy-efficient and environmentally-friendly than conventional
- **Ultra High Voltage (UHV) Transmission –** Power transmission lines with voltages of 1,000 kV or higher for alternating current or 800 kV or higher for direct current that allow power to be transmitted at greater distances with lower losses than lower voltage transmission lines

SMART GRID

- **Advanced Metering Infrastructure (AMI)** – Integrated system that measures, collects, stores and analyzes utility usage, such as electricity, gas or water usage; is a broader concept than AMR-IP based solution
- **Digital Substation** – Automated and computerized substation that provides greater transparency, higher reliability and efficiency of operations
- **IP-Based Automatic Meter Reading (AMR)** – Solutions that automatically gather data from energy metering devices and transmit to a central processing facility where billing is handled and consumption patterns are analyzed
- **Real-Time Information Processing** – Solutions that enable real time communication between core nodes in the electric network, inlcuding customer premise, and allow better management of demand, improved reliabiliity and flexibility of the network
- **Wide Area Management System (WAMS)** – Integrated system that monitors and controls elements of the electrical power grid to ensure availability and improve reliability and efficiency of the network

ENERGY STORAGE

- **NaS Battery** – Sodium-sulphur battery with high energy density and high efficiency of charge/discharge that requires high operating temperatures
- **Vanadium Redox Battery** – Flow battery with deep cycling life that can be mechanically refueled and has low negative environmental impact

GRID ACCESS

- **Electric Auto Vehicle (EAV) Charging System** – System that allows for plug-in electric vehicles to be charged using power from the grid
- **Renewable Energy Access - Flexible Alternating Current Trasmission System (FACTS**) – System comprised of static equipment used for the alternating current transmission that is meant to enhance controllability and increase power transfer capability of the network

Green Building Solutions

THE CHINA GREENTECH INITIATIVE PRIORITIZED 15 GREEN BUILDING SOLUTIONS for detailed evaluation from an original list of nearly 30. Prioritized solutions fall into four categories: Energy Efficiency, Water Efficiency, Optimized Materials and Cross-Area solutions.

KEY FINDINGS FROM THE GREEN BUILDING SOLUTIONS EVALUATION ANALYSIS INCLUDE:

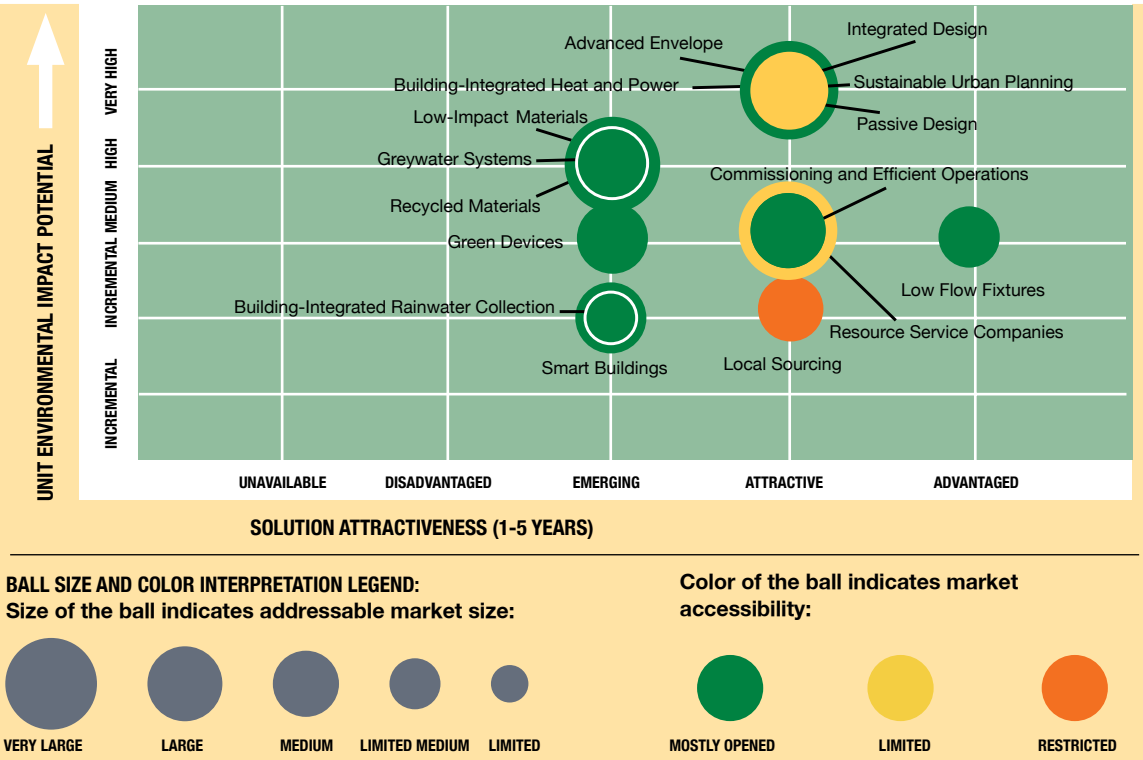
■ **HALF OF ALL SOLUTIONS HAVE *HIGH* TO *VERY HIGH* UNIT ENVIRONMENTAL IMPACT POTENTIAL.**
Solutions that offer *very high* environmental impact include Advanced Envelope, Building-Integrated Heat and Power, Passive Design, Integrated Design and Sustainable Urban Planning. Each, when applied separately, has the potential to improve a building's energy efficiency by 40% or more. The three planning and design solutions have the potential to ensure a building's sustainability early in the development process, when it is still possible to apply a wide range of optimization techniques, including building location, construction materials used and systems intergrated. Solutions with *high* environmental impact include Greywater Systems, Low-Impact Materials and Recycled Materials. All other solutions are estimated to have a *incremental-medium* to *medium* environmental impact.

■ **THE MAJORITY OF GREEN BUILDING SOLUTIONS ARE *ATTRACTIVE* TO ADOPTERS.**
Low-Flow Fixtures are considered to be *advantaged* as they deliver operational savings while their initial cost is comparable to conventional alternatives. Advanced Envelope, Building-Integrated Heat and Power, Comissioning and Efficient Operations, Resource Service Companies and the three design and planning solutions are considered to be *attractive*, as the technologies are mature and the savings delivered during the operation part of the building life cyle outweigh additional upfront costs. However, because of the necessary additional investment and lack of alignment of interest in the value chain between developers and users of buildings, these solutions are not yet widely applied in China.

■ **SOLUTIONS VARY BY ADDRESSABLE MARKET SIZE AND ONE THIRD OF ALL SOLUTIONS HAVE *LARGE* TO *VERY LARGE* MARKETS.** Advanced Envelope, Low-Impact Materials and Recycled Materials were all evaluated to have *very large* addressable markets, driven by the large amount of new building construction that takes place in China every year. At the same time, Building-Integrated Heat and Power and Resource Service Companies solutions were estimated to have *large* addressable market size, which is driven by the rapidly growing floorspace in China and the low existing penetration of these solutions. Most other solutions were evaluated to have medium addressable market size.

■ **EXCEPT FOR PLANNING AND DESIGN SOLUTIONS, NEARLY ALL GREEN BUILDING SOLUTIONS MARKETS ARE VIEWED AS *MOSTLY OPEN*.** China currently limits the scope of operations of foreign building design firms by requiring the involvement of local architecture, design and planning bureaus in design approval, and does not permit foreign construction firms. This said, except for Local Sourcing and Resource Service Companies, markets for all other solutions are viewed as *mostly open* for foreign and private participants. In particular, Green Devices and Smart Buildings, among others, are considered to be areas with the highest market accessibility.

Fig.9: GREEN BUILDING SECTOR SOLUTION EVALUATION MATRIX (1-5 Years)



ENERGY EFFICIENCY SOLUTIONS

- **Advanced Envelope** – Includes insulation, windows, roofing and other passive solutions either installed more accurately than China's market convention or combined with active systems such as moisture or temperature sensors to enable reduced heat gain or loss
- **Building-Integrated Heat and Power** – Combination of heating and power generation solutions that could be integrated into a building, such as solar photovoltaic cells, wind turbines and solar water heaters
- **Green Devices** – Electronic devices used inside buildings, including lighting solutions, appliances and consumer electronics that are more energy efficient than conventional alternatives
- **Smart Buildings** – Buildings that rely on integrated IT-based resource use measurement and monitoring, intelligent analysis of the internal environmental and performance data, and automation of connected building systems

WATER EFFICIENCY SOLUTIONS

- **Building-Integrated Rainwater Collection** – System that collects and

stores rainwater from the rooftop of a building to be used locally
- **Greywater Systems** – Systems for the reuse of water generated from domestic processes such as dish washing, laundry and bathing for either indoor use or in irrigation
- **Low-Flow Fixtures** – Faucets and other water use systems that use less water than conventional systems but deliver the same or greater benefit to the user

OPTIMIZED MATERIALS SOLUTIONS

- **Local Sourcing** – Procurement and sourcing of building materials within the geographical proximity of their intended use
- **Low-Impact Materials** – Building materials produced using less resources and that generate less pollution compared to conventional building materials over their life cycle
- **Recycled Materials** – Building materials manufactured from materials that have been recycled

CROSS-AREAS SOLUTIONS

- **Comissioning and Efficient Operations** – Assuring that all systems in a building are installed, tested, operated and maintained as originally intended
- **Integrated Design** – Approach that brings together all the stakeholders in the building process at an early stage to maximize building comfort and usability while minimizing resource use
- **Passive Design** – Building design that takes advantage of the local climate to provide some or all of the heating, cooling, lighting and ventilation needs of the occupants
- **Resource Service Companies** – Professional service companies, including Energy Service Companies (ESCOs), that provide project management, consulting, engineering, financing, operation and maintenance services that reduce energy and water use in buildings
- **Sustainable Urban Planning** – Urban planning that optimizes the use of the built environment, transportation system, energy, water and land, while aiming to minimize the negative impact of the community on the natural environment

Cleaner Transportation Solutions

THE CHINA GREENTECH INITIATIVE SELECTED 18 CLEANER TRANSPORTATION SOLUTIONS for detailed evaluation. Solutions were identified across four segments: Cleaner Road Transportation, Cleaner Rail Transportation, Cleaner Air Transportation and Cleaner Waterway Transportation.

KEY FINDINGS FROM THE CLEANER TRANSPORTATION SOLUTIONS EVALUATION ANALYSIS INCLUDE:

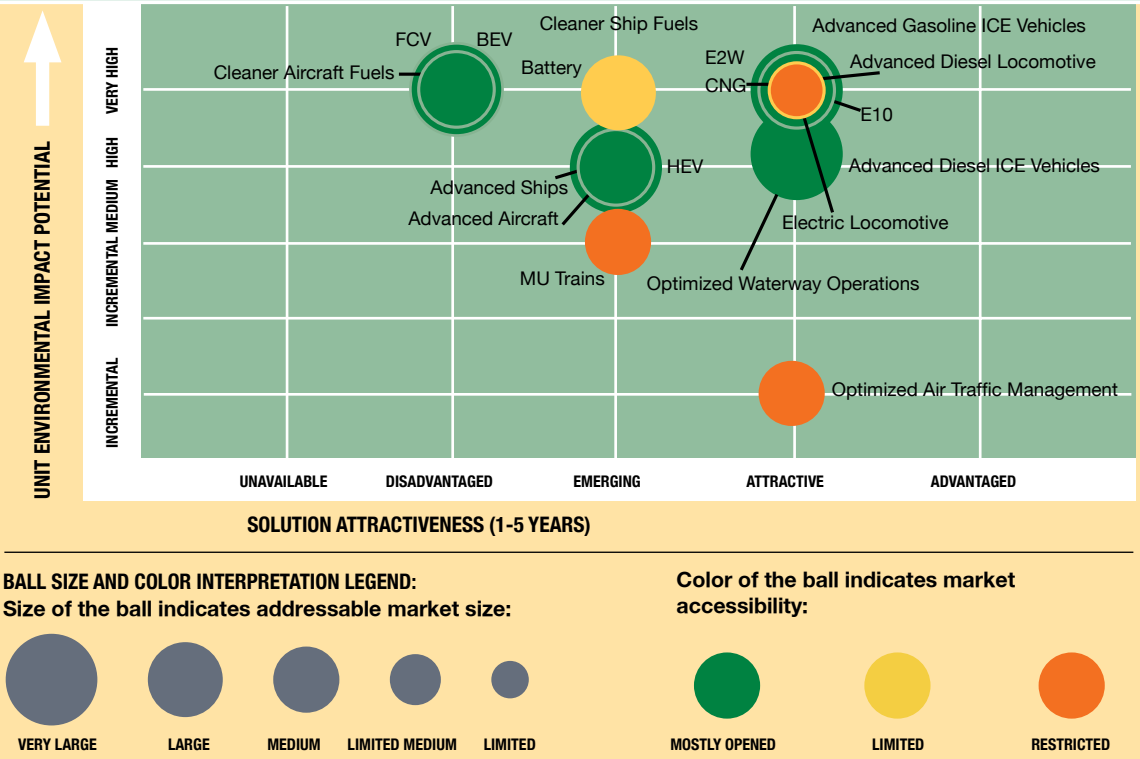
■ **A LARGE MAJORITY OF SOLUTIONS HAVE *VERY HIGH* UNIT ENVIRONMENTAL IMPACT POTENTIAL AND SEVEN OF THESE ARE SIMULTANEOUSLY *ATTRACTIVE* TO ADOPTERS.** Advanced Gasoline and Diesel ICE Vehicles, Compressed Natural Gas (CNG) and Bioethanol (E10) alternative fuels, Electric Two Wheelers (E2W) and Advanced Diesel and Electric Locomotives all have the potential to abate CO_2 and other air polluting emissions related to the combustion of fossil fuels by over 40% on a per unit basis. They are attractive to adopters as costs are either comparable to, or less than, conventional alternatives (CNG, for example), or the fuel savings delivered through efficiency gain justifies the higher upfront cost.

■ **ALTHOUGH HALF OF ALL SOLUTIONS ARE *ATTRACTIVE* TO ADOPTERS, MANY ARE STILL *EMERGING* OR *DISADVANTAGED*.** In addition to solutions described above, Optimized Air Traffic Management and Optimized Waterway Operations are *attractive*. For these solutions, cost savings from fuel efficiency gains delivered by the improved management normally outweigh the investment required for its optimization. At the same time, Advanced Aircraft, Advanced Ships, and Advanced Ship Fuels are considered to be *emerging*. A number of promising solutions, such as Fuel Cell Vehicles (FCV), Battery Electric Vehicles (BEV) and Cleaner Aircraft Fuels, are still *disadvantaged*. This is primarily due to the early technological maturity and still relatively high cost of these solutions.

■ **THE ADVANCED GASOLINE ICE VEHICLES AND THE THREE NEW ENERGY VEHICLE SOLUTIONS (BEV, FCV, HEV) HAVE *VERY LARGE* ADDRESSABLE MARKET SIZE.** This implies addressable market size of over US$50 billion (350 billion yuan) per year, and is determined by China's motor vehicles market, which is one of the largest in the world by the number of units sold and is growing rapidly. A number of solutions were estimated to have *medium* addressable market size in China, as with Advanced Aircraft, Advanced Ships and cleaner fuels solutions for air and waterway transport.

■ **WHILE MARKETS FOR NEARLY ALL ROAD SOLUTIONS ARE *MOSTLY OPEN*, IN THE CASE OF RAIL, AIR, AND WATERWAY TRANSPORTATION THE MAJORITY OF SOLUTIONS FACE *LIMITED* TO *RESTRICTED* MARKET ACCESSIBILITY.** The majority of markets for railway equipment are open to foreign participation through joint ventures, while in case of Electric Locomotives and Multiple Unit Trains, China is pursuing the development of indigenous technologies and exercises a greater influence. The Bioethanol (E10) market is concentrated under several State Owned Enterprises (SOEs) and the government maintains strong control. This is partially due to concerns over the disruption of the food supply chain if the market for Bioethanol feedstock is not managed.

Fig.10: CLEANER TRANSPORTATION SECTOR SOLUTION EVALUATION MATRIX (1-5 Years)



BALL SIZE AND COLOR INTERPRETATION LEGEND:
Size of the ball indicates addressable market size:

VERY LARGE | LARGE | MEDIUM | LIMITED MEDIUM | LIMITED

Color of the ball indicates market accessibility:

MOSTLY OPENED | LIMITED | RESTRICTED

CLEANER ROAD TRANSPORTATION - ADVANCED ICEs	• **Advanced Diesel Internal Combustion Engine (ICE) Vehicle** – Vehicle with diesel ICE that is more fuel efficient and produces less emissions than conventional models used in China • **Advanced Gasoline Internal Combustion Engine (ICE) Vehicle** – Vehicle with gasoline ICE that is more fuel efficient and produces less emissions than conventional models used in China
CLEANER ROAD TRANSPORTATION - ALTERNATIVE FUELS	• **Bioethanol (E10)** – A mixture of gasoline with ethyl alcohol, a petroleum substitute produced from certain agricultural crops through a microbial sugar fermentation process, in a combination where 90% is gasoline and 10% is ethyl alcohol • **Compressed Natural Gas (CNG)** – Fossil fuel substitute for gasoline, diesel or propane made by compressing natural gas which is then stored in special compressed gas cylinders
CLEANER ROAD TRANSPORTATION - NEW ENERGY VEHICLE SOLUTIONS	• **Battery** – Combination of electrochemical cells that store electric energy • **Battery Electric Vehicle (BEV)** – Vehicle that completely relies on electricity storage batteries as a power source and is driven by an electric motor • **Electric Two Wheelers (E2W)** – Bikes and scooters equipped with a rechargeable battery and an electric motor used for propulsion • **Fuel Cell Vehicle (FCV)** – Vehicle propelled by an electric motor using electricity generated through a chemical process within a fuel cell, which requires hydrogen fuel and oxygen from the air as feedstock • **Hybrid Electric Vehicle (HEV)** – Vehicle that combines an internal combustion engine with an electric motor to drive the vehicle and relies on gasoline or diesel and electricity storage batteries as power sources
CLEANER RAIL TRANSPORTATION SOLUTIONS	• **Advanced Diesel Locomotive** – Diesel locomotive that is more fuel efficient and produces less emissions than conventional models used in China • **Electric Locomotive** – Locomotive powered by an electric engine which uses an electricity source, such as an overhead line, third rail or an on-board electricity storage device, rather than fossil fuel to meet its energy requirements • **Multiple Unit (MU) Train** – Train that relies not on a locomotive but a series of self-propelling carriages controlled from one cabin for its propulsion
CLEANER AIR TRANSPORATION SOLUTIONS	• **Advanced Aircraft** – Aircraft that are more fuel efficient and produce less emissions than conventional models used in China • **Cleaner Aircraft Fuels** – Aircraft fuels that produce considerably less air emissions than conventional aircraft fuels while delivering equal or better performance • **Optimized Air Traffic Management** – Set of processes to achieve the highest possible productivity of the air fleet and ground facilities by optimizing flight planning, logistics and air traffic management, while ensuring safety and convenience and minimizing the negative impact on the environment
CLEANER WATERWAY TRANSPORTATION SOLUTIONS	• **Advanced Ships** – Ships that are more fuel efficient and produce less emissions than conventional models used in China • **Cleaner Ship Fuels** – Ship fuels that produce less air emissions than conventional ship fuels while delivering equal or better performance • **Optimized Wasterway Operations** – Set of processes to achieve the highest possible productivity of ships and related facilities, such as ports, by optimizing water traffic planning, logistics and traffic management, while ensuring safety and convenience and minimizing the negative impaction the environment.

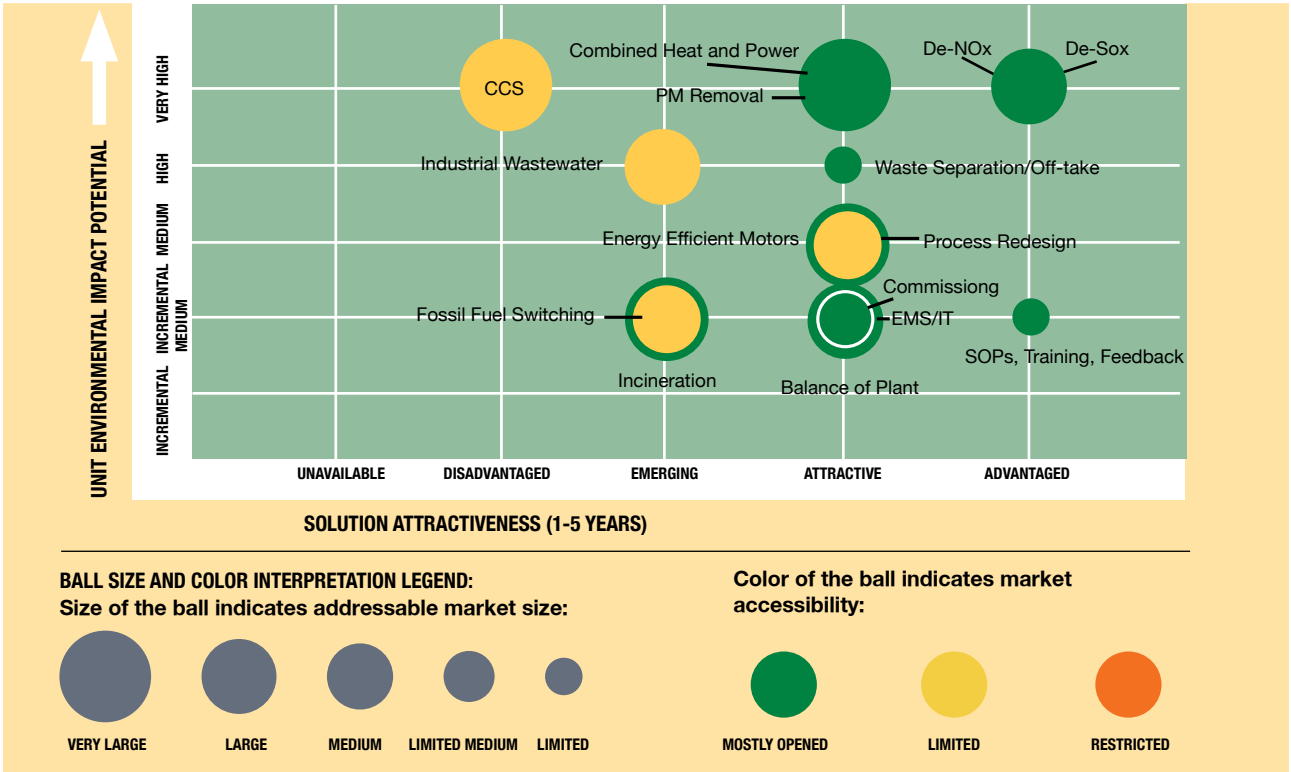
Cleaner Industry Solutions

FROM THE 75 CLEANER INDUSTRY SOLUTIONS ORIGINALLY IDENTIFIED, the China Greentech Initiative prioritized 15 for detailed evaluation. The prioritized solutions apply to multiple industries, including heavy and light industries, and can be categorized into four areas: Energy Efficiency, Air & Water Pollution Mitigation, Solid Waste Management and Cross-Area solutions.

KEY FINDINGS FROM THE CLEANER INDUSTRY SOLUTIONS EVALUATION ANALYSIS INCLUDE:

- **UNIT ENVIRONMENTAL IMPACT POTENTIAL VARIES GREATLY ACROSS SOLUTIONS.** Combined Heat and Power (CHP), Flue Gas Desulfurization (De-SOx), Flue Gas Denitration (De-NOx), Particulate Matter (PM) Removal and Carbon Capture and Sequestration (CCS) solutions were identified to have the highest environmental impact. CHP may provide a gain in energy efficiency of over 40%, and the remaining solutions have the potential to abate over 40% of the pollutants they target. On the other hand, solutions such as Balance of Plant, Fuel Switching and Comissioning received an *incremental-medium* evaluation due to lower, although still considerable, environmental impact improvements they offer.
- **MOST SOLUTIONS ARE *ATTRACTIVE* TO ADOPTERS.** De-SOx and De-NOx systems are mandated through regulation in heavy industries and therefore were assinged the evaluation of *advantaged*. Management techniques, such as Standard Operating Procedures (SOPs), Training and Feedback are standard practice, although not yet applied universaly in China, and were also evaluated as *advantaged*. Energy efficiency solutions, such as CHP, Energy Efficient Motors and Balance of Plant are technologically mature and economically feasible on life cycle basis, despite higher upfront costs compared to conventional alternatives, and are considered *attractive*.
- **CCS AND CHP SYSTEMS ARE ESTIMATED TO HAVE THE LARGEST ADDRESSABLE MARKET SIZE.** This is driven by the large amount of new industrial construction that is projected to take place in China as well as the potential to retrofit existing facilities. These two solutions are followed by, most notably, De-SOx, De-NOx and PM Removal systems, which have *medium* addressable market size. This is detemined by the many industrial sites that are required to install these solutions and their current, relatively low market penetration. A number of solutions were evaluated to have limited to limited-medium addressable market size.
- **MARKETS FOR NEARLY ALL SOLUTIONS ARE CONSIDERED TO BE *MOSTLY OPEN* TO PRIVATE AND FOREIGN PLAYERS.** The four markets perceived to have *limited* accessibility, due to greater government control, are Process Redesign, Fossil Fuel Switching, Industrial Wastewater and CCS. It is noteworthy that due to early maturity of CCS, there are few official policies on whether international cooperation will be encouraged or restrcted. However, given the importance and safety concerns associated with CCS, the technology will likley remain under close government supervision in China.

Fig.11: CLEANER INDUSTRY SECTOR SOLUTION EVALUATION MATRIX (1-5 Years)



EFFICIENT ENERGY SOLUTIONS	• **Balance of Plant** -Optimization of a plant's equipment aimed at maximizing energy and water efficiency and minimizing pollution and waste • **Combined Heat and Power (CHP)** -System that simultaneously generates electricity and usable heat by capturing heat that would normally be lost • **Energy Efficient Motors** -Electric motors that are more energy efficient than conventional models currently used in China
AIR AND WATER POLLUTION MITIGATION SOLUTIONS	• **Carbon Capture and Sequestration (CCS)** -System that captures carbon dioxide from fossil fuel, either prior to or after combustion, and sequesters it for long term storage underground • **Flue Gas Denitration (De-NOx)** -System that removes nitrogen oxides from flue gas • **Flue Gas Desulferization (De-SOx)** -System that removes sulfur oxides from flue gas • **Fuel Switching** -Ability to make use of alternative fuels either by using multiple fuels simultanously or by switching between fuels • **Industrial Wastewater System** -Systems used at industrial sites to treat water after use prior to either reuse or release into the natural environment • **Particulate Matter (PM) Removal System** -A System that removes particulate matter – harmful fine partticles – from flue gas
SOLID WASTE MANAGEMENT SOLUTIONS	• **Incineration Energy Recovery** -Waste to energy solution that generates power from the combustion of solid waste • **Waste Separation and Off-take** -Sorting of solid waste at the industrial facility to assist its exchange, recycling, incineration or disposal
CROSS-AREA SOLUTIONS	• **Commissioning** -Process of assuring that all systems at the industrial object are installed, tested, operated and maintained as originally intentended • **Environmental Management System (EMS) and IT Systems** -Comprehensive, systematic, documented management of an organization's environmental programs that rely on IT solutions for effective operation • **Process-Redesign** -Redesign of the operation with the purpose of increasing resource use efficiency and minimizing pollution • **Standard Operating Procedures (SOPs), Training, Feedback -** Collection of management tools designed to improve the efficiency of employees as well as the effectiveness of the managent at an industrial site.

Clean Water Solutions

THE CHINA GREENTECH INITIATIVE PRIORITIZED 12 SOLUTIONS FOR DETAILED EVALUATION FROM AN ORIGINAL LIST OF 75. Prioritized solutions fall into four broad categories: Water Supply, Water Pollution Treatment, Water-Use Efficiency and Multi-Use solutions.

KEY FINDINGS FROM THE CLEAN WATER SOLUTIONS EVALUATION ANALYSIS INCLUDE:

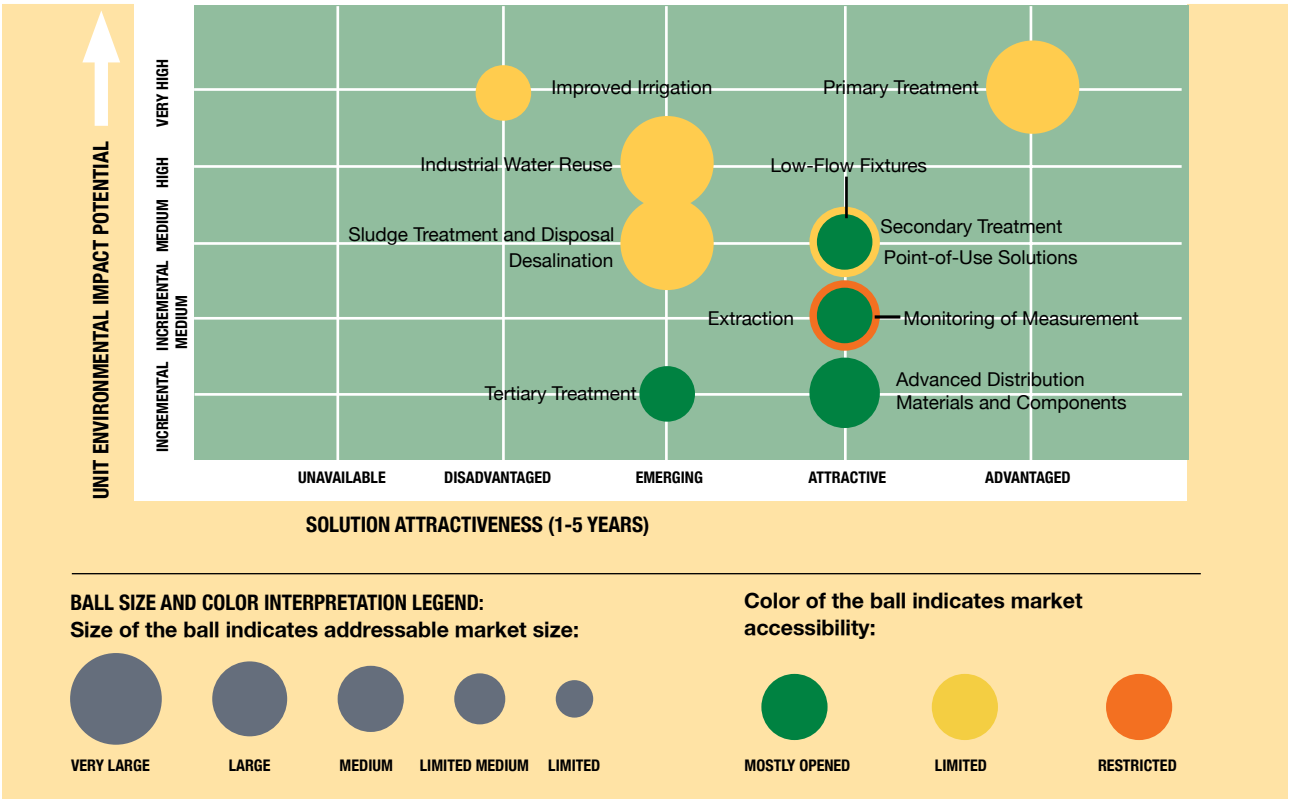
■ **SOLUTIONS COVER A WIDE RANGE OF UNIT ENVIRONMENTAL IMPACT POTENTIAL.** Primary Treatment and Improved Irrigation solutions have the highest evironmental impact. This is due to their role in removing the highest percentage of pollution from the water in the treatment process, to their ability to significantly conserve water in irrigation, which presents an area of great improvement potential in China. In comparison, Tertiary Treatment Technologies and Advanced Distribution Materials and Components solutions have comparatively lower environmental impact due to their relatively incremental, but nevertheless still important, role in mitigating negative impact on the environment.

■ **HALF OF THE ANALYZED SOLUTIONS ARE *ATTRACTIVE* TO ADOPTERS.** Extraction Solutions, Secondary Treatment, Low-Flow Fixtures, Point-of-Use Solutions, Monitoring and Measurement, Advanced Distribution Materials and Components and Industrial Water Reuse are all considered *attractive*. All of these solutions either conserve sufficient amount of water over the life cycle to justify the upfront investment, or deliver benefits at reasonable costs for adopters to actively seek them out. Primary Treament is considered to be *advantaged* due to its standard use in the industry in China.

■ **ONE THIRD OF THE SOLUTIONS HAVE *LARGE* ADDRESSABLE MARKET SIZE.** Desalination, Primary Treatment, Sludge Treatment and Disposal and Industrial Water Reuse solutions are estimated to have *large* addressable markets. The addressable market size is driven by the need for reliable sources of water in the case of Desalination, and by China's current strategy to deploy water treatment facilities throughout the country in the case of the other three solutions. On the other hand, Tertiary Treatment Technologies are estimated to have a *limited* addressable market size due to the fact that few facilities require such treatment.

■ **COMPONENT SOLUTIONS FACE *MOSTLY OPEN* AND SYTEMS SOLUTIONS FACE *LIMITED* ACCESSIBILITY MARKETS.** Component solutions, such as Low-Flow Fixtures, Monitoring and Measurement Solutions, and Advanced Distribution Materials and Components, face markets that are considered *mostly open* to private and foreign players. Most of the other solutions are systems solutions, such as Desalination, Primary Treatment, and Sludge Treatment and Disposal, for which markets are considered to have *limited* accessibility due to significant government control and strong presence of SOEs in the sector. The Extraction Solutions market is considered to be *restricted*, as the government closely regulates it, in part due to the risk of mismanaging underground water reservoirs.

Fig.12: CLEAN WATER SECTOR SOLUTION EVALUATION MATRIX (1-5 Years)



SUPPLY SOLUTIONS

- **Extraction Solutions** - Solutions that help locate, access and extract water from underground sources
- **Desalination** - Process that removes salt and other minerals from saline water, such as sea water, in order to make it suitable for human consumption or irrigation

POLLUTION TREATMENT SOLUTIONS

- **Secondary Treatment Solutions** - Solutions that substantially remove the biological content of sewage, including derivates of human waste, food waste, soaps and detergent
- **Sludge Treatment and Disposal** - Solutions including dewatering, landfill storage and fertilizer conversion that treat sludge generated from wastewater treatment to remove usable substances and properly dispose of residual wastes
- **Tertiary Treatment Solutions** - Solutions that provide a final treatment to raise the effluent quality of the water before it is discharged into the receiving environment

WATER-USE EFFICIENCY SOLUTIONS

- **Improved Irrigation** - Irrigation solutions such as sprinkler or drip irrigation that use water more efficiently than China's conventional irrigation methods with equal or greater benefit to the user
- **Low-Flow Fixtures** - Faucets and other water use systems that use less water that conventional systems but deliver the same or greater benefit to the user

MULTI-USE SOLUTIONS

- **Advanced Distribution Materials and Components** - Pipes, valves and nozzles that are used to transport water, primarily between treatment plants and usage points that are higher quality and/or are more sophisticated and represent lower risk of leakage than conventional models
- **Industrial Water Reuse** - Process whereby certain pollutants are removed from industrial wastewater so that the water can be recycled for further uses at the same site
- **Monitoring and Measurement Solutions** - Solutions that track the composition or volumes of water flows in natural water sources, water distribution systems, water treatment plants or user premises, which are often integrated with IT and or GPS technologies
- **Point-of-Use Solutions** - Water monitoring or treatment solutions that are installed at the point where water is actually used, such as apartments, commercial and industrial facilities
- **Primary Treatment Solutions** - Solutions used primarily at the sedimentation stage, where the solids are separated from the wastewater stream

CHINA'S

GREENTECH DEVELOPMENT CHALLENGES

While China's greentech market opportunities are attractive, there are still hurdles that must be addressed in order to achieve the vision of an environmentally sustainable China.

THE CHINA GREENTECH INITIATIVE'S PARTNERS AND STRATEGIC ADVISORS believe that greentech markets in China represent attractive opportunities, and are optimistic that market conditions will become even more favorable over time. In the spirit of uncovering greentech solutions, the Initiative identified key market challenges, which if overcome, would enable and accelerate the vision of an environmentally sustainable China. Many of these are similar to those of other countries, while some are China specific. This chapter outlines what these challenges are, while the following chapter highlights opportunities stakeholders have to accelerate greentech markets in China.

In order for China to continue its rapid economic development while preserving the health of its citizens, conserving the natural environment for future generations and solidifying its status as an international leader, it has the opportunity to embrace new approaches to clean energy generation, pollution mitigation and the efficient use of resources. The Initiative identified 12 challenges that must be addressed, organized into four major categories – market, technology, financing and regulatory – as shown in Figure 1. Where specific challenges correspond to multiple categories, they have been placed in the category that most closely describes their impact on China's greentech market development.

A detailed analysis of the challenges facing individual greentech sectors is included in the full report.

Fig.1: CHINA'S KEY GREENTECH DEVELOPMENT CHALLENGES

MARKET	■ **Inadequate awareness about greentech solutions** ■ **Underdeveloped value chains** ■ **Highly-concentrated markets**
TECHNOLOGY	■ **More expensive than conventional alternatives** ■ **Lacks adaptation to China's specific market requirements** ■ **Intellectual property and technology transfer issues**
FINANCING	■ **Fewer financing options** ■ **Financing practices lack synergy with greentech requirements**
REGULATORY	■ **Complex regulatory environment** ■ **Developing policy incentives** ■ **Uneven compliance with existing policies** ■ **Limited policy visibility**

Market Challenges

MARKET CHALLENGES IN CHINA CONSTRAIN THE ABILITY OF SOLUTION PROVIDERS to deliver green products and services, and limit market demand for greentech solutions.

INADEQUATE AWARENESS ABOUT GREENTECH SOLUTIONS

Limited knowledge of the availability and benefits of greentech solutions causes adopters and end users in China to continue using conventional practices, largely due to misconceptions about greentech benefits. End users often still see greentech as an incremental cost rather than a potential benefit, and may not understand how their consumption of conventional alternatives impacts the environment. Electricity consumers, for example, do not realize the connection between their consumption and China's coal-based electricity generation, and the associated growing levels of air pollution, related illnesses and long-term climate change risks.

Potential adopters may also believe that green technologies cost more than they actually do, as perceptions are based upon historical rather than current prices. For example, costs to adopt solar power technologies have fallen significantly in recent years due to increased competition, manufacturing scale and process innovation; however, buyers still perceive prices as prohibitive. Some greentech solutions are even becoming cost-negative over their life cycles, particularly if the assumption of rising utility costs is included in the purchase analysis.

Another aspect of the awareness challenge is the limited knowledge adopters have of China's greentech distribution channels. For example, while potential adopters may be aware of and desire greentech solutions, they often do not know where to purchase them.

UNDERDEVELOPED VALUE CHAINS

Underdeveloped value chains across many of China's greentech markets result in disconnects between geographies and stakeholders, limiting the ability of solution providers and adopters to enter into mutually beneficial agreements, thus restricting greentech solution penetration.

One area of disconnect is due to many of China's energy resources being located geographically far away from the country's demand centers. For example, 70% of China's large natural gas reserves are located in western China or offshore fields, far removed from population centers. The lack of transmission lines from these reserves to the demand centers, along with China's relatively scarce natural gas resources, are among the main reasons why, in 2006, natural gas accounted for only 4% of the nation's total energy consumption versus the global average of 24%.[1,2] Similarly, coal is currently transported over long distances from where it is mined to coal-burning electricity plants located near major cities. Geographic disconnects also exist with renewable energy sources, such as wind and solar, which require significant grid upgrades to transmit electricity long distances.

The separation of costs and benefits across participants involved in different parts of greentech solution life cycles is another type of disconnect. As an example, property developers typically incur the upfront costs of outfitting buildings with green technologies, such as Integrated Heat, Power Generation and Greywater Systems. Tenants, on the other hand, receive the key benefits of these technologies through reduced heat, electricity or water costs while they occupy the buildings over time. Developers are more likely to be attracted to greentech solutions when they can benefit directly through higher property values and increased rents.

HIGHLY-CONCENTRATED MARKETS

The high levels of concentration in some of China's greentech markets result in decreased competition, which can potentially decrease efficiency and innovation amongst companies. Greentech markets frequently identified as highly-concentrated or state-dominated include, for example, China's electrical power grids, some types of conventional and renewable power generation, and certain elements of the railroad transportation value chain.

[1] *National Bureau of Statistics of China, "China Energy Statistical Yearbook, 2007"*
[2] *BP, "BP Statistical Review of World Energy 2009"*

There are a few good reasons for maintaining centralized control over China's greentech markets. Since energy security is a key policy concern, policymakers would prefer to see less reliance on energy imports. Because China is already highly dependent on petroleum imports, the Chinese government is currently building up its reserves and diversifying the country's energy mix. Security is also a reason for China to be concerned about who has access to energy supply, generation and infrastructure. Market experts suggest that some policymakers also are beginning to question the security implications of widespread foreign involvement in the operation of China's water infrastructure.

Another frequently cited rationale for supporting highly concentrated markets, in China and elsewhere, is the idea that many greentech markets represent natural monopolies where high capital or interoperability requirements require strong firms operating at near-universal scales. Infrastructure markets have traditionally been identified as natural monopolies, and this rationale has been used in China with respect to transportation infrastructure, electrical power grids and large-scale water diversion projects.

Simplified regulatory compliance monitoring and enforcement is an argument for concentrated markets with strong ties to the government. For example, close relationships currently exist between the government and China's relatively small number of coal-based power generators. These relationships help the firms to understand China's increasingly-stringent nitrous-oxide emissions requirements and drive them to invest in solutions to meet upcoming standards. These relationships may also mean that firms are able to anticipate and prepare for regular and even 'random' emissions inspections. Meanwhile, in China's highly-fragmented real estate development market, as is the case in other countries, enforcing building energy efficiency standards is a difficult and costly endeavor due to the diversity of organizations involved.

The benefits of China's concentrated and state-dominated greentech markets are offset by poor incentives; lack of competition reduces efficiencies and innovation that come from open and competitive markets. The challenge for any nation, including China, is to know how and when to strike a balance between these two sides. China has utilized competitive pressures to achieve balance in its telecommunications and banking sectors in the past, and now has the opportunity to do the same in greentech.

Dominant market players, particularly state-controlled entities, have historically enjoyed relatively easy access to capital, which sometimes discouraged efficient economic practices. China's 'Big 4' commercial banks (Agricultural Bank of China, Bank of China, China Construction Bank and Industrial and Commercial Bank of China) have occasionally been subject to policy-directed lending. Even though they appear to have become more disciplined in recent years, with non-performing loan ratios dropping from nearly 16% in 2004 to under 3% in 2008, policy-directed lending continues, and several market analysts suggest that these non-performing loans are currently on the rise.[3]

There are circumstances under which policy lending may not in itself be bad for the development of markets. For example, China's directed lending strategy under its current economic stimulus plan is expected to be a considerable driver of local greentech markets. It is important however, for policy concerns not to override commercial risk considerations in order to channel funding to the most economically beneficial uses.

Since most greentech markets rely on relatively new and rapidly changing technologies, limiting competition can negatively impact the development of efficient and innovative solutions. For example, in China's early push to promote wind power, regulators used policies to direct China's existing conventional energy generating enterprises into the wind sector, yet excluded foreign wind farm developers from national concession projects and limited the extent to which foreign turbine manufacturers could supply national projects. While this approach may have enabled China to build up its infrastructure rapidly with a view towards

[3] *Stratfor, "China: Renewed Risk of China NPLs," January 19, 2009, http://www.stratfor.com/*

optimizing its operations in the future, it contributed to China's early wind farms being less efficient and requiring higher ongoing maintenance costs than those in other countries.

Technology Challenges

TECHNOLOGY CHALLENGES ARE SLOWING THE DEVELOPMENT AND APPLICATION of greentech solutions in China, hindering the widespread adoption of solutions that meet the cost and feature requirements of potential adopters.

MORE EXPENSIVE THAN CONVENTIONAL ALTERNATIVES

While greentech solution costs have decreased, and should continue to do so with ongoing technological development, learning curves and increasing economies of scale, they are often still more expensive than conventional alternatives. Most renewable energy solutions, (e.g. Concentrating Solar Installations and Offshore Wind Farms) are in relatively early stages of technological maturity, with relatively high adoption costs due to rapidly-evolving designs, suboptimal scale and incomplete manufacturing optimization.

In China as in many other countries, subsidized resource and utility costs may also limit the attractiveness of greentech solutions. An example of this is diesel fuel prices. While fuel prices constantly fluctuate, an October 2008 study found that one liter of diesel fuel cost 20 yuan per liter in Hong Kong but only five yuan in nearby Shenzhen due to differences in subsidization and taxes.[4] Regulators throughout China have realized that some cost controls, which make electricity, potable water, cooking gas and central heating more affordable for low-income citizens, also reduce incentives for efficiency. Aside from reducing demand-side conservation, subsidization also limits the appeal of efficiency-enabling greentech solutions. Recognizing this challenge, regulators around China are raising utility prices and beginning to develop new volumetric and income-related pricing systems.

One example of these new pricing approaches is simple block pricing for domestic water use. In Lijiang City, for instance, the base water price is 1.40 yuan per cubic meter but climbs to 2.10 yuan and then 2.80 yuan per cubic meter as a household uses more than 25 and then 35 cubic meters per month respectively.[5] While this volume-based pricing policy is moving in the right direction, the World Health Organization suggests that a family of four will only use about 4.8 cubic meters of water per month (40 liters per person per day), so the thresholds are likely still too high to encourage significant conservation.

The current low international market prices of natural resources and commodities also limit the attractiveness of some greentech solutions. As noted above, China has been relaxing its subsidization of commodity and utility prices; while this can make greentech solutions relatively more attractive, it also exposes China to changes in global commodity prices. Fluctuations in global oil prices, for example, have a direct impact on the profitability of greentech solutions like electric vehicles, biofuels and solar energy.

The China Greentech Initiative expects that prices for many greentech solutions will continue to decrease as technologies mature and solution providers exploit learning curve effects in manufacturing processes. At the same time, energy and other commodity prices are expected to appreciate as the world emerges from the current economic downturn. The cost of using fossil fuels is also expected to increase, due to regulatory mechanisms which cap or tax carbon emissions, both internationally and in China. While short-term fluctuations could still impact adoption, over the next ten years it seems likely that many of the 125 solutions investigated by the Initiative will achieve cost parity or better with conventional alternatives.

[4] 庞昌伟，”油价补贴： 肥水流向国际游资，” 清华大学中国与世界经济研究中心, *[Pang Chang Wei, "Oil subsidies: hot money flow to international speculation," Tsinghua University Center for China in the World Economy], October 3, 2008*

[5] *The World Bank, Addressing China's Water Scarcity: Recommendations for Selected Water Resource Management Issues, (Washington DC, U.S.: The World Bank Group, 2009), 91*

LACKS ADAPTATION TO CHINA'S SPECIFIC MARKET REQUIREMENTS

Many greentech solutions are not customized yet to meet China's environmental and market requirements, which in some cases differ from other countries. It is necessary to understand that while China bears the hallmarks of both developed and developing nations, factors such as a large population, limited natural resources, high pollution levels and a developing economy with cost-conscious adopters, present unique characteristics that need to be incorporated into greentech solutions. The companies that succeed in China's greentech markets will be those that most effectively understand these characteristics and their impact on requirements.

The ability to adapt technologies developed internationally to the unique conditions of China's market is very important. Such adaptation entails localizing product features for China-specific demands or minimizing solution production costs without sacrificing functionality. For example, enzymes that are used to aid water treatment processes must be suited to the pollution profiles of China's varying water resources, which differ across and within river basins. The greater the extent to which these customized enzymes can be commercialized at costs affordable to the operating budgets of Chinese municipal water and wastewater treatment plant operators, the more attractive they will become to this price-conscious market.

While Chinese companies across many sectors have strong track records in adapting, replicating and scaling solutions for large-scale manufacturing and distribution within China and throughout the world, they are less known for their ability to innovate new solutions. Companies, either local or foreign, who best understand the product features, functions and costs demanded by potential Chinese greentech adopters, will likely be the most successful in the Chinese market.

INTELLECTUAL PROPERTY AND TECHNOLOGY TRANSFER ISSUES

Legal, regulatory and cultural barriers complicate the transfer of technologies into and out of China. While China's government has taken notable steps in the past decade to support the legal protection of intellectual property (IP) rights, there remains a common perception among foreign firms that their IP assets cannot be suitably protected in China. This perception, in turn, limits their willingness to produce or sell IP-intensive products in China, creating a significant obstacle for China's greentech market development.

Although there are signs of improvement, there is still little question that China's enforcement of IP rights has yet to reach developed world standards. One main impediment is that judges outside top-tier cities may have limited experience with cases related to IP infringements. Moreover, when IP-related legal penalties are awarded in China's courts, collection of payments on these judgments can cause further complications. Some analysts find that the value of damages awarded in Chinese IP cases are generally below the economic value of the damages resulting from the IP infringement in the first place, further reducing incentives for the local innovation of new solutions.[6]

Cultural and policy barriers also limit the use of foreign technologies in China. A variety of ministries support the funding of greentech demonstration projects, for instance, but come under pressure if they significantly promote the use of foreign technologies in pilot projects. As in other countries, preferences towards locally-developed technologies are occasionally formal and policy-based, but more commonly operate through informal influence channels such as opaque bidding evaluation processes for public works infrastructure projects.

Finally, Chinese firms often have limited familiarity with both domestic and international IP regulations and limited capacity to manage their own IP assets effectively. This can result in Chinese IP being misappropriated by other Chinese firms, or limit the ambitions of Chinese firms to export greentech solutions to other countries.

[6] *NERA Economic Consulting, "Intellectual Property Rights Protection in China: Trends in Litigation and Economic Damages," (National Economic Research Associates, 2009), 2*

Financing Challenges

DESPITE STRONG POLICY SUPPORT AND GOVERNMENT FUNDING, greentech financing in China is limited by the relative immaturity of financial markets. More specifically, this includes fewer financing options than developed markets and often more basic financing practices that are not well-suited to greentech requirements.

FEWER FINANCING OPTIONS

Compared to developed markets, there are generally fewer options in China for raising debt or equity capital across the life cycle of greentech solutions.

China does not have a mature public bond system to finance public infrastructure projects, such as water treatment or municipal railway systems, like those that exist in many other countries. As a result, China's provincial and municipal governments must rely on tax income or transfers from the central government to fund the expansion or modernization of municipal systems.

Another aspect of the public funding gap relates to the fact that while environmental asset exchanges have been established in Beijing, Shanghai and Tianjin, there are no cap-and-trade systems currently in place to facilitate trading on those markets. This leaves companies that engage in pollution and greenhouse gas reduction with no domestic opportunities to monetize their emissions reductions.

At the moment, China's state-owned commercial banks and private financiers do not provide sufficient financing to small-scale greentech market participants. Commercial banks generally invest in large-scale projects and prefer fully-collateralized loans, creating key challenges for emerging providers that may want to participate in greentech projects like renewable power plants and smaller scale adopters of greentech solutions.

China's banks are commonly given targets for investments in certain sectors, which may result in a push to meet these markers, distorting the optimal risk-adjusted allocation of capital. While China's domestic venture capital and private equity markets have been growing rapidly in recent years, it is important to remember that they are still at an early stage of development, and therefore not as efficient in mobilizing capital.

Finally, foreign financing in China's greentech markets is often restricted. For example, many elements of electrical power, rail and municipal heating sectors are all relatively inaccessible to foreign investors. The global carbon market is often used as evidence that foreign capital is effectively being channeled to greentech investments via the emissions market. While China has generated the most emissions trading credits under the Kyoto protocol, the actual situation is much more complex.

China's current policy environment allows projects to apply for certification to be traded under the Kyoto Protocol if they are at least 51% controlled by Chinese entities.[7] While there are signs that this policy may be softening to allow Hong Kong companies a greater Clean Development Mechanism role in China, this restriction has nevertheless limited the willingness of foreign participants to make large-scale contributions to Chinese greentech projects that were hoping to use carbon market capital as a financing tool. Uncertainties about the post-Kyoto emissions trading regime have also increased risks and slowed foreign investment in China's carbon-market oriented greentech projects.

FINANCING PRACTICES LACK SYNERGY WITH GREENTECH REQUIREMENTS

Greentech investments often have unique characteristics that complicate financing, such as high front-end capital needs and long payback periods. Furthermore, solutions are not well developed or understood by China's markets, and present complex business models, as illustrated by renewable energy power-purchase agreements or energy procurement contracts for buildings. Lenders, who generally have limited experience with these new solutions and business models, find the evaluation of these investments challenging.

[7] *National Development and Reform Commission, "Measures for Operation and Management of Clean Development Mechanism Projects in China," November 21, 2005, http://www.cdm.ccchina.gov.cn/*

Investments required at different stages of product development and commercialization are complicated by the current state of China's financial markets. For instance, there are few instruments available for investing in the early stages of research and development. When greentech solutions are ready to be deployed, the range and sophistication of project financing involved is limited, compared to other countries. A significant understanding of the technical aspects of environmental issues is required for investments in a range of greentech sectors. The profitability of solar power generation, for example, partially depends on the ability to forecast and measure local solar resources, which are areas in which most financial investors in China have little experience to date. More broadly, China's investors are often limited in their ability to assess the environmental, health and safety risks of greentech investments, which in turn inhibit their ability to provide sound analysis for project valuations and cash flow projections.

Regulatory Challenges

BASED ON THE PACE OF REGULATORY CHANGES, China's regulatory environment is a clear and positive driver to the acceleration of the country's greentech markets. Certain challenges remain, however, including complexity of the regulatory environment, developing policy incentives, uneven compliance with existing policies and limited policy visibility.

■ COMPLEX REGULATORY ENVIRONMENT

Greentech markets, by their nature broad and emerging, are overseen by a wide range of Chinese regulatory entities, which are increasingly influenced by international governments and inter-governmental organizations. This creates a complex regulatory environment that is difficult to navigate. Energy issues, for example, are regulated by several agencies at the central level (e.g. National Energy Administration and the Ministry of Industry and Information Technology) as well as other bodies at local and provincial levels. In recent years, progress has been made to provide greater clarity. For example, the National Development and Reform Commission and National Energy Administration coordinate to provide cohesive planning of energy activities across related agencies. In other areas, such as water policy, numerous regulatory agencies are working to provide better management with increased coordination and cooperation.

Coordination between national and local departments and their respective policies is always challenging. China's central policies should be credited for providing clear targets, guidelines and direction for the development of the greentech market. When implementation occurs at the local level however, variations in local policies create non-uniform environments. For example, while Beijing should be applauded for adopting air pollution standards higher than national levels particularly during the Olympic Games, this policy variation creates operational challenges for industrial companies with operations in both Beijing and other provinces. [8]

Since many industries are regulated by industry-specific government agencies, this sometimes leads to conflicting treatments for common environmental issues. National initiatives such as the Top-1000 Energy-Consuming Enterprises Program, promotes change across multiple industries. However, many greentech opportunity areas, such as rail transportation and electric power infrastructure, are regulated independently and are permitted to have differing targets with respect to air, water and other emissions compared to other industries.

Finally, international conventions and treaties, such as those governing international shipping and air travel, impact standards and other greentech issues within China, even when no explicit domestic policies exist. For example, the Standards and Recommended Practices of the International Civil Aviation Organization (which are incorporated as Annexes to the Convention on International Civil Aviation) contain provisions on aircraft operations that impact emissions from China's air transportation. As China becomes further integrated into the world economy, it is expected that international entities will exercise even more influence on China's greentech markets.

[8] 中国环境科学研究院，"中国区域大气污染控制，" 2008年11月6日［*Chinese Research Academy of Environment and Science, "For Regional Air Pollution Control in China," November 6, 2008]*

DEVELOPING POLICY INCENTIVES

Most market participants acknowledge that the overall direction of China's subsidies for greentech solutions development and adoption is extremely positive. China's government has committed significant funds to the commercialization of greentech solutions across a range of areas. The four trillion yuan (US$586 billion) stimulus package puts in place notable support for electric power infrastructure, cleaner conventional energy, cleaner roads and cleaner rail transportation.[9]

While this trend is encouraging, there is limited published evidence that subsidies take into account detailed analyses of cost trends for greentech solutions. Subsidies that are created without an understanding of a solution's costs risk not being sizeable enough to stimulate significant demand or being too large and discouraging innovation. Some industry experts have pointed to the 2009 Building-Integrated Solar Photovoltaic subsidy as one that lacked transparency in its development.

Political considerations influence subsidies by affecting their size, but also the timing of their announcement. In greentech sectors where multiple regulators have potentially overlapping authority, some market participants have spoken of incentive competition, where multiple government agencies compete with each other to subsidize growth industries either first or more effectively. It is important to note that influences exerted behind the scenes are not always not visible to the market, as some market observers noted before the NDRC solar subsidy in 2009. Subsidies for specific technologies available from multiple agencies also are not usually coordinated. Subsidy applicants need to understand and fulfill the obligations of different agencies to qualify for funding under separate programs.

Finally, even when subsidies have been announced, it is not always clear what conditions applicants must meet to qualify for and receive them. For example, in a survey of 100 China-based building designers and engineers conducted jointly by the China Greentech Initiative with the construction market research firm RCC China, 41% of respondents indicated they had participated in green building projects that targeted government subsidies, but nearly 80% of this group claimed to have not received eventual benefit. While the reasons for this failure were not quantified in the survey, these respondents indicated they were often unclear on the conditions they were required to meet to qualify for funding subsidies.

UNEVEN COMPLIANCE WITH EXISTING POLICIES

In many cases, even when China has the appropriate environmental policies in place at the national level, monitoring and enforcing compliance at local levels remains a significant challenge, exacerbated by China's size, regional variations and dynamically changing economy. One aspect of this challenge is identifying the appropriate level of supervision for each policy. For example, local governments may experience a conflict of interest if they are responsible both for the growth of local state-owned companies and for compliance with national environmental regulations. This creates a plausible incentive for allowing lax compliance, due to the benefits these companies bring to the local economy. China has not traditionally relied on independent, third-party compliance monitoring of the type used in other countries, so finding the right balance between national, local, civic and third party compliance monitoring is a challenge that affects almost all greentech sectors. At the same time, it may not be efficient for national agencies to create large compliance monitoring bureaucracies for environmental issues. Developing an approach for environmental policy compliance of the magnitude and scope required by a country the size of China has never been attempted before. This creates an opportunity for China to define a new model of environmentally sustainable development.

Mixed incentives for local compliance monitoring may also lead to differing degrees of policy enforcement across regions. First-tier cities like Beijing and Shanghai are commonly recognized as having more effective policy enforcement capabilities than smaller cities. There may also be regional differences. For

[9] *International Civil Aviation Organization, "Making an ICAO standard," http://www.icao.int/ (accessed on May 10, 2009)*
[10] *Hinge, Adam, "Compliance with Building Energy Standards: One Perspective from the U.S." (presentation given at the Workshop on Energy Efficiency Compliance, Monitoring & Evaluation, Paris, France, February 9-28, 2009)*

example, a design review of over 3,000 buildings the Ministry of Construction (now the Ministry of Housing and Urban-Rural Development) carried out in 2005, revealed only 10% of projects in Southern China were found to have designs compliant with energy efficiency building codes, compared to 80% in Northern China.[10]

LIMITED POLICY VISIBILITY

Greentech market participants often have limited knowledge of medium and long-term policy plans. This lack of understanding of pace, specifics and timing complicates business decision making. Although market participants are relatively well informed of the broad direction of China's greentech policies, knowledge of the specific timing and detail of individual policy measures remains limited. Companies and investors in China's greentech markets are sometimes surprised by specific greentech-related policy announcements.

One example of these uncertainties are policies related to the construction and operation of local infrastructure projects, which are highly dependent on local administrations. Private companies entering into long-term concessions with local governments for construction or operation of infrastructure assets may find that while some public servants are willing to grant assurances or protections at the early stage, their replacements may not respect agreements entered into by former administrations. For example, water treatment plant concessions in China can be in excess of 15 or even 30 years. While the administration staff granting concessions to private market participants may make commitments to future water price increases, subsequent staff may not abide by these commitments.

Overcoming challenges will accelerate China's greentech market growth

THE FOUR CATEGORIES OF CHALLENGES discussed – market, technology, financing and regulatory – presently constrain the speed at which China's greentech markets are developing. However, the China Greentech Initiative believes that all of these challenges can be largely overcome by the range of stakeholders committed to helping China achieve its goal of environmental sustainability. Successfully addressing these challenges will greatly accelerate the development of China's greentech markets, helping the country tap renewable energy sources, clean the air, curtail growth in greenhouse gas emissions, decrease water consumption and pollution and address solid waste problems – all the while supporting continued economic growth. Specific opportunities to address these challenges are discussed in the next chapter.

OPPORTUNITIES

TO ACCELERATE GREENTECH MARKETS

Clear opportunities exist for solution adopters, solution providers, financial investors, goverment regulators and other stakeholders to address challenges, accelerate the growh of greentech market and help China transform into an environmentally sustainable economy.

What can stakeholders do to overcome the challenges facing the commercialization of greentech solutions in China in order to accelerate the development of these markets?

THE CHINA GREENTECH INITIATIVE POSED THIS QUESTION to its partners and advisors, who helped develop the set of opportunities outlined in this chapter. These opportunities are not meant to be explicit recommendations, but rather suggestions of concrete steps different stakeholder groups may take to accelerate greentech markets and enable China's further evolution to a sustainable economy.

While each of the greentech sectors analyzed in this report has its own characteristics and challenges, the Initiative identified five overall opportunities cutting across sectors which would have a significant positive impact on China's greentech market development, as shown in Figure 1.

Fig. 1: OVERALL OPPORTUNITIES TO ACCELERATE CHINA'S GREENTECH MARKETS

OVERALL OPPORTUNITY	DESCRIPTION
RAISE DECISION-MAKER AWARENESS	■ Help decision makers understand the benefits, costs and risks of green technologies
DRIVE THE MATURITY OF STANDARDS-BASED SOLUTIONS	■ Support evolution of standards-based technologies to enable widespread adoption
SUPPORT FAIR MARKET PLAYING FIELDS	■ Include costs into regulatory and market frameworks which properly value impacts of pollution and resource use
ENHANCE CAPABILITIES	■ Build greentech skills necessary to design, develop, market, finance, implement, monitor and regulate greentech solutions
PROMOTE COLLABORATION	■ Strengthen collaboration between public and private sectors and throughout value chains, at all stages of greentech solution life cycles

Fig. 2: KEY STAKEHOLDERS IN CHINA'S GREENTECH MARKETS

STAKEHOLDERS	DESCRIPTION
SOLUTION ADOPTERS	■ Organizations and individuals purchasing or using green technologies
SOLUTION PROVIDERS	■ Businesses who develop and provide green technologies and services
FINANCIAL INVESTORS	■ Commercial banks, private equity, venture capital, investment banks and other financial services providers
GOVERNMENT REGULATORS	■ China's central, provincial and local regulators, as well as relevant international policy makers
OTHER STAKEHOLDERS	■ Academia, non-governmental organizations, international organizations and other stakeholders

The Initiative also identified five over-arching opportunities relevant across all sectors and every stakeholder group. These opportunities, shown in Figure 2, present clear actions all stakeholders can take to expedite the development of a sustainable China. Sector-specific opportunities were also explored, and are discussed in the respective sector chapters of the full version of this report.

The five cross-sector opportunities are:

■ **RAISE DECISION-MAKER AWARENESS**

Educate decision makers about the benefits of green technologies, not only in terms of reducing negative environmental impact and risks, but also in terms of potential cost savings and other benefits from adopting greentech solutions. Raising awareness will help adopters overcome misconceptions and make informed decisions when evaluating greentech solutions.

■ **DRIVE THE MATURITY OF STANDARDS-BASED SOLUTIONS**

Drive and support the evolution of greentech solutions from the early research

Fig. 3: KEY STAKEHOLDER OPPORTUNITIES TO ACCELERATE CHINA'S GREENTECH DEVELOPMENT

STAKEHOLDERS	KEY OPPORTUNITIES
SOLUTION ADOPTERS	■ Promote sustainability ■ Buy green ■ Improve compliance
SOLUTION PROVIDERS	■ Match solutions to local market requirements ■ Educate adopters to greentech benefits ■ Supply products with minimized life cycle environmental impact ■ Leverage commercial partnerships
FINANCIAL INVESTORS	■ Enhance capabilities ■ Utilize new financing mechanisms
GOVERNMENT REGULATORS	■ Refine policies and optimize standards ■ Enforce compliance ■ Facilitate financing ■ Liberalize markets ■ Support environmental exchange
OTHER STAKEHOLDERS	■ Drive greentech training ■ Engage other stakeholders ■ Sponsor research ■ Monitor compliance

phase to maturity. Standards-based solutions (i.e. those based on broadly-accepted industry standards) should achieve suitable pricing and provide adequate risk profiles to enable widespread adoption.

■ SUPPORT FAIR MARKET PLAYING FIELDS

Promote regulatory regimes and market mechanisms that incorporate environmental costs into the price of conventional solutions, such as mandatory caps, pollution fines, taxes and other mechanisms. For example, the U.S. Environmental Protection Agency's Acid Rain Program used cap-and-trade systems to increase the costs of polluting sulfur dioxide (SO_2), thereby driving the market for SO_2 removal solutions. The program led to overall significant decline in SO_2 emissions, which by 2008 were 56 percent below 1980 levels.[1]

■ ENHANCE CAPABILITIES

Build leadership skills and staff capabilities across stakeholder groups to enable the design, development, marketing, financing, implementation, monitoring and regulation of China's greentech markets. This includes providing specialized training to managers, technicians, financiers, buyers, regulators and others across a broad range of greentech-related knowledge and skill areas.

■ PROMOTE COLLABORATION

Encourage collaboration between commercial, government and non-government stakeholders across all sectors and at all stages of greentech solutions' development cycles. As demonstrated by the China Greentech Initiative, collaborative platforms promote a range of benefits, including increased market understanding, relationship building, business model development, commercial venture expansion and improved dialogue between public and private entities.

The five overall opportunities identified above help frame the more specific opportunities available to each stakeholder group. Based on the input of partners and strategic advisors, the China Greentech Initiative focused its efforts on identifying and describing particular opportunities available to each major stakeholder group. These are summarized in Figure 3, and explored in the following pages.

Solution Adopters

ADOPTERS AND END USERS HAVE MUCH TO GAIN FROM THE DEVELOPMENT of China's green technology markets. In China and elsewhere, corporations are increasingly aware of the potential benefits that come from being environmentally-minded. Promoting sustainability may enable stronger relationships with customers, suppliers and employees. The use of green technologies, with direct and indirect cost benefits, can drive greater long-term profitability. Commitments to environmental sustainability also can help minimize negative impacts before being required by regulators.

PROMOTE SUSTAINABILITY

An organization that promotes sustainability internally with employees, and externally with local communities, is likely to gain the advantage of a good corporate reputation as its brand becomes associated with sustainability. With respect to environmental benefits, pioneering solution adopters can establish a significant multiplier effect as their interactions with suppliers, customers and business partners become more sustainability-oriented.

One way companies can minimize their environmental impact and create cultures of efficiency is by training staff in environmental awareness, which can lead to improved employee satisfaction, controlled costs and improved relationships with regulators and other stakeholders.

Chinese consumers are paying increasing attention to sustainability issues. Notably, the number of Corporate Social Responsibility reports issued by Chinese companies has seen a strong increase, from as few as four companies in 2004 to more than 121 by 2008.[2]

[1] *United States Environmental Protection Agency, "Acid Rain Program 2008 Progress Reports: Emissions, Compliance and Market Data," http://www.epa.gov/ (accessed on August 13, 2009)*
[2] *SynTao, A Journey to Discover Values 2008: Study of Sustainability Reporting in China (Beijing, China: SynTao, December 2008), 8*

PROMOTING SUSTAINABILITY IN THE ALUMINUM INDUSTRY

One company frequently cited for its endorsement of sustainability and support of greentech solutions is Alcoa, the global aluminum production and management company.

- **Alcoa's sustainability strategy includes investing in green technology areas such as Carbon Capture and Sequestration and renewable energy-powered aluminum smelting facilities**
- **The company has adopted an internal strategic framework for sustainability through 2020, including targets for sustainable performance metrics in areas such as Safe and Sustainable Products and Processes and Respect and Protect Employees and Communities[3]**
- **As a result, Alcoa has received significant reputational benefits, including a listing in the Dow Jones Sustainability Index over the last seven years and being named one of the World's Top 100 Sustainable Corporations at the World Economic Forum in Davos, Switzerland[4]**

Potential greentech adopters in China can strive to attain similar benefits by studying the approaches that Alcoa and other companies have taken to support sustainability, and adapting them to their own businesses.

The promotion of sustainability should go beyond an organization's internal practices and extend to the broader role of supporting long-term, ecologically-conscious economic growth in the local community. Helping to create an environmentally sustainable China is a key opportunity for greentech solution adopters and the local regulators who support them.

BUY GREEN

The most direct way solution adopters can promote China's greentech markets is by buying green, rather than conventional, products and services whenever feasible.

The first part of 'buying green' is identifying what is 'green.' Potential adopters can investigate the environmental impacts of their purchases and urge suppliers to participate in labeling programs or other transparent performance data. Sharing data, for example, helps tenants lease energy efficient office space, or further up the supply chain, assists building developers buy energy efficient lighting systems.

Another aspect of 'buying green' is fully evaluating the life cycle capital expenditure and operating expenditure implications of solutions. Many greentech solutions have higher upfront capital costs, but will still have net life cycle benefits due to decreased operating costs or long-term environmental benefits.

'Buying green' can also entail putting in place greentech systems to support effective environmental management. Regular energy audits, for example, help inform energy consumers about which parts of their operations may be able to achieve improved efficiencies. However, manual audits are often imprecise. The implementation of greentech systems to support accurate audits can help monitor the efficiency of devices used in homes (e.g. air conditioning units and refrigerators), large commercial buildings (e.g. water heaters and elevators) and industrial facilities (e.g. processing equipment and cooling systems).

IMPROVE COMPLIANCE

Solution adopters who comply with existing environmental policies can realize benefits while minimizing risk. While compliance with regulatory policies often necessitates increased costs, there are many potential benefits. For example, procuring and operating the solutions necessary to remove nitrous oxide from industrial smokestacks or to remove toxic contaminants from industrial wastewater can result in better relations with monitoring bodies, regulatory enforcers and other government entities.

Complying with policies reduces the risk of incurring financial penalties, or even being shut down, for non-compliance. As illustrated in the YiXing example, meeting regulatory requirements, especially when compliance is independently

[3] *Alcoa, "2020 Framework for Sustainability," http://www.alcoa.com/, (accessed on August 18, 2009)*
[4] *Alcoa, "Alcoa Again Named One of the World's Most Sustainable Corporations at Davos," January 29, 2009, http://www.alcoa.com/*

Benefits of Compliance [5,6,7]

YiXing-Union Cogeneration Co., Ltd. is a coal-fired cogeneration power plant located in YiXing, Jiangsu province, a historic city famous for its teapots. Yixing teapots have a long and colorful history dating back to the Song Dynasty (960 - 1279) when purple clay was first mined around the YiXing area.

- **Being located in the center of a historic city creates challenges for an industrial facility like the YiXing-Union Cogeneration plan**
- **To maintain good relationships within the local community, the company is an early adopter of advanced emission reduction technologies, including their spring 2009 project to lower nitrous oxide emissions**
- **Working with LP Amina, an environmental and energy solution provider, the facility upgraded their steam generator to become one of the first plants in China to perform an in-furnace de-NOx modification**
- **The modification improved the plant's overall efficiency and lowered its NO_x emissions to 40% below China's existing standard, in-line with current U.S. and European standards**
- **As a direct result of meeting mandates ahead of schedule, YiXing-Union Cogeneration is building a positive relationship with local and provincial governments**
- **In turn, regulators are now promoting YiXing-Union Cogeneration's results as a showcase of what they want other local power generators to accomplish**

Being a good corporate citizen brings benefits both to YiXing-Union Cogeneration and to the broader YiXing community. As cities like YiXing continue to grow, companies like YiXing-Union Cogeneration can meet rising energy needs while protecting local environments and building strong reputations.

and transparently verified, can help companies build reputations as responsible corporate citizens and contribute to strong market positioning.

Policy compliance can also facilitate a company's ability to engage with regulators on multiple topics, including the evolution of policies and the optimization of standards. Firms with poor government relations may be less likely to be invited to such high-level forums of discussion.

Solution Providers

SIMILAR TO SOLUTION ADOPTERS, SOLUTION PROVIDERS have tremendous opportunities to accelerate greentech markets in China. These include better matching greentech solutions to local market requirements, educating adopters on greentech benefits, minimizing life cycle environmental impact of products and leveraging commercial partnerships.

MATCH SOLUTIONS TO LOCAL MARKET REQUIREMENTS

Many existing green technologies, developed for use in other countries, have yet to be customized to China's specific market needs. One potential difference between China and other markets, for example, is that Chinese adopters are often more cost-sensitive. More economically-priced solutions or new long-term contract structures can support the widespread adoption of already proven solutions.

Aside from pricing, unique market features, such as the type of pollutants in China's water bodies or the associated regulatory requirements, may also necessitate different greentech solutions than those required elsewhere. Once

[5] *China Greentech Initiative interview with Mr. Hu Zhijie, Deputy General Manager at YiXing-Union Cogeneration Co., Ltd. on August 14th, 2009*
[6] *China Greentech Initiative interview with Will Latta, Managing Director at LP Amina on August 14th, 2009*
[7] *Jiangsu Frontier Electric Technologies, "Boiler Performance Test Report after Combustion System Retrofit for Yixing Xielian Cogeneration Plant Boiler Unit #8, DL-BG-2009-767," 2009*

PROMOTING GREENER CHINESE CITIES

GENERAL ELECTRIC (GE) PARTNERED WITH BEIJING'S QINGHE WASTEWATER TREATMENT PLANT TO RECYCLE WASTEWATER BEFORE THE BEIJING OLYMPICS.[8]

- Beijing is one of China's most water-scarce cities due to rapid urbanization and economic development, and exacerbated by limited water resources and strong upstream water consumption
- To address this problem, GE put in place wastewater treatment membranes and other technologies to treat effluent from Qinghe Wastewater Treatment Plant's clarification pool
- Aside from increased municipal water supply for the residents of Haidian and Zhouyang districts, Beijing residents and visitors during the Olympic festivities benefitted broadly from the numerous plants, trees and flowers which were irrigated by this recycled wastewater

solutions are adapted to these market needs and regulatory requirements, solution providers can market improved regulatory compliance as an additional driver for adoption.

By developing innovative market-specific solutions, foreign solution providers have the potential to improve their market share in China. Forging partnerships with local providers that help develop a better understanding of local needs may bring greentech solutions to market more efficiently.

Partnerships with local universities are also a productive way of working to adapt solutions to China's market needs. The Tsinghua-BP Clean Energy Research and Education Center in Beijing, with its numerous collaborative projects on a range of clean energy issues, is a prime example of this type of approach.

EDUCATE ADOPTERS ON GREENTECH BENEFITS

Given the current lack of recognition and understanding of greentech solution benefits, providers have an opportunity to educate potential adopters, helping to establish demand for greentech products and services.

Collaboration with other solution providers, adopters, NGOs or government agencies provides solution providers the opportunity to raise awareness and promote the diffusion of green technologies they represent. This type of engagement often allows enterprises to enhance their corporate reputations as environmentally-minded companies. As industrialized countries have developed, reputation building and brand enrichment have grown in importance, and there are few reasons to believe that China's experience will be substantially different.

Solution providers across China are also able to build consumer awareness about the advantages of adopting green technologies by working to improve environmental, health and safety conditions in the communities in which they are involved.

SUPPLY PRODUCTS WITH MINIMIZED LIFE CYCLE ENVIRONMENTAL IMPACT

Solution providers have significant opportunities to develop and commercialize solutions that minimize life cycle environmental impact.

Under pressure to minimize costs and to maximize profits, solution providers occasionally supply products with shorter life spans, resulting in higher maintenance costs and higher negative environmental impact than might be considered optimal from the environmental perspective. For example, residential buildings in China generally are of substantially lower quality than buildings in other countries and, correspondingly, have shorter life spans. Demolitions are both expensive and result in significant solid waste and air pollution. However, since landowners generally pay for the demolition costs to clear the area for construction, these costs are not factored into the economic models of real estate developers. Because of this, most developers and building owners fail to consider the environmental costs of demolition when deciding what real estate

[8] *General Electric, "Water reuse project of Qinghe Wastewater Treatment Plant," 2008*

to develop or own. As China's greentech markets mature, providers with solutions that minimize life cycle environmental impact will be able to differentiate their products from the competition. These benefits can be further promoted by greater transparency and education about life cycle environmental costs and benefits.

LEVERAGE COMMERCIAL PARTNERSHIPS

Solution providers can address challenges associated with geographic diversity and cost-benefit disconnects by partnering with companies that offer complimentary geographical footprints or operate in different parts of the value chain. One good example of such partnerships is the new biofuel relationship between China National Cereals, Oil & Foodstuff Corporation (COFCO), Novozymes and Sinopec, which is profiled below.

Financial Investors

THERE ARE A NUMBER OF OPPORTUNITITES for financial investors to increase their ability to effectively finance and invest in China's greentech markets. Key opportunities exist in the development of greentech-relevant financing skill-sets and the employment of new financing mechanisms to support market development.

BIOFUEL VALUE CHAIN INTEGRATION OPPORTUNITY[9]

- **As a leading grain, oils and foodstuffs import and export group in China, COFCO has access to biomass supply chains necessary for large-scale biofuel production**
- **The Danish company Novozymes has the technical expertise to optimize the enzymes necessary to convert the biomass resources from COFCO's supply chains into usable ethanol supplies**
- **On the distribution side, Sinopec owns roughly a third of China's gas stations, providing the infrastructure required to distribute ethanol produced by the partnership**

BENEFITS:
None of these companies individually had the capacity to collect, process and distribute bioenergy supplies to commercial consumers in China. Without a formal partnership, each company would have had to enter into complex contractual relationships to guarantee that revenue generated from commercial customers could be passed through the supply chain for the benefit of all participants. A collaborative approach was required, so that the costs of bioethanol commercialization could be integrated with revenue, stimulating investment and creating a more profitable long-term partnership for all three companies.

ENHANCE CAPABILITIES

China-based financial investors have the potential to enhance their capabilities in areas such as the assessment and monitoring of clients' environmental, health and safety (EHS) risks. Another is mastering the use of new approaches to value investments in greentech sectors.

Improving EHS risk evaluation and assessment will likely allow for greater participation by financial investors in China's greentech markets. EHS risks include direct risks such as liabilities for environmental damages or more indirect market, credit or reputational risks as greentech businesses interact with the market. Similarly, revenue streams for solar or wind power generation are highly dependent on resource availability, and financiers have to take in to account significant potential disruptions to cash flow as a result. The greater the ability for China's financiers to assess the potential impact of direct and indirect EHS risks, the greater the ability they will have to invest profitably in China's greentech markets.

At a global level, 69 banks have adopted the Equator Principles, which include a voluntary set of benchmarks for managing environmental issues in development finance.[10] These banks, however, are not actively financing China's greentech sectors. As of August 2009, only one medium-sized Chinese bank, Industrial Bank Co., had adopted the Equator Principles. Widespread adoption could help China's banks demonstrate a commitment to environmental principles and give them tools to enhance their project capabilities.

[9] *Novozymes, "Novozymes and Sinopec," http://www.novozymes.com/, February 2, 2009 (accessed on 12 August 2009)*
[10] *The Equator Principles, "A Benchmark for the Financial Industry to Manage Social and Environmental Issues in Project Financing," http://www.equator-principles.com/ (accessed on August 12, 2009)*

OUTSOURCING ENVIRONMENTAL EXPERTISE

Investors can enhance their capabilities to evaluate greentech-related investments opportunities by collaborating with companies with established environmental expertise.

One option is outsourcing environmental help desks to third-party specialists. For example, PricewaterhouseCoopers has provided help desk services to assist financial investors with:

- **Integrating environmental criteria in credit processing, procedures and instructions**
- **Training credit officers, back-offices, sales offices and recovery managers**
- **Developing instructions, training documents and train-the-trainer concepts**
- **Ensuring compliance with environmental credit risk instructions**
- **Conducting environmental due diligences for various types of financial transactions**

The second opportunity is to increase the sophistication of the valuation approaches as used to assess the impacts of sustainability on clients' financial performance. In China, like elsewhere, financiers tend to use modeling frameworks and tools with which they are most comfortable. While traditional tools can support greentech financing decisions, they often need to be combined with other types of analysis that incorporate diverse perspectives (e.g. regulatory risk modeling of potential future pollution taxes) in order to fully capture greentech financing dynamics.[11]

Chinese financiers could enhance their greentech capabilities as described above in a number of ways. The most common would be to partner with foreign banks and learn from their experiences. A second way would be to recruit specialized staff and develop training programs targeting the necessary skill sets. Alternatively, partnering with companies who can provide the necessary expertise on-demand can avoid the costs associated with building up new capabilities in house.

UTILIZE NEW FINANCING MECHANISMS

New financing mechanisms applicable to greentech investments could present additional opportunities for accelerating the development of China's greentech market. Relevant financial tools exist across greentech product cycles, from early-stage R&D through demonstration, deployment and diffusion of greentech solutions.

The earliest stages of greentech R&D in China and elsewhere are commonly funded by the public sector. However, there are opportunities for angel investors and technology incubators to get involved in early stages of financing technology development. Many venture capital funds also have capital that they distribute in relatively small amounts to early-stage companies. This type of financing should present an area of opportunity as it becomes more common in China.

Venture capital and private equity funds can play a more important role at the demonstration stage. China's central government is supportive of channeling venture investment into greentech projects and companies, providing financial investors with opportunities to build relationships with local regulators in order to facilitate their access to China's greentech markets.

Debt and equity financing for demonstrating and deploying solutions is also an important tool in advancing greentech opportunities. In asset-light greentech investment environments such as the pre-construction stages of solar power plant development, Chinese banks typically require full corporate guarantees on greentech investments and rarely offer non-recourse debt. Credit lines and loan guarantees between banks have been used in other regions to diversify credit risks and facilitate debt investment in this type of environment, suggesting there should be opportunities to further make use of this type of financing in China.

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[11] CFO Research Services and Jones Lang LaSalle, The Role of Finance in Environmental Sustainability Efforts (Boston, MA, U.S.: CFO Publishing Corp., March 2008), 11
[12] International Finance Corporation, IFC CHUEE Program to Finance Two Energy Efficiency Projects in Western China (Washington DC, U.S.: The World Bank, 2007)
[13] Xu, Calvin Q., "China Utility-based Energy Efficiency Finance (CHUEE) Program: One Finance Solution to Climate Change" (presentation given at Financing Cambodia's Sustainable Energies, Phnom Penh, Cambodia, September 3, 2007)
[14] MacLean, John, "New Developments in Energy Efficiency Finance in China" (presentation given at Asia Development Bank's Asia Clean Energy Week, Manila, Philippines, June 4, 2008)

DEVELOPING MULTI-PARTY APPROACHES [12,13,14]

The International Finance Corporation (IFC) has a China Utility-based Energy Efficiency Finance Program (CHUEE), which addresses three key opportunities to enhance greentech financing in China:

- **Promote financing through guarantees – The IFC provides partial guarantees to local banks for their investments in power utility energy efficiency projects or equipment purchases**
- **Use partners to identify opportunities - Utility companies, energy management companies and energy efficiency suppliers act as commercial banks' channel partners to recommend projects to bank loan officers**
- **Build capabilities – The CHUEE program contains a training element whereby banks can improve their skills in evaluating and monitoring environmental investments**

While the CHUEE program has benefits, investors have also identified drawbacks to the program. Firstly, a relatively small number of banks are currently participating in the CHUEE program, and secondly, financing amounts may not be sufficient for the energy efficiency projects China's utilities would like to undertake.

Despite its drawbacks, the CHUEE program is a good starting point for effective greentech financing in China. The Chinese government and banking sector could build on the CHUEE experience to launch a program that can both scale guarantee financing instruments as well as mobilize financing partners' technical expertise to more effectively evaluate potential greentech investments.

Project finance, required at the demonstration and deployment stages of greentech commercial solution development, may require more complex and sophisticated financial instruments and structures. In addition to multiple debt and equity components, these can also include syndicated loans provided by a number of financial investors to share project risks. Standard Chartered Bank, for example, offers both project structuring advice as well as genuine non-recourse lending to well-structured renewable energy projects in China. This may be able to serve as a model for other banks in China seeking to do the same.

Several of China's greentech sectors are seeing the increasing use of equity investments as a way of raising capital. In China's water sector, for example, where financing a few years ago was obtained more commonly through Engineering, Procurement and Construction (EPC), build-operate-transfer (BOT) or other project financing approaches, water companies are now taking equity stakes in numerous water infrastructure projects.

Capital markets, both inside and outside China, also provide an opportunity for China's greentech companies to raise capital. Financiers can work with local greentech companies to support their flotation on the Shenzhen, Shanghai, Hong Kong or other markets. Packaging multiple risk-diversified greentech investments into a common portfolio and securitizing the portfolio to raise public capital is a method that can be used by financiers. Singapore's Hyflux Water Trust is an early innovator in this area with its Singapore-listed public security representing multiple water projects in both China and other countries.

Different greentech sectors have diverse needs and require customized financial products. As financial service providers innovate products to meet these needs in China there will be opportunities to uncover attractive greentech investments.

Energy service companies (ESCOs), for example, commonly carry out energy efficiency retrofits of buildings and industrial facilities and are reimbursed from the resulting electricity cost savings. For an individual building energy retrofit, generally

a relatively small amount of capital is needed upfront to finance equipment purchase and installation. In China however, where large-scale loans are the norm, many ESCOs find it difficult to secure financing.

Industry experts suggest that Chinese banks have an opportunity to launch new debt products specifically customized for ESCOs and individual energy efficiency retrofits. Similarly, third-party intermediaries could aggregate smaller energy efficiency projects across multiple entities and seek financing for these projects on a joined basis. In the U.S., where public buildings have been avid ESCO adopters and banks more willing to lend to small projects, the ESCO industry grew around 20% each year between 1990 and 2006, reaching over US$3.5 billion annually by 2006.[15]

One other risk-related finance opportunity for China's greentech financial service providers is insurance. Environmental insurance products are used frequently both inside and outside China, most commonly to protect farmers from weather disturbances, but also to protect wind farms against wind resource disturbances. China-based insurers may also have the opportunity to insure assets and income streams of greentech financiers, solution providers and adopters.[16]

Government Regulators

AS STRESSED THROUGHOUT THIS REPORT, China's policy makers have already made substantial progress in creating and implementing policies that protect the environment and enable the development of the greentech market. Given the pace desired and magnitude of the challenges faced, policy makers still have a number of opportunities to support China's efforts to become an environmentally sustainable economy.

REFINE POLICIES AND OPTIMIZE STANDARDS

To address the challenges of China's complex greentech policy environment, China's policy makers can continue to support relevant medium and long-term policy planning efforts, placing emphasis on coordinating plans across multiple regulatory agencies. As outlined previously, China's greentech markets are overseen by a wide range of regulatory entities using a diverse set of policy instruments. This has resulted in a complex and at times confusing regulatory environment.

One approach used in other countries to manage the complexity of environmental issues is to introduce new cross-sector regulatory agencies. To manage the complex policy environment surrounding water issues, for example, Singapore's government created the Ministry of Environment and Water Resources, which has overall responsibility for water resources and coordinates the water policy activity of other regulators.

While the NDRC is putting in place some measures for national harmonization of energy policy, many of China's renewable energy market observers have pointed to feed-in electricity tariffs as an area where substantial policy divergence has occurred at local levels across China. Greater interprovincial coordination on this and other issues should improve the attractiveness of national markets.

Addressing policy gaps in specific greentech sectors also presents regulators with methods to strengthen target greentech markets in China. The country's government is moving rapidly to deploy a wide range of subsidies, tax benefits and other industry promotion policies to drive the development of China's greentech markets. Continuing to refine these policy tools to enhance their impact can only further benefit the development of China's greentech sectors. The China Greentech Report sector chapters identify policy circumstances in each of the seven greentech sectors investigated by the Initiative and highlight specific opportunities to accelerate market development.

[15] *Hopper, Nicole et al., "A Survey of the US ESCO Industry: Market Growth and Development from 2000 to 2006," (Berkeley, CA, U.S.: Lawrence Berkeley National Laboratory, May 2007), 11*
[16] *United Nations Environment Programme and Global Environment Facility, "UNEP Feasibility Studies for the Development of Insurance Solutions for Renewable Energy Projects: Project Status Note Number Three," September 2008, http://www.uneptie.org/*

Also at the individual sector level, opportunities exist to improve environmental and greentech solution standards above today's levels. China's government has made dramatic steps to upgrade many environmental standards, in areas including automobile emissions, building energy efficiency and potable water quality, to levels equal to or even superior to international levels. However, standardization represents a complex and fast-changing landscape, providing the government additional opportunities to further develop China's policy environment. Emerging greentech areas, such as coal mining land recovery and collapse provisions or interconnection of vehicles to China's electric power infrastructure, currently lack relevant standards, contributing to market uncertainty.

China has well-established standards development processes, but may accelerate greentech market development by enhancing collaboration with China's industry associations in order to incorporate greater diversity of technical expertise into the development process. In addition, as global trade increasingly links China's greentech markets with markets in other parts of the word, participating in the development of international standards and building domestic standards that are in line with international norms may enable China to more effectively import advanced technologies and export Chinese solutions to the world.

ENFORCE COMPLIANCE

China has taken dramatic steps in recent years to bring its policies and standards in line with international norms and best practices. Compliance, however, remains uneven across different regions and across different sized market players. While central policy makers usually draft the laws and standards with which market participants are required to comply, it is commonly provincial and municipal regulators who have enforcement responsibility. Central agencies may address this challenge by supporting centralized training programs for local regulators or highlighting strong cases of effective local enforcement as best practices to be replicated. The scale and speed at which China is trying to address its environmental issues in the absence of a single best-in-class model to follow make this effort more challenging, but also more rewarding as China has an opportunity to define a new model of sustainable development.

Regulators can also increase policy compliance by supporting the development of robust auditing or verification practices for policy compliance. As an example, companies under China's Top-1000 Energy-Consuming Enterprises program are required to submit annual energy audits to the government, but there are few standards for the methodologies or controls to be used in these auditing processes.

Outside China, governments sometimes outsource policy compliance monitoring to non-governmental entities. For example, Seattle, Washington, in the U.S., requires public buildings larger than 5,000 square feet to achieve LEED (a third-party green building standard) certification.[17] Using a third-party certification and compliance monitoring mechanism precludes municipal regulators from having to maintain a policy compliance monitoring workforce.

Third-party verification of policy compliance can also have other benefits, particularly when local-level authorities have both regulatory and managerial responsibility for local state-owned companies. Independent policy compliance verification can help support transparency and political legitimacy, and can enable consumers to easily buy compliant products. In other countries, firms are often required to publicly disclose evidence of their compliance with environmental policies. This disclosure, in turn, allows consumers to show their preferences for green technologies through their purchasing activities.

An additional aspect of promoting compliance across China's industrial landscape relates to the government's potential role as an educator for potential greentech adopters around China. Government agencies have close relationships with many of China's industry associations, and this channel could be used as a

[17] *Stephenson, Janet, "Case Study: Seattle Sets the Standard for U.S. Green Buildings" (paper presented at the C40 Large Cities Climate Summit, New York, May 25, 2007)*

FACILITATING GREENTECH DEVELOPMENT AND DEPLOYMENT

The economic development agency of the Republic of Chile has instituted programs to help power generating companies assess financial viability of renewable energy projects and to assist commercial banks in lending to the renewable energy sector.[19]

FOR RENEWABLE ENERGY PROJECT OWNERS:

- Project preparation matching funds for natural resource assessment, feasibility and environmental studies, and CDM documentation
- Cost-sharing on other areas of advanced project preparation

FOR RENEWABLE ENERGY INVESTORS:

- Credit lines for lending to renewable energy projects offering 30-month grace periods and repayment terms of up to 12 years allowing them to invest as much as US$13 million in individual projects

conduit for government outreach efforts to inform potential greentech adopters about economic and environmental costs and benefits of their procurement decisions.

FACILITATE FINANCING

As noted above, in the early stages of greentech solution development, companies in China and elsewhere often rely heavily on public funding, either in collaboration with academia or through direct government support. With more than 20 subordinate institutes in its "Science and Technology for Resources and the Environment" research area, the Chinese Academy of Sciences (CAS) is one of China's most influential channels for state-sponsored research. China's government is already making significant investments in greentech research, but might have yet more opportunity to further use grants, prizes and other public funding mechanisms to support greentech innovation.

Directly funding greentech development through research institutes or grant programs is not the only way that China's government can financially support the development of greentech in China. Obtaining debt financing is often a difficult challenge for greentech providers and adopters who are hoping to deploy greentech solutions in China. In the same way that many of these projects are often eligible for concessionary financing from international organizations like the Asian Development Bank, China can and already does make use of its policy banks to provide reduced-interest or otherwise favorable lending.

There is potential for China's government to utilize a loan softening program (which often includes either an interest subsidy or a partial guarantee) to enable commercial banks to make risk assessment-based investments in greentech sectors on concessionary terms. The Indian Ministry of New and Renewable Energy, for example, has successfully used such an approach to help Indian banks offer loans for the adoption of solar water heaters.[18]

As a further opportunity to use policy tools to facilitate the flow of private capital into greentech sectors, China's government can also support greentech market development by taking steps to help China's financiers improve their greentech-relevant capabilities. China's government is already helping to stimulate the expansion of these skills. As noted in the Regulatory Response chapter, China's government rolled out a so-called Green Credit program in July of 2007 whereby banks were required to put in place environmental impact assessment and risk management controls for investments to environmentally damaging industries.[20]

As the government directly supports and leverages China's financial sector to support the development of greentech solutions, another area where China's government can play a key enabling role is in the formation of a commercial

[18] *MaClean, John et al., "Public Finance Mechanisms to Mobilise Investment in Climate Change Mitigation," (United Nations Environment Programme, 2008), 35*
[19] *Ibid., 15*
[20] *Ministry of Environmental Protection, "Calendar in July 2007," http://english.mep.gov.cn/, November 27, 2007 (accessed on August 12, 2009)*

environment conducive to greentech industries and solutions. The U.S.-China Clean Energy Forum, a dialogue on clean energy issues facing the two countries, has called for the creation of "Strategic Energy Zones" to facilitate innovation in new technologies, partially through the use of new financing mechanisms.[21] Creating special industrial zones to promote the development of selected industries is an area in which China has extensive experience and national and local policymakers should be able to leverage this to further enable the development of substantial greentech industries.

LIBERALIZE MARKETS

As discussed in the previous chapter, some of China's greentech markets are highly-concentrated or controlled primarily by state-owned enterprises. While there are important benefits to having certain industries under closer government control at critical stages in their development, more open markets also have clear benefits, particularly related to enabling efficiency and innovation. Finding the right balance will provide China an opportunity to effectively utilize foreign and private sector expertise and technologies to address its environmental issues, while also supporting the development of healthy domestic greentech industries.

One path is to create mechanisms for private and foreign participation in state-dominated markets. For instance, in the coal sector, regulators could accelerate market development by lowering tariffs on the importation of mining solutions and by encouraging foreign investment in coal mining and infrastructure development. Capitalization requirements and opaque public works bidding processes constitute barriers to private involvement in some greentech markets such as wind power. One approach regulators might take to promote efficiency and innovation in China's greentech sectors could be a relaxation of restrictions on private and foreign market participation where appropriate. A further step regulators could take would be a continued gradual relaxation of currency exchange restrictions, which could help provide Chinese greentech companies easier access to foreign capital as an additional source of funding.

Another path regulators could pursue to support the financing of greentech solutions would be to establish special technology-focused or even greentech-focused capital markets, akin to NASDAQ in the U.S., to enable simplified flotation for greentech companies. The benefits of such a move could be compounded if new clusters of financial institutions could be developed, potentially in the same areas as these markets, to provide specialized finance opportunities.

More generally, many of the financing opportunities highlighted above can be fully realized only with strong regulatory support. This support could include best-practice guidelines for greentech public-private partnerships or other effective investment arrangements, such as power purchase agreements. Additionally, regulatory support could entail incentives for domestic commercial banks to issue concessionary loans through guarantee programs.

SUPPORT ENVIRONMENTAL EXCHANGES

Another opportunity regulators have for further promoting China's greentech markets relates to supporting increased use of national and international environmental exchanges. These exchanges allow companies to respond flexibly to environmental policies by giving them options to purchase 'environmental assets'[22] from other companies rather than invest in the greentech solutions needed to create them themselves. This would allow market forces to allocate capital to projects that most effectively reduce emissions or achieve other environmental benefits.

It seems likely that environmental exchanges will continue to be a part of environmental issue management for some time to come. No matter where these future markets develop, Chinese greentech companies are well placed to benefit. China's greentech adopters will be able to monetize their environmental assets and thereby gain additional channels for financing their capital investments. China's

[21] *US-China Clean Energy Forum, "Initiatives," http://cleanenergyforum.net/ (accessed on August 11, 2009)*
[22] *While carbon emissions reductions are the most well-known environmental assets, other examples include emissions reductions of other air, water, or solid waste pollutants, or improvements in energy, water, or raw material efficiency.*

greentech solution providers will meanwhile have opportunities to sell solutions to companies participating in relevant environmental markets.

Therefore, the question for China's regulators is how to most effectively support the development of environmental exchanges to bring resulting benefits to China's greentech providers and adopters. One approach would be to enable further participation in the Kyoto Protocol's Clean Development Mechanism (CDM). As noted in the previous chapter, there are limitations in place on foreign investments in CDM projects in China. Creating mechanisms for increased foreign involvement could facilitate greater deployment of advanced foreign CDM-applicable greenhouse gas emissions reduction solutions, such as landfill gas-to-energy technologies. Encouraging international environmental exchanges could also extend to supporting the creation of other international environmental exchanges, as successors to the CDM or otherwise.

Irrespective of developments at the international level, China has already established domestic environmental exchanges in Beijing, Shanghai and Tianjin. These exchanges are discussing future potential trading of sulfur oxide (SO_X), nitrous oxide (NO_X) and chemical oxygen demand (COD) emissions reduction certificates in addition to wider trading of carbon or other environmental assets. China's government could drive the development of China's greentech markets by further supporting the development of such exchanges.

As noted in the Regulatory Response chapter, China's government has gained experience with allocation of environmental targets to individual companies through the Top-1000 Energy-Consuming Enterprises Program. This experience should be useful if the government makes a move towards requiring company-level reductions of other types of emissions related to its national environmental targets. Once individual companies have targets for environmental performance, using exchanges to minimize the costs of reaching these targets is a logical next step, and one to which regulatory support could lend further momentum.

Like many opportunities to promote the development of greentech in China, building strong environmental exchanges is not something any one group of market stakeholders can do alone. Whether in relation to international or domestic environmental asset trading, China's greentech adopters will have to work with financiers to develop effective strategies for monetizing environmental assets and using them to support capital investments. Greentech providers will also have to work more closely with adopters to help them understand how adoption of specific solutions can be partially financed by capital mobilized through environmental exchange transactions. Other market stakeholders also have important roles to play in creating the environments necessary for vibrant environmental exchanges and spreading information about them to encourage companies to participate.

Other Stakeholders

A NUMBER OF OTHER STAKEHOLDERS, including academic institutions, non-governmental organizations (NGOs) and international organizations, also have interest in and potential ability to influence the development of China's greentech markets.

DRIVE GREENTECH TRAINING

A core opportunity is to develop and support environmental education and greentech training initiatives in China. Academic, non-governmental and international organizations often have considerable technical expertise in environmental issues, which qualifies them to support regulatory capacity building at national and local levels. One example of this support is the Joint U.S.-China Cooperation on Clean Energy (JUCCCE) Mayoral Training Program, which together with China's Ministry of Housing and Urban-Rural Development, trained over 50 mayors from China's largest cities on sustainability issues in 2008.[23]

Like regulators, solution providers and adopters also require training in the economic and environmental values of greentech solutions in China. This

[23] *TreeHugger.com, "Greening China's Mayors: A Q&A with Dr Steve Hammer of the Mayoral Training Program on Energy Smart Cities," http://www.treehugger.com/ (accessed on August 11, 2009)*

knowledge can directly contribute to more effective investment decisions by solution providers and increased adoption by solution adopters.

General public training initiatives and campaigns also support the development of the greentech market. Many NGOs, such as the Jane Goodall Institute, organize public awareness campaigns on environmental issues within China. These campaigns effectively raise the environmental awareness of the Chinese consumer, who is encouraged to support environmentally-friendly products and services, thus accelerating China's greentech market development.

ENGAGE OTHER STAKEHOLDERS

Another opportunity for academic, NGO and international organizations is to leverage their independent status to build links and communications channels between solution providers, solution adopters, financial investors and regulators. For example, by hosting forums, conferences and other industry meetings they provide a range of market participants with platforms to exchange information and build relationships, as well as address policy issues with regulators.

Activities can develop beyond bringing stakeholder groups together. There are already a wide range of greentech conferences in China, but academic, non-governmental or international organizations should have further opportunity to move beyond conferences to action-oriented meetings and ongoing dialogues rather than one-off events. These unaffiliated organizations can even take direct action to support China's greentech market development. For example, Econet China, coordinated by the German Industry and Commerce Greater China, hosts an extensive directory of Chinese and foreign greentech companies on their website as a tool for companies to locate and contact each other.[24]

Other organizations such as China Sustainable Energy Program (CSEP), funded by The Energy Foundation, provide grants to government-affiliated research institutes that aid in shaping the Chinese government's energy policies to reduce carbon dioxide emissions. The research institutes along with international policy experts advise the government on new energy policies.[25]

SPONSOR RESEARCH

Academic, non-governmental and international organizations can also support the development of China's greentech markets by conducting and disseminating research in greentech basic science and greentech solutions. For example, research institutes at China's top universities typically have strong relationships with regulators, and are consequently in a good position to advise the government on issues as diverse as resource pricing policies and technical solution standards.

Outside of academia, other groups such as China's Energy Management Company Association (EMCA), an industry association with more than 200 company members active in the ESCO field, also conduct and disseminate greentech research. EMCA grew from 59 organizations in 2003 to 212 ESCOs in 2007 and assisted the NDRC in the management of a World Bank/Global Environment Fund project to build ESCO capacity in China. Much of its focus is on disseminating information on new policies and regulations related to energy efficiency and helping build ESCO capabilities.[26]

MONITOR COMPLIANCE

Third-party stakeholders can play a role in creating and supporting mechanisms for tracking compliance with existing policies. The use of independent regulatory compliance monitoring is somewhat limited in China compared to other countries. While many smaller, more local NGOs in China have transparency issues and unclear agendas, larger international NGOs have opportunities to investigate whether or not market participants are in compliance with policies and promote information transparency.

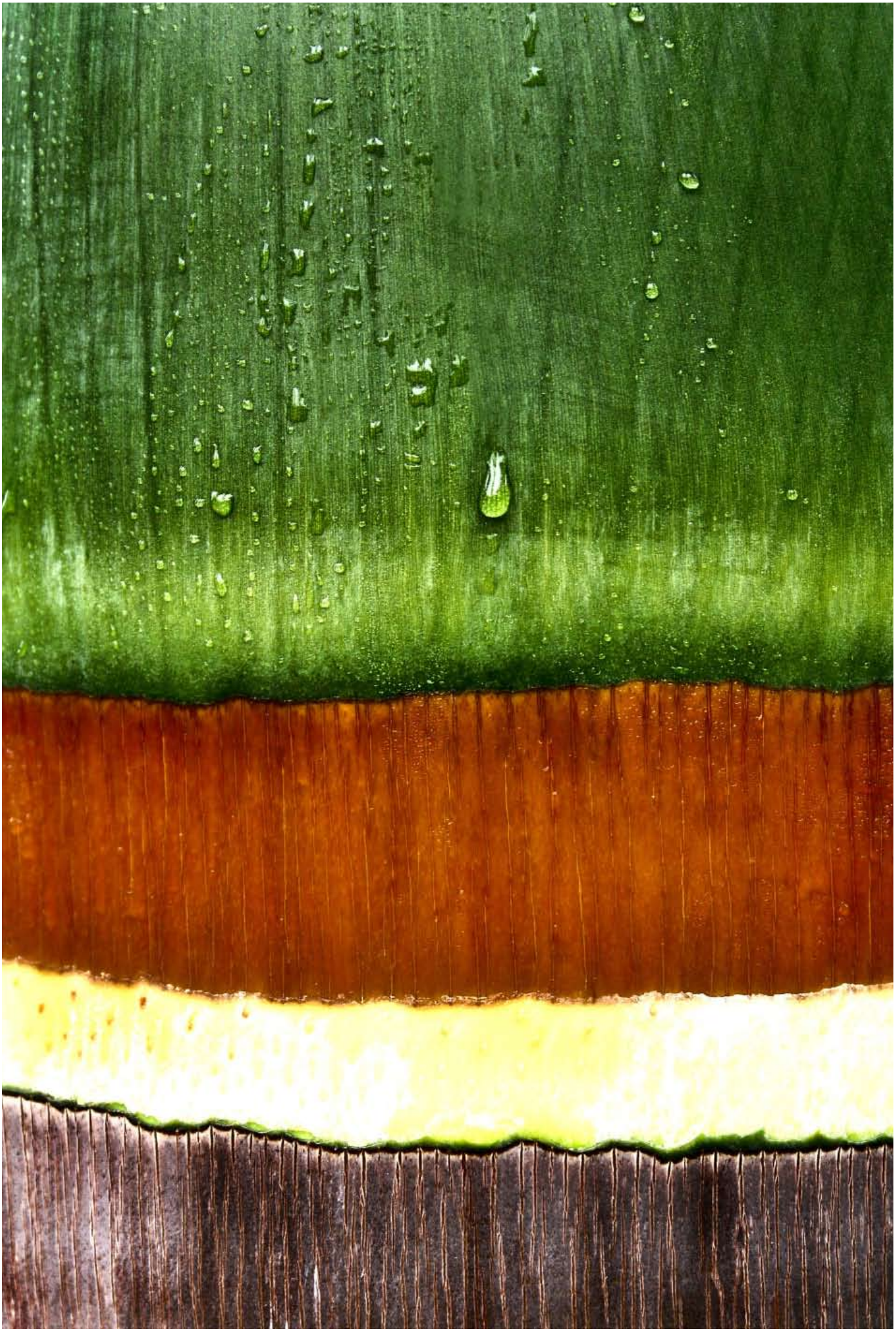
[24] Econet China, "Company Directory," http://www.econet-china.com/ (accessed on August 11, 2009)
[25] The China Sustainable Energy Program, "Approach," http://www.efchina.org/ (accessed on August 13, 2009)
[26] Zhu, Lin, " Enhanced Stakeholder's Involvement in Energy Efficiency Action at Municipal Level" (presentation given at the International Seminar on Energy Efficiency Action at Municipal Level, Ulanbataar, Mongolia, May 9-10, 2006)

Opportunities Are a Starting Point

THE OPPORTUNITIES DISCUSSED IN THIS CHAPTER represent steps that China's greentech market stakeholders – solution adopters, solution providers, financial investors, government regulators and others – can take to address existing challenges, accelerate the development of greentech markets and contribute to China's environmental sustainability.

Developed with the input of the Initiative's partners and strategic advisors, these opportunities are intended to provide guidance, rather than specific recommendations, which can be customized and used in the decision-making processes of individual organizations. As such, these opportunities represent a starting point for the innovative steps that organizations will take over the next several years in China. More detailed sector-specific opportunities are included in the individual sector chapters of the full report.

With thousands of organizations and millions of people involved in the ongoing development of China's greentech markets, the China Greentech Initiative is optimistic that development challenges will be largely overcome, greentech markets will generally flourish and the country will accelerate its transformation to an environmentally sustainable future.



SECTOR SNAPSHOTS

CLEANER CONVENTIONAL ENERGY

RENEWABLE ENERGY

ELECTRIC POWER INFRASTRUCTURE

GREEN BUILDING

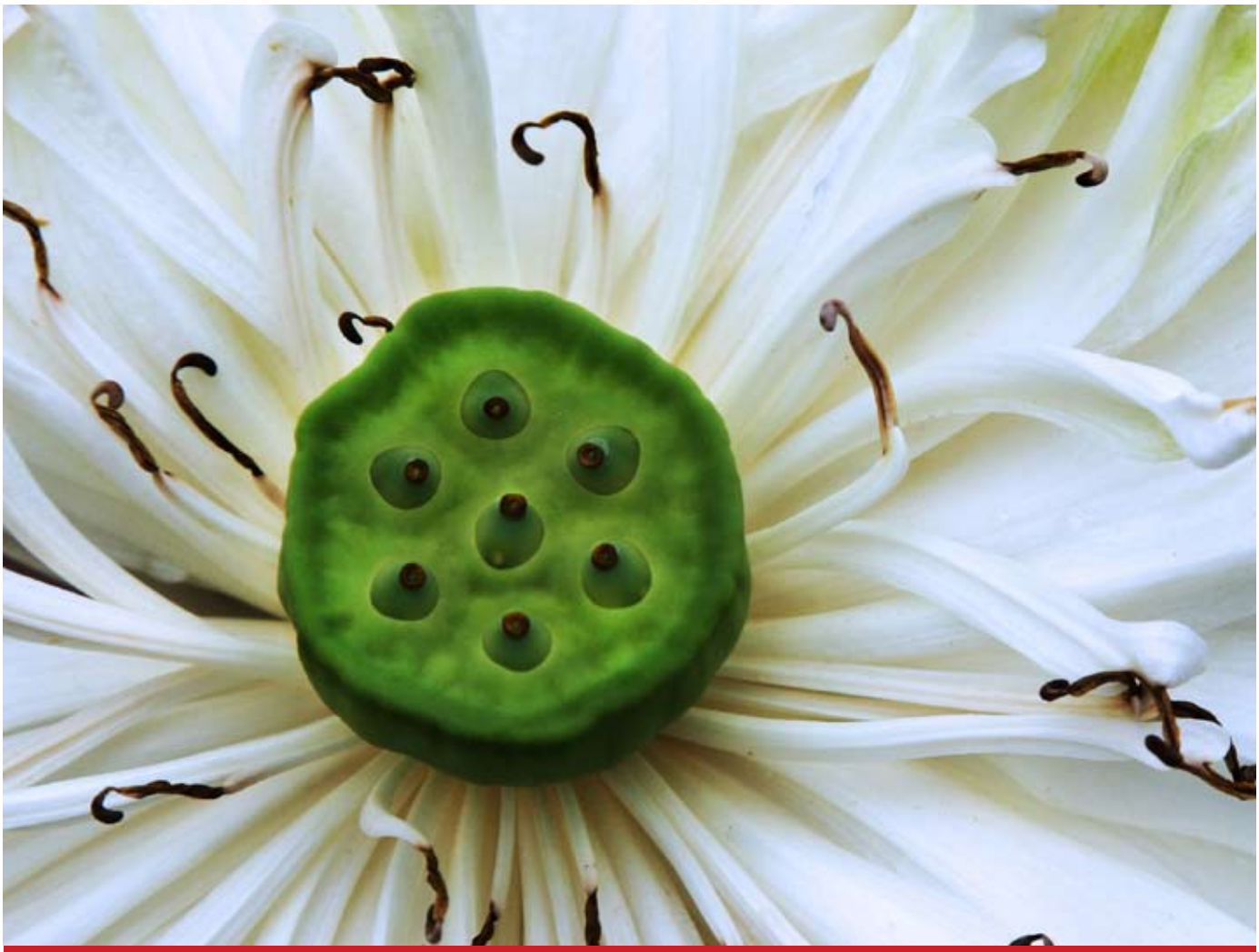
CLEANER TRANSPORTATION

CLEANER INDUSTRY

CLEAN WATER

The full version of *The China Greentech Report*™ contains detailed chapters that cover the Definition, Market Context, Regulatory Response, Solutions, Challenges and Opportunities for each sector.

The full report is available at www.china-greentech.com.



SECTOR SNAPSHOT

CLEANER CONVENTIONAL ENERGY

DEFINITION

Cleaner Conventional Energy is defined as energy derived from non-renewable fossil (e.g., coal, oil, natural gas) or nuclear fuel sources in ways which minimize the negative impact on the natural environment.

- Cleaner coal includes solutions such as Coal Screening and Scrubbing, Integrated Gasification Combined Cycle (IGCC) and Carbon Capture and Sequestration (CCS)[1]
- Cleaner gas consists of solutions like Capture and Use of Coal Mine Ventilation Air Methane and Natural Gas Combined Cycle (NGCC)
- Cleaner oil is made up of solutions such as Efficient Oil Extraction, Water Reinjection and Optimized Reservoir Management that allow oil to be extracted in ways which minimize negative impact on the natural environment
- Nuclear power is energy derived via controlled nuclear fission of radioactive materials at nuclear power plants

MARKET CONTEXT

China is the world's largest energy consumer after the U.S. and its energy demand is forecasted to grow as much as 4% annually to reach 4,691 million tons of oil equivalent (Mtoe) by 2030.[2] Despite China's commitment to the development of renewable energy as an alternative source for its energy demand, analysts predict that China's dependence on conventional energy will continue in the coming decades. Coal is predicted to remain the dominant energy source in the country's fuel mix through to at least 2030.[3]

China's reliance on conventional energy has had a substantial environmental impact, with China's coal combustion alone contributing more than 15% of global CO_2 emissions in 2005.[4] In addition to CO_2, other conventional pollutants produced during conventional energy generation, such as nitrogen oxides and sulfur oxides, are also often released into the atmosphere untreated. China's oil industry, as a result of exploitation, production and refining processes, produces substantial amounts of pollution, in water, gas and solid form.

CHINA'S REGULATORY RESPONSE

In order to manage reliance on conventional energy and the pollution that results from its utilization, China's government has issued a number of segment-specific development plans.

In the 11th Five-Year Plan for Coal Industry Development (2006-2010), China's government called for coal industry integration to be achieved through the closing of small and inefficient coal mines and power plants.[5] The Medium and Long-Term Development Plan for the Oil Refining Industry (2005-2020) provides a similar goal for closing small and medium-sized refineries with limited capacities, outdated technologies and high pollution intensities, replacing them with larger, more efficient refineries.[6]

In China's Medium and Long-Term Development Plan for Nuclear Power (2005-2020), the government called for the acceleration of nuclear development to achieve low-carbon progress. While nuclear power accounted for only 1.1% of China's total power mix in 2008, China plans to increase total nuclear capacity from 9 GW in 2008 to 75 GW by 2020.[7,8]

EXISTING AND EMERGING GREENTECH SOLUTIONS

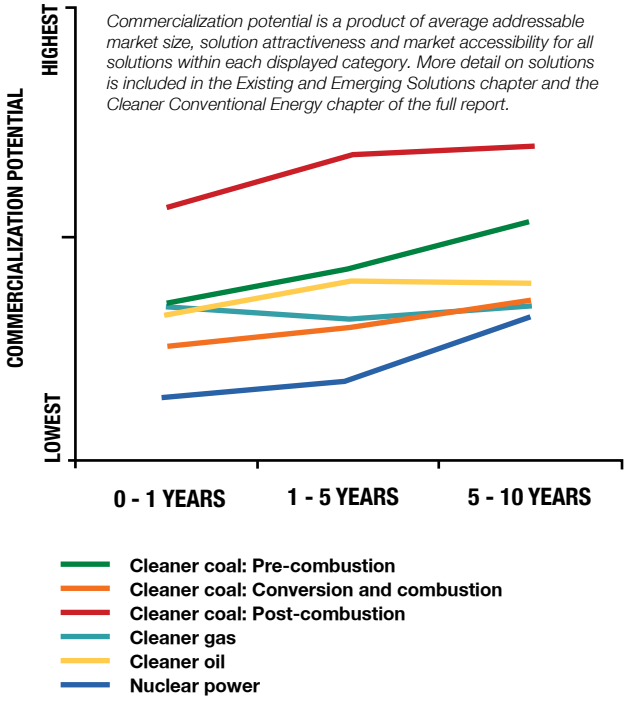
As described in the Existing and Emerging Solutions chapter, the China Greentech Initiative evaluated greentech solutions across two key dimensions, environmental impact potential and commercialization potential (an aggregation of addressable market size, solution attractiveness and market accessibility). See the Solutions chapter for a more complete description of the methodology used.

CLEANER CONVENTIONAL ENERGY SOLUTIONS EVALUATION SUMMARY

SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL
CLEANER COAL: PRE-COMBUSTION	
Advanced Coal Mining Equipment	●
Coal Blending	○
Coal Screening and Scrubbing	●
CLEANER COAL: CONVERSION AND COMBUSTION	
Coal Liquefaction	○
F-Class Gas Turbine	◔
Integrated Gasification Combined Cycle	◑
Ultra Supercritical Power Generation	◔
Underground Coal Gasification Combined Cycle	◑
CLEANER COAL: POST-COMBUSTION	
Carbon Capture and Sequestration	●
Flue Gas Desulfurization	●
Flue Gas Denitration	●
Particulate Matter Removal	●
CLEANER GAS	
Capture and Use of Coal Mine Ventilation Air Methane	●
Combined Heat and Power	◑
Natural Gas Combined Cycle	◔
CLEANER OIL	
Water Reinjection	●
NUCLEAR POWER	
Fast Neutron Reactor	●
Modular High-Temperature Gas-Cooled Reactor	●

COMMERCIALIZATION POTENTIAL OVER TIME

Commercialization potential is a product of average addressable market size, solution attractiveness and market accessibility for all solutions within each displayed category. More detail on solutions is included in the Existing and Emerging Solutions chapter and the Cleaner Conventional Energy chapter of the full report.



LEGEND

Unit environmental impact potential of solutions:

● = More than 40% ○ = Less than 10%

The individual Cleaner Conventional Energy solutions in each of the analyzed solution areas were generally found to have sizeable unit environmental impacts, providing power plant operators with a variety of solutions they can implement to improve their environmental performance. Environmental impacts differ within opportunity areas, such as among the different types of coal conversion and combustion solutions, and are explored in more detail in the Cleaner Conventional Energy sector chapter of the full report.

With respect to commercialization potential, while many analyses have focused on coal combustion and conversion technologies, the Initiative's analysis indicates that cleaner coal pre-combustion and post-combustion solutions may have a stronger commercial potential in China over the next 10 years. Within the gas segment, Combined Heat and Power along with Capture and Use of Coal Mine Ventilation Air Methane were found to have positive commercialization trends over the 10-year period analyzed, but due to potentially rising costs and increasingly difficult extraction of China's scarce natural gas resources, Natural Gas Combined Cycle solutions are expected to have a declining commercialization potential in China over time.

GREENTECH DEVELOPMENT CHALLENGES

A number of challenges complicate the development of China's Cleaner Conventional Energy, including:

CATEGORY	CHALLENGES
MARKET	■ Market fragmentation in some value chain stages (e.g. mines and refineries) and concentration in others (e.g. oil exploration and gasoline distribution) leading to efficiency challenges and high pollution levels
TECHNOLOGY	■ While some cleaner conventional energy solutions are already being deployed, others are not yet technologically mature enough to support widespread commercialization
FINANCING	■ State financing of conventional energy sector limiting private and foreign investment and potential diversification of investment risks
REGULATORY	■ Compliance with some conventional energy standards improving much more quickly than compliance with others

OPPORTUNITIES TO ACCELERATE MARKET DEVELOPMENT

Cleaner Conventional Energy sector opportunities include:

- Participating in Chinese and international research and development efforts to enhance innovation and domestic production of solutions
- Encouraging the development of standardization, safety monitoring systems and waste management policies via collaborations between providers, adopters and the government
- Developing financing mechanisms, utilizing both public and private investment, to stimulate the development of innovative technologies
- Building adopter capacity to integrate multiple cleaner conventional energy solutions into energy-optimized generation systems

A breakdown of opportunities for different stakeholder groups is available in the full version of the report.

[1] *Also often referred to as Carbon Capture and Storage (CCS)*
[2] *International Energy Agency, World Energy Outlook 2007: China and India Insights (Paris, France: International Energy Agency, 2007), 109*
[3] *Ibid., 122*
[4] *Ibid., 199*
[5] 中华人民共和国国家发展和改革委员会，"煤炭工业发展"'十一五'规划，" 2007年1月，[NDRC, *"11th Five Year Plan for Coal Industry Development," January 2007]*
[6] 中华人民共和国国务院，"炼油工业中长期发展专项规划，" 2006年1月*[The State Council, People's Republic of China, Medium and Long Term Development Plan of Oil Refining Industry, January, 2006]*
[7] *World Nuclear Association, "Nuclear Power in China," August 21, 2009, http://www.world-nuclear.org/*
[8] 中华人民共和国国家发展和改革委员会, 核电中长期发展规划, *[NDRC,Middle and Long Term Development Plan of Nuclear Power(2005-2020)]*

SECTOR SNAPSHOT

RENEWABLE ENERGY

DEFINITION

Renewable Energy is produced from sources that are naturally replenishing, such as solar light, wind, waves, underground heat, surface water flows and biomass. The China Greentech Initiative focused on China's solar, wind and bioenergy markets.

SOLAR ENERGY CONSISTS OF THERMAL OR ELECTRIC ENERGY DERIVED FROM SOLAR LIGHT using Photovoltaic cells, Concentrating Solar installations or Solar Water Heaters. Wind power is defined as electric energy generated from wind using power generation turbines. Bioenergy is thermal or electric energy produced from biomass, and includes solutions such as bioethanol, biodiesel, biogas and biomass combustion.

The China Greentech Initiative's focus on solar, wind and bioenergy solutions was based on feedback from partners and advisors, an understanding of current market opportunities and consideration of the Initiative's available time and resources. This focus by no means implies a judgment on the environmental or commercial potential of other renewable energy market segments.

MARKET CONTEXT

China's dramatic industrialization has led to substantial growth in energy demand. Total electricity consumption grew more than five times from 1990 to 2007, while growing petrol consumption has made China the world's second largest oil consumer after the U.S.[1] Faster growth in demand than supply has led to a heavy reliance on imports of foreign oil, creating national security concerns.

The energy produced from coal serves most of China's energy demand — 70% versus a global average of 28% in 2006.[2] While this is not surprising, as coal is cheap and abundant in China, it creates environmental challenges since coal power generation is significantly more CO_2-intensive than power production from other energy sources.[3]

Yet in addition to its abundance of coal, China is fortunate to have renewable resources in abundance:

- **SOLAR:** Two-thirds of China's land area enjoys over 2,200 radiation hours annually and has solar resources in excess of 500 KJ/cm2/year (by comparison, Germany and Japan average only 400 KJ/cm2/year and 450 KJ/cm^2/year respectively)[4,5]
- **WIND:** China also has abundant wind energy resources, which if fully tapped could generate at least as much electricity as the country's current total installed electrical capacity[6]
- **BIOENERGY:** In 2006, China had 280 million tons of coal equivalent (Mtce) biomass supply[7]

CHINA'S REGULATORY RESPONSE

China is focused on mitigating the impact of climate change. Its National Climate Change Program (June 2007) outlines China's strategic priorities for addressing climate change, including key policies to be developed. This was the first such plan by a developing country to moderate greenhouse gas emissions and adapt to changing environmental conditions.[8]

Recognizing the dual need to both address climate change and improve energy security, China has, under its Renewable Energy Law (2005) and subsequent policies, put in place numerous regulations, incentives and subsidies to support the utilization of renewable energy. As directed by China's Medium and Long-Term Development Plan for Renewable Energy (2007-2020), China's power producers are working to build non-hydro renewable energy generation capacity to 3% of their total energy mix by 2010 and 8% by 2020.[9]

China's desire to increase the use of renewable energy has supported the development of domestic renewable energy industries. The government has implemented a wide range of subsidies to encourage investment in the sector, such as investments supporting access roads and electricity transmission infrastructure, tariff and VAT rebate programs for imports of parts and raw materials, and direct payments to renewable energy plant owners to compensate for losses. These policies, which have supported the growth of domestic renewable energy companies, have prompted some foreign companies to question whether the evolution of local conditions will allow them to continue participate in these markets.

EXISTING AND EMERGING GREENTECH SOLUTIONS

As described in the Existing and Emerging Solutions chapter, the China Greentech Initiative evaluated greentech solutions across two key dimensions, environmental impact potential and commercialization potential (an aggregation of addressable market size, solution attractiveness and market accessibility). See the Solutions chapter for a more complete description of the methodology used.

Most renewable energy solutions score high for environmental impact potential since renewable energy generation produces zero or minimal greenhouse gas emissions, a substantial advantage over conventional generation. Within certain renewable energy market segments, however, there are environmental impact differences, such as the greater CO_2 abatement potential of cellulosic biofuels compared to first generation biofuels. In addition, there are several individual

[1] *Bureau of East Asian and Pacific Affairs, Fact Sheet: Economic Relations Between the United States and China (Washington, DC, U.S.: United States Department of State, 2006), 2*
[2] *Li, Junfeng and Wang, Sicheng, 2007 China Solar PV Report (China: China Environmental Science Press, 2008), 6*
[3] *Energy Information Administration, International Energy Outlook 2009 (Washington, DC, U.S.: United States Department of Energy, 2009), 109*
[4] *Bai, Charles, Solar Energy Demand in China (Zhejiang, China: ReneSola), 2*
[5] *Chinagate, "Medium and Long-Term Development Plan for Renewable Energy in China," September 4, 2007, http://en.chinagate.cn/*
[6] *Li, Junfeng et al., 2007 China Wind Power Report (China: China Environmental Science Press, 2008); World Nuclear Association, "Nuclear Power in China," August 21, 2009, http://www.world-nuclear.org/; The China Greentech Initiative Analysis*
[7] *National Devleopment and Reform Commission, China Renewable Energy Development Overview (Beijing, China: Energy Bureau of the NDRC and Energy ,Research Institute of the NDRC, 2008), 14*
[8] *National Devleopment and Reform Commission, China's National Climate Change Program (Beijing, China: NDRC, 2007)*
[9] *中华人民共和国国家发展和改革委员会, 可再生能源中长期发展规划, 2007年8月, [China Climate Change Info-Net, Medium and Long-Term Plan for Renewable Energy Development (2007-2020)], (Beijing, China: National Development and Reform Commission, August, 2007), 30*

RENEWABLE ENERGY SOLUTIONS EVALUATION SUMMARY

WIND SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL	SOLAR SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL	BIOENERGY SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL
WIND - TURBINES		**SOLAR - PHOTOVOLTAICS**		**BIO - ELECTRICITY**	
Offgrid / <1MW / Horizontal	●	Crystalline Silicon PV	●	Biomass Combustion	●
Offgrid / <1MW / Vertical	●	Thin Film PV - Amorphous Silicon	●	Biomass Co-Firing	◑
Ongrid / 1-3 MW / Onshore	●	Thin Film PV - Cadmium Telluride	●	**BIO - HEAT**	
Ongrid / >3 MW / Onshore	●	Thin Film PV - CIGS	●	Industrial Heat	●
Ongrid / >3 MW / Offshore	●	Building-Intergrated PV	●	Civil Heat	●
WIND - DEVELOPMENT		**SOLAR - CONCENTRATING**		**BIO - FUELS**	
Micrositing	◑	Parabolic Trough	●	Sweet Sorghum (ethanol)	●
Wind Assessment	◑	Fresnel Mirror	●	Cassava (ethanol)	●
WIND - MAINTENANCE		Power Towers	●	Cellulose (ethanol)	●
Control Systems	◔	Parabolic Dish -Stirling Engine	●	Waste Vegetable Oil (diesel)	●
Maintenance	◔	Concentrating PV	●	Jatropha (diesel)	●
Standard Operating Procedures (SOPs)	◔			Microalgae (diesel)	●
Conversion Technology	◕				
WIND - ENERGY STORAGE		**SOLAR WATER HEATERS**			
Compressed Air Storage	●	Solar Water Heater	●		
Battery Storage	●				
Pumped Hydro Storage	●				

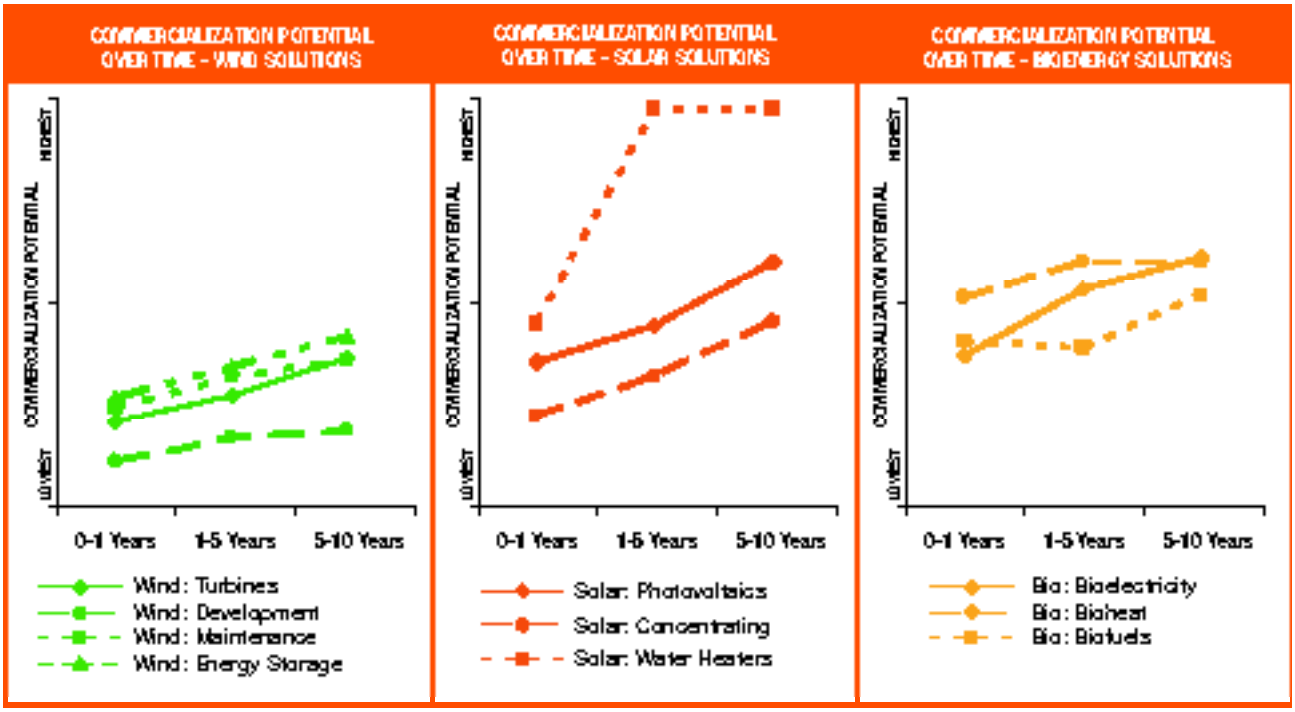
LEGEND
Unit environmental impact potential of solutions:
● = More than 40% ○ = Less than 10%

renewable energy solutions which have lifecycle environmental concerns due to the resources used or waste generated in their manufacturing, maintenance or disposal. These concerns are explored in greater detail in the Renewable Energy sector chapter of the full China Greentech Report.

With respect to commercial potential, Solar Water Heaters, Wind Energy Storage solutions and Biofuel solutions were found to have the highest average 10-year commercialization potential in their respective segments of China's renewable energy landscape. Across renewable energy segments, many wind solutions, particularly those related to the development and operations and maintenance of wind farms were found to be more attractive to adopters than many bioenergy or solar solutions. This is partially due to the relative technological maturity and attractive economics, driven by potential to improve operating efficiency, of these wind solutions. At the same time, the bioenergy and solar solutions analyzed were found to have significantly larger addressable market sizes, due to the type of solutions selected, which in aggregate resulted in higher evaluations of overall commercial potential for these two segments. Direct comparisons of the solution attractiveness, addressable market size and market accessibility dimensions (the three components of 'commercial potential') are included in the Renewable Energy Sector chapter.

GREENTECH DEVELOPMENT CHALLENGES

Various challenges hinder the full development of China's renewable energy sector. A high-level sample of these challenges is included below, and more specific challenges are investigated both in the Challenges chapter and the Renewable Energy Sector chapter of the full report.



Commercialization potential is a product of average addressable market size, solution attractiveness and market accessibility for all solutions within each displayed category. More detail on solutions is included in the Existing and Emerging Solutions chapter and the Renewable Energy chapter of the full report.

CATEGORY	CHALLENGES
MARKET	■ A renewable energy is largely about power generation and thus energy security, China's laws, incentives and local procurement practices often favor local over foreign participants (as is the case in many other nations), potentially discouraging competition and investment
TECHNOLOGY	■ Chinese renewable energy technologies sometimes are less efficient than foreign equiva lents, due to the comparative technological maturity of foreign solutions and greater experi-ence of foreign companies in these areas ■ Domestic providers often have less experience in managing intellectual property assets than foreign companies
FINANCING	■ Complicated financing policies and project approval practices make it difficult for large-scale renewable energy projects to secure financing without full corporate/sponsor guarantees, particularly in the high-cost pre-operational phase when projects have minimal assets
REGULATORY	■ Lack of transparency and specificity in renewable energy regulation, combined with limited communication on the specifics and timing of policies and direction, makes it difficult for companies to predict risks as well as level and timing of potential returns, thus slowing investment

OPPORTUNITIES TO ACCELERATE MARKET DEVELOPMENT

Renewable Energy opportunities sector include:

- Encourage the development of unified and evenly enforced standards, such as standards for interfacing technologies and costing methodologies for connecting renewable energy generation to China's electric power infrastructure, by collaborating with providers, adopters and the government
- Introduce innovative financing mechanisms, such as pre-construction power-purchase agreements, to encourage investments in China's renewable energy industry
- Establish frameworks for public-private and Sino-foreign collaboration such as joint solutions development or renewable energy plant operations to encourage best practice solutions and operational processes to scale quickly to meet China's rising energy demand

A breakdown of opportunities for different classes of stakeholders is available in the full version of the China Greentech Report.

SECTOR SNAPSHOT

ELECTRIC POWER INFRASTRUCTURE

DEFINITION

Electric Power Infrastructure refers to "smart" electric grids and networks, supported by IT applications, which deliver power to users on demand in an efficient and reliable way, from a broad range of generating sources.

THE ELECTRIC POWER INFRASTRUCTURE VALUE CHAIN INCLUDES CONVENTIONAL GRID COMPONENTS, such as power generation, transmission and distribution, and service location as well as storage and information communications technology components central to smart grids.

MARKET CONTEXT

China's electricity consumption has grown rapidly over the past 20 years, leading to a total demand of 3,271 gigawatt hours in 2007, second only to the U.S.[1,2]

With nearly 70% of the country's coal resources located in Western China, growth in demand has placed pressure on China's electric power infrastructure to connect power resources to the fast-growing industrial load centers in Eastern and Southern China.[3]

China's increased focus on renewable energy exerts yet greater demands on China's electric power infrastructure. Power generation based on renewable energy sources (e.g. wind or solar energy) necessitates greater use of intermittent generation management and storage solutions compared to power generated from conventional energy sources. Due in part to these challenges, up to 30% of

China's installed wind capacity was not connected to the grid in 2008, and among the capacity that was connected, much was underutilized.[4]

Demand growth has reinforced the need to increase efficiency at all stages of the electricity value chain, including generation, transmission, distribution and demand-side electricity usage. China's State Grid has announced plans to build a "strong and smart grid" to meet these challenges by 2020.[5]

CHINA'S REGULATORY RESPONSE

To respond to the dramatic growth in electricity demand, China's regulators have taken a number of concrete steps to promote further development of China's electric power infrastructure.

One of the key components of China's regulatory response has been support and funding for the development and interconnection of regional grids. The 1.5 trillion yuan (US$222 billion) allocated to infrastructure development in China's 4 trillion yuan (US$586 billion) economic stimulus plan is only one of several such infrastructure funding programs.[6]

To respond to efficiency pressures, regulators have supported efficient ultra high-voltage (UHV) transmission technologies and the replacement of inefficient small-scale coal generation capacity with more efficient large-scale plants.

Additionally, regulators have taken an active approach to managing electricity pricing structures, both at the generation side, with feed-in tariffs for renewable energy companies, and at the demand side, with time-of-use and market segment price differentiation for end users.

EXISTING AND EMERGING GREENTECH SOLUTIONS

As described in the Existing and Emerging Solutions chapter, the China Greentech Initiative evaluated greentech solutions across two key dimensions, environmental impact potential and commercialization potential (an aggregation of addressable market size, solution attractiveness and market accessibility). See the Solutions chapter for a description of the methodology used.

The two energy storage solutions evaluated, Vanadium Redox and NaS batteries, were found to have the highest ratings both for unit environmental impact potential and commercialization potential. While grid access solutions were also found to have high potential for unit environmental impact due to their ability to unlock environmental potential in areas such as new energy vehicle transportation and renewable power generation, their commercialization potential appears smaller than other electric power infrastructure solutions over the coming 10 years.

Many different components contribute to transmission and distribution electricity loss, and on an individual unit basis, none of the solutions in this category investigated by the China Greentech Initiative were found to have a significant independent environmental impact. The analysis did not incorporate other benefits such as improved reliability and the potential to enable other future solutions, nor did it incorporate the aggregate environmental benefits that could be achieved were China's existing electrical power infrastructure be significantly transformed.

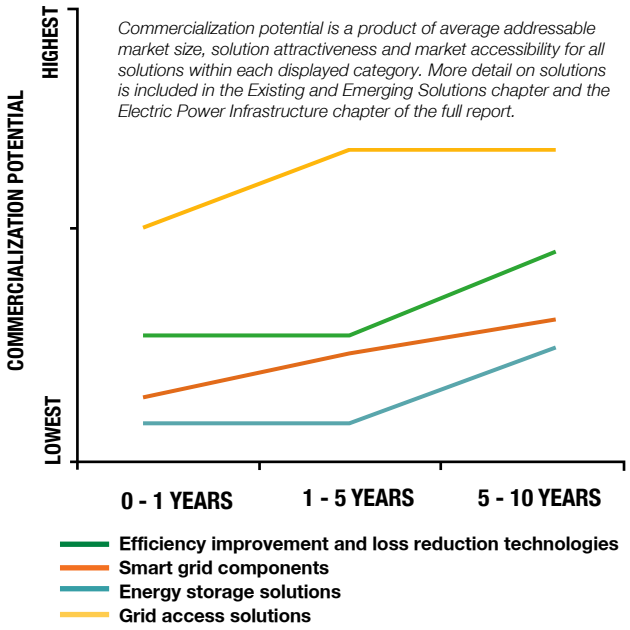
[1] *National Bureau of Statistics of China, "China Statistical Yearbook 2008"*
[2] *"BP," BP Statistical Review of World Energy June 2009"*
[3] "中国电力科学研究院，" "中国电力 " *[China Electricity Research Institute, "China Electric Power 'Highway'"] http://www.epri.ac.cn/ (accessed on July 18, 2009)"*
[4] 中国电力企业联合会，"统计与分析:全国电力工业统计快报 *(2005 - 2008)" [China Electricity Council, National Power Industry Statistical Reports 2005-2008]*
[5] *People's Daily, "China's Strong Smart Grid Leads the Way," August 11, 2009, http://english.people.com.cn/*
[6] 中央政府门户网站，"投资数据尽显亮色"4万亿"投资计划初见成效"，2009年3月29日 *[Central Government Website, "4 Trillion Investment Has Achieved Preliminary Results", March 29, 2009], http://www.gov.cn*

ELECTRIC POWER INFRASTRUCTURE SOLUTIONS EVALUATION SUMMARY

SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL
EFFICIENCY IMPROVEMENT AND LOSS REDUCTION TECHNOLOGIES	
Composite Materials Cables	○
Transformers with Amorphous Core	○
Ultra High Voltage Transmission	○
SMART GRID COMPONENTS	
Advanced Metering Infrastructure	◔
Digital Substation	○
IP-Based Automatic Meter Reading	○
Real-Time Information Processing	○
Wide Area Management System	○
ENERGY STORAGE SOLUTIONS	
NaS Battery	●
Vanadium Redox Battery	●
GRID ACCESS SOLUTIONS	
Electric Auto Vehicle Charging System	●
Renewable Energy Access - Flexible Alternating Current Transmission System (FACTS)	●

COMMERCIALIZATION POTENTIAL OVER TIME

Commercialization potential is a product of average addressable market size, solution attractiveness and market accessibility for all solutions within each displayed category. More detail on solutions is included in the Existing and Emerging Solutions chapter and the Electric Power Infrastructure chapter of the full report.



LEGEND

Unit environmental impact potential of solutions:

● = More than 40% ○ = Less than 10%

GREENTECH DEVELOPMENT CHALLENGES

A number of challenges complicate the development of China's Electric Power Infrastructure, including:

CATEGORY	CHALLENGES
MARKET	■ Monopoly markets with high entry barriers combined with diverse application environments
TECHNOLOGY	■ High unit costs and safety issues contributing to relative commercial immaturity of many electric power infrastructure greentech solutions
FINANCING	■ Nascent business models and restrictions on private and foreign investment limiting the availability of capital for electric power infrastructure investments
REGULATORY	■ Market-insulated upstream and end-user electricity prices ■ Limited fiscal incentives for modernization coupled with limited supervision of electric power infrastructure environmental impacts

OPPORTUNITIES TO ACCELERATE MARKET DEVELOPMENT

Electric Power Infrastructure sector opportunities include:

- Improving the capabilities of solution providers and adopters to innovate, evaluate and manage advanced electric power infrastructure solutions necessary to improve grid efficiency, reliability security and manageability
- Supporting effective public-private partnerships in both the financing and operations of China's Electric Power Infrastructure, particularly in areas related to modernizing distribution infrastructure
- Increasing the impact of market forces on electricity price considerations at the supply and demand sides of China's Electric Power Infrastructure so as to help power generators, grid operators and users make effective decisions on new capital projects

A detailed description of opportunities for different stakeholders is in the full version of the report.

SECTOR SNAPSHOT

GREEN BUILDING

DEFINITION

Green Building covers planning, building and operating solutions that are more sustainable, efficient and healthy than conventional solutions for an equivalent level of comfort and service. Green Building includes solutions such as integrated design, sustainable materials, energy efficient appliances and building automation.

MARKET CONTEXT

With nearly twice the total floor space of the U.S. and more than four times as much as Western Europe, China's building market is the largest in the world.[1] Key drivers of construction, including GDP growth and urbanization, are projected to remain strong through 2030, and China is expected to overtake Japan in 2009 to become the second largest construction market in the world.[2]

But green building in China's expanding building market is comparatively rare. Despite the increasing rate of 'green' materials, services and solutions adoption by designers, builders and developers, the China Greentech Initiative estimates that certified "green" floor space constitutes less that 1% of the new built environment.[3]

Significant energy, water and natural resources go into the manufacturing of building materials (with steel, aluminum and concrete being particularly resource intensive), plus the construction and operation of the buildings in which these materials are used. China's buildings use nearly four times less energy per square meter than buildings in developed countries, yet generate nearly 17% of China's annual greenhouse gas

emissions.[4,5] However, due partially to poor construction practices, some building types in China (e.g. many office buildings in first-and second-tier cities) have far worse heat and energy efficiency than foreign counterparts. Irrespective of current resource use, if China's consumption patterns follow the developed world's, annual building emissions will increase considerably in the future. [6]

CHINA'S REGULATORY RESPONSE

China's government has set ambitious targets and guidelines for green building. Energy efficiency is one of China's key environmental policy goals, and buildings are expected to contribute 40% of China's total energy efficiency improvements in the 11th Five-Year Guidelines period (2006-2010).[7] Water conservation is also growing in political importance, and China's domestic green building standard already focuses more on water issues than other green building standards throughout the world.

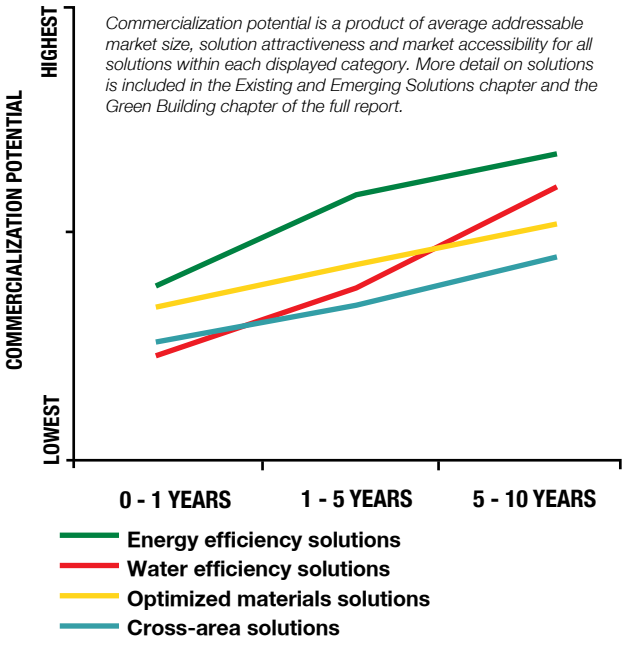
While numerous green building policies, guidelines and standards have been put forward by the National Development and Reform Commission (NDRC), Ministry of Housing and Urban-Rural Development (MOHURD), Ministry of Environmental Protection (MEP) and other central and local regulators, compliance levels have varied significantly across the country. China is expected to face continued challenges monitoring compliance with either current or future green building regulations or codes.

EXISTING AND EMERGING GREENTECH SOLUTIONS

As described in the Existing and Emerging Solutions chapter, the China Greentech Initiative evaluated greentech solutions across two key dimensions, environmental impact and commercialization potential (an aggregation of addressable market size, solution attractiveness and market accessibility). See the Existing and Emerging Solutions chapter for a more complete description of the methodology used.

GREEN BUILDING SOLUTIONS EVALUATION SUMMARY

SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL
ENERGY EFFICIENCY SOLUTIONS	
Advanced Envelope	●
Building-Integrated Heat and Power	●
Green Devices	◑
Smart Buildings	◔
WATER EFFICIENCY SOLUTIONS	
Greywater Systems	◕
Building-Integrated Rainwater Collection	◔
Low-Flow Fixtures	◑
OPTIMIZED MATERIALS SOLUTIONS	
Local Sourcing	◔
Low-Impact Materials	◕
Recycled Materials	◕
CROSS-AREA SOLUTIONS	
Commissioning and Efficient Operations	◑
Integrated Design	●
Passive Design	●
Resource Service Companies	◑
Sustainable Urban Planning	●



Commercialization potential is a product of average addressable market size, solution attractiveness and market accessibility for all solutions within each displayed category. More detail on solutions is included in the Existing and Emerging Solutions chapter and the Green Building chapter of the full report.

LEGEND
Unit environmental impact potential of solutions:
● = More than 40% ○ = Less than 10%

While all classes of Green Building solutions were found to have fairly high unit environmental impact potential, cross-area solutions scored highest on this dimension, mainly driven by planning and design solutions (Passive Design, Integrated Design and Sustainable Urban Planning), which can be applied in early stages of a building's design and offer multiple opportunitites to improve sustainability. Sustainable Urban Planning can also reduce the environmental impacts associated with other systems such as electrical, communications or transportation infrastructure.

Developing energy efficient solutions is a top priority for may Green Building solution providers and is well-aligned with government priorities. With rising energy prices, energy efficiency solutions should also become more important for solution adopters and end users, driving increased commercial uptake. As China's water scarcity issues become more signifficant, water-related Green Building solutions are also expected to have fast growing market potential.

GREENTECH DEVELOPMENT CHALLENGES

A number of challenges complicate the ongoing development of China's Green Building sector:

CATEGORIES	DESCRIPTION
MARKET	■ Low adopter awareness and inadequate domestic design and construction skills are hampering commercialization
TECHNOLOGY	■ Adoption of green building solutions and techniques slowed by limited supply and distribution
FINANCING	■ Decoupling of costs and benefits between developers, end-users and energy suppliers, which prevents any party from proactively adopting solutions
REGULATORY	■ Uneven implementation of and compliance with policies, limited integration with municipal utility networks, and low resource and utility prices

OPPORTUNITIES TO ACCELERATE MARKET DEVELOPMENT

There are numerous opportunities for market stakeholders to take action to accelerate the development of China's Green Building Sector, including:

- Forming new models of multi-party collaboration across the Green Building value chain to minimize life cycle, economic and environmental costs while improving building services
- Engaging existing and potential building owners to communicate preferences for buildings that minimize environmental impacts and comply with environmental regulations
- Innovating green financing products for providers and adopters
- Developing and expanding green building component product labeling and standards

A breakdown of opportunities for different classes of stakeholders is available in the full version of the report.

[1] *Calculated as the product of a country's population (Source: United Nations, "World Population Prospects: The 2008 Revision") and total floor space per capita (Source: China Council for International Cooporation on Environment and Development, Annual General Meeting 2008: Energy Efficiency and Urban Development (Beijing, China: CCICED, 2008)). Western Europe includes the U.K., Ireland, Belgium, France, Netherlands, Portugal, and Spain."*

[2] *Crosthwaite David et al., World Construction 2007-2008 Report, (London, U.K.: Davis Langdon, 2007), 4*

[3] *Based on the proportion of 2009 expected construction that is certified as "LEED" (Source: US Green Building Council, "LEED Registered Projects Directory") or by "Green Building Label" (Source: MOHURD, "Announcement of 'Green Building Label' Project Names," July 16, 2008) as of March, 2009"*

[4] *China Council for International Cooperation on Environment and Development, Energy Efficiency and Urban Development Task Force: Background Report 2008 (Beijing, China: CCICED, 2008), 21*

[5] *Zhang, Haimeng et al., China's Green Revolution: Prioritizing Technologies to Achieve Energy and Environmental Sustainability (Chicago, U.S.: McKinsey & Company, 2009), 10*

[6] *China Council for International Cooporation on Environment and Development, Annual General Meeting 2008: Energy Efficiency and Urban Development (Beijing, China: CCICED, 2008), 21*

[7] *United National Environment Programme, Sustainable Buildings & Climate Initiative, "Briefing: Policies for Energy Efficient Buildings in China," March 26, 2008, http://www.unepsbci.org/*

SECTOR SNAPSHOT

CLEANER TRANSPORTATION

DEFINITION

The China Greentech Initiative defines Cleaner Transportation as solutions that increase energy efficiency, reduce emissions and improve resource utilization to minimize negative impact of transportation on the environment.

ROAD, RAILWAY, AIR AND WATERWAY transportation represent the four main segments of the Cleaner Transportation sector. Cleaner road transportation includes solutions such as more Efficient Engines, Cleaner Fuels, Alternative Vehicle Energy Systems and Comprehensive Road Network Planning and Development. Cleaner rail transportation includes Energy Efficient Trains, Electrification of Railways and Optimized Operations Management. Cleaner air and waterway transportation include solutions such as Fuel Efficient Aircraft and Ships, Well-Planned and Constructed Airport and Waterway Infrastructure and Optimized Air and Water Traffic Management.

MARKET CONTEXT

China's strong economic growth and increasing government infrastructure investment over the past few decades have made the country one of the world's most significant transportation markets. This has resulted in substantial oil imports, significant transportation energy consumption, increased emissions and high levels of urban traffic congestion.

China is experiencing strong growth across all modes of transport. Its fleet of passenger vehicles grew at nearly 22% CAGR between 2002-2007.[1,2] Railway traffic growth has been spurred by government plans to further expand municipal

and inter-provincial rail networks and extend electrification. China has four of the world's top 10 shipping operators (by number of ships) and leads the world in shipping port container throughput.[3] In a relatively short period of time, China has become a major player in air transportation, with over 200 million passengers flying on over 1,300 commercial aircraft in 2007.[4]

Along with China's expanding transportation markets, transportation-based energy consumption has grown substantially (nearly 40% since 2004) and is forecasted to more than double between 2010 and 2025.[5] Driven by China's burgeoning road transportation, oil consumption is forecast to grow at a 6.5% CAGR from 1990-2020, far exceeding the global average of 2.3%.[6] Oil and other transportation energy consumption has led to the significant emission of greenhouse gases and other pollutants, accounting for nearly 8% of China's CO2 emissions in 2005.[7]

CHINA'S REGULATORY RESPONSE

China's government is investing heavily in transportation infrastructure and aggressively promoting clean transportation solutions by supporting policies and stricter standards in emissions and fuel consumption.

For road transportation, China's government supports the growth of a domestic auto industry and has also announced plans to reduce total oil consumption on a per-vehicle basis of nearly 60% by 2020.[8]

The national railway system is highly efficient compared to other modes of transportation, and the expansion of railway transport capacity is a top priority for China's government. By raising the present rail electrification level of 32% to more than 45% by 2010 and more than 60% by 2020, China hopes to promote efficiency and reduce dependence on oil imports.[9,10] Meanwhile, potential future liberalization of China's rail sector would also serve to support increasing efficiency levels.

For both waterway and air transportation, international treaties and regulations already contain measures to address the environmental impacts of the transport of both goods and people, including climate change impacts. As policymakers have unveiled revitalization plans designed to further develop the country's shipbuilding industry, China's shipbuilders should be obliged to conform to emerging standards for energy efficient ship design and operations. Alongside China's heavy investment in both air transport infrastructure and airplane manufacturing capabilities, the Civil Aviation Administration of China (CAAC) has recently established an Office of Energy Conservation, Pollutants and Emissions to put forward plans to address the environmental impact of China's air transport.

EXISTING AND EMERGING GREENTECH SOLUTIONS

As described in the Existing and Emerging Solutions Chapter, the China Greentech Initiative evaluated greentech solutions across two key dimensions, environmental impact potential and commercialization potential (an aggregation of addressable market size, solution attractiveness and market accessibility). See the Solutions chapter for a more complete description of the methodology used.

Nearly all cleaner road transportation solutions were found to have high unit environmental impact potential, reducing up to 40% of CO_2 emissions. While the commercial attractiveness of alternative fuels for road transportation is expected to decline over time due to stricter limitations on market access driven by regulations, both new energy vehicles and advanced internal combustion engine-based vehicles are expected to have increasing commercial potential as solutions mature and global oil prices maintain the risk of increase.[11] Electric bicycles have seen strong growth in China (with unit sales growing at an estimated 25% CAGR for 2004-2010), and are one of the potential drivers of China's expected growth in electric vehicles.[12]

Rail solutions were also found to have high unit environmental impact potential, but more limited commercialization potential due to China's many highly concentrated railway solution markets.

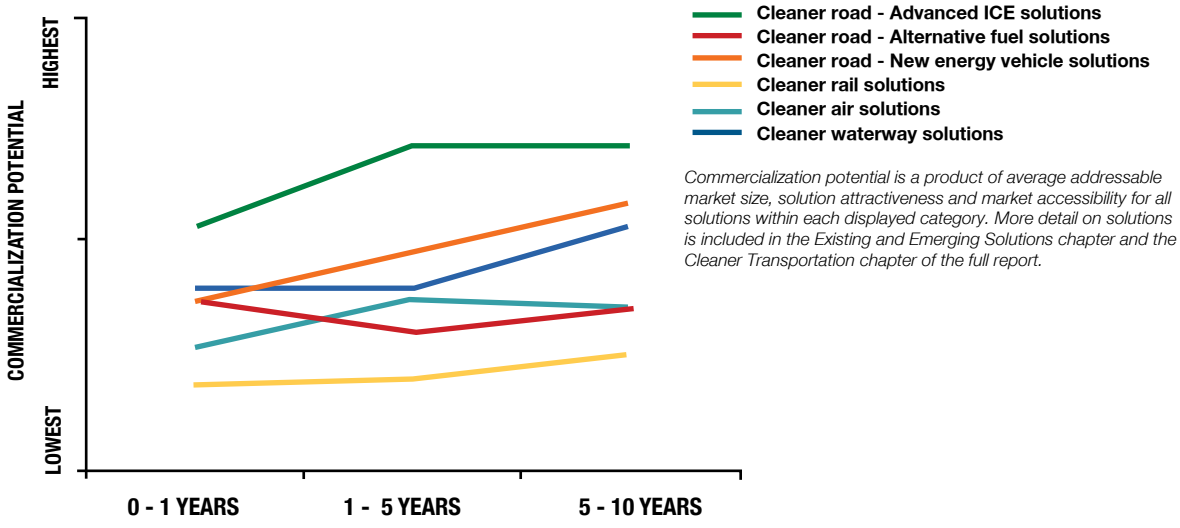
Cleaner air and waterway solutions also score high on environmental impact potential, but vary in commercialization potential. On average, cleaner waterway transportation solutions are relatively more commercially attractive due to China's drive to fully leverage its manufacturing sector through a world-leading shipping industry and given China's market accessibility restrictions of air traffic management industry.

CLEANER TRANSPORTATION SOLUTIONS EVALUATION SUMMARY

AREA	SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL
CLEANER ROAD TRANSPORTATION - Advanced ICE solutions	Advanced Diesel ICE	●
	Advanced Gasoline ICE	●
CLEANER ROAD TRANSPORTATION - Alternative fuel solutions	Bioethanol (E10)	●
	Compressed Natural Gas	●
CLEANER ROAD TRANSPORTATION - New energy vehicle solutions	Battery	●
	Battery Electric Vehicle	●
	Electric Two Wheelers	●
	Fuel Cell Vehicle	●
	Hybrid Electric Vehicle	◕
CLEANER RAIL TRANSPORTATION	Advanced Diesel Locomotive	●
	Electric Locomotive	●
	Multiple Unit Train	◑
CLEANER AIR TRANSPORTATION	Advanced Aircrafts	◕
	Cleaner Aircraft Fuels	●
	Optimized Air Traffic Management	○
CLEANER WATERWAY TRANSPORTATION	Advanced Ships	◕
	Cleaner Ship Fuels	●
	Optimized Waterway Operations	◕

LEGEND: Unit environmental impact potential of solutions: ● = **More than 40%** ○ = **Less than 10%**

CLENER TRANSPORTATION COMMERCIALIZATION POTENTIAL



Commercialization potential is a product of average addressable market size, solution attractiveness and market accessibility for all solutions within each displayed category. More detail on solutions is included in the Existing and Emerging Solutions chapter and the Cleaner Transportation chapter of the full report.

[1] *National Bureau of Statistics of China, "China Statistical Yearbook 2008"*
[2] *CAGR stands for Compound Annual Growth Rate*
[3] *United Nations Conference on Trade and Development, Review of Maritime Transport 2008 (Geneva, Switzerland: United Nations Conference on Trade and Development, 2008), 96*
[4] *National Bureau of Statistics of China, "China Statistical Yearbook 2008"*
[5] *Parkash, Manmohan, Promoting Environmentally Sustainable Transport in the People's Republic of China (Mandaluyong City, Philippines: Asian Development Bank, 2009), 21*
[6] *Ibid.*
[7] *McKinsey & Company, China's Green Revolution (Chicago, U.S.: McKinsey & Company, 2009), 31*
[8] *中国机电网, "汽车专家谈中国汽车业的可持续发展," [China Electromechanical Website, "Automotive experts on China's auto industry for sustainable development"], March 12, 2005, http://www.chinanics.com/*
[9] *Gerson Lehrman, "Rail and electric sectors to benefit from China's stimulus plan", http://www.glgroup.com/ (accessed on Mar.15, 2009)*
[10] *中华人民共和国国家发展和改革委员会,"国家发展改革委批准'中长期铁路网规划 (2008年调整)" 2008年10月, [National Development and Reform Commission, "On issuing Medium and Long-Term Plan for Rail Network Development (2008 revision)," October, 2008], http://www.ndrc.gov.cn/*
[11] *The China Greentech Initiative Cleaner Transportation working group evaluated one type of biofuel - bioethanol. Bioethanol is used to create a hybrid fuel E10, which is a mixture of bioethanol with regular gasoline in 10% to 90% respective composition. The Renewable Energy sector chapter contains a more detailed treatment for different types of biofuels.*
[12] *Asia Consulting Alliance, "M&A Analysis and Research on Electric Bicycle Industry in China 2008", http://www.acunion.net/ (accessed on July 28, 2009)*

GREENTECH DEVELOPMENT CHALLENGES

A number of challenges complicate the ongoing development of China's Cleaner Transportation sector:

CATEGORY	DESCRIPTION
MARKET	■ Low awareness of benefits and resistant market incumbents hinder the commercialization of Cleaner Transportation solutions
TECHNOLOGY	■ Many Cleaner Transportation solutions have high adoption costs, unclear future development trends and/or are not yet sufficiently mature for mass commercialization
FINANCING	■ Immature transportation technologies have significant investment risks; private investors have limited access to transportation infrastructure investments
REGULATORY	■ Underdeveloped transportation infrastructure combined with suboptimal regulatory planning, coordination and enforcement slow the development of China's Cleaner Transportation markets

OPPORTUNITIES TO ACCELERATE MARKET DEVELOPMENT

Cleaner Transportation sector opportunities include:
Three of the key opportunities highlighted by the China Greentech Initiative to accelerate market development in Cleaner Transportation include:

- Enhancing the capabilities of local solution providers to develop customized Cleaner Transportation solutions for China's market conditions
- Continuing to support the expansion of China's transportation infrastructure via options such as public-private investment partnerships
- Adopting best management practices and advanced IT solutions from other countries with respect to the planning and operations of both public transportation and goods transport

A breakdown of opportunities for different classes of stakeholders is available in the full version of the report.

SECTOR SNAPSHOT

CLEANER INDUSTRY

DEFINITION

Cleaner Industry encompasses practices that increase energy efficiency, reduce pollution of air and water and decrease the amount of solid waste produced by industrial activities. Solutions include on-site Combined Heat and Power (CHP), Energy Efficient Motors, Flue Gas Desulfurization (FGD) systems and Process Redesign.

MARKET CONTEXT

CHINA'S INDUSTRIAL SECTOR, which has grown rapidly since the 1970s and at an even more accelerated rate since China joined the World Trade Organization in 2001, manufactures a wide range of consumer and industrial products used around the world. As China's industrial output has grown to meet global demand and the needs of China's ongoing industrialization, so has its industrial sector's consumption of energy. China's industrial sector accounts for 76% of the country's total energy consumption, compared to the world average of 52%.[1] In 2006, China was the second largest consumer country of primary energy worldwide, accounting for 16% of the world's total.[2]

Production in China generally uses resources less efficiently than production in other countries. For example, while the energy intensity of many of China's basic material products has been declining steadily for the past twenty years, levels remain significantly higher than those in more developed countries.[3] China's energy intensity per unit of GDP is four times that of the U.S. and eight times that of Japan.[4]

China's industrial activity has a significant impact on the environment, with the industrial sector responsible for the overwhelming majority of China's CO_2 emissions. Industrial activities in China generate significant air and water pollution as well as solid waste, resulting in strained air, water and land resources.

CHINA'S REGULATORY RESPONSE

While China's regulatory response to the Cleaner Industry challenge has been resolute and broad, market participants often have limited knowledge of medium and long-term policy pace, specifics and timing. A number of ministries and administrative bodies are involved in regulating the industrial sector, with the National Development and Reform Commission (NDRC), the Ministry of Industry and Information Technology (MIIT) and the Ministry of Environmental Protection (MEP) playing central roles.

At the national level, China's 11th Five-Year Guidelines (2006-2010) established ambitious targets for improving energy efficiency, reducing emissions and minimizing natural resource use across a range of primary and secondary industries. Key targets for the 11th five-year period include a 20% reduction in GDP energy intensity and a 10% reduction in both sulfur dioxide (SO_2) and chemical oxygen demand (COD). In 2006, China's central government launched the Top-1000 Energy-Consuming Enterprises Program, one of the key initiatives behind its targeted energy intensity reduction.[5] The central government has also instituted a number of subsidies and incentive schemes to promote industrial energy efficiency and resource conservation.[6]

Aside from China's national regulators, provincial governments and local authorities also play critical roles in implementing sustainability policies, monitoring compliance and enforcing regulations.

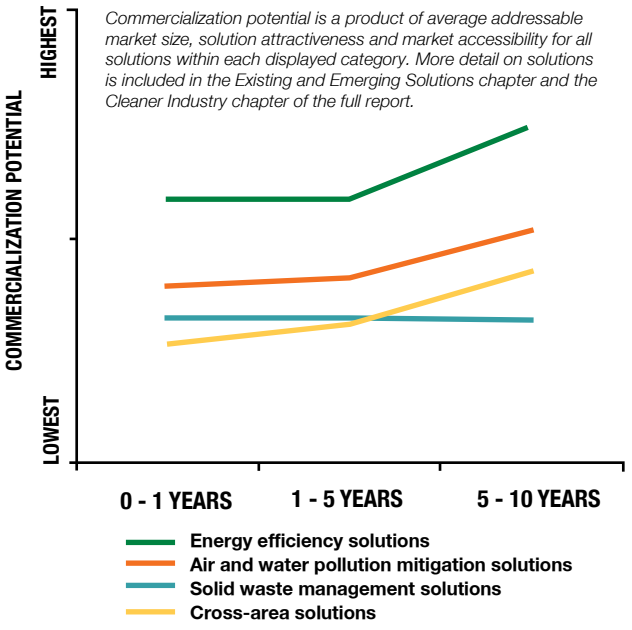
EXISTING AND EMERGING GREENTECH SOLUTIONS

As described in the Existing and Emarging Solutions chapter, the China Greentech Initiative evaluated greentech solutions across two key dimensions, environmental impact potential and commercialization potential (an aggregation of addressable market size, solution attractiveness and market accessibility dimensions). See the Solutions chapter for a description of the methodology used.

CLEANER INDUSTRY SOLUTIONS EVALUATION SUMMARY

SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL
ENERGY EFFICIENCY SOLUTIONS	
Balance of Plant	◔
Combined Heat and Power	●
Energy Efficient Motors	◑
AIR AND WATER POLLUTION MITIGATION SOLUTIONS	
Carbon Capture and Sequestration	●
Flue Gas Denitration	●
Flue Gas Desulfurization	●
Fuel Switching	◔
Industrial Wastewater	◕
Particulate Matter Removal	●
SOLID WASTE MANAGEMENT SOLUTIONS	
Incineration Energy Recovery	◔
Waste Separation and Off-Take	◕
CROSS-AREA SOLUTIONS	
Commissioning	◔
Environmental Management System and IT Systems	◔
Process Redesign	◑
Standard Operating Procedures, Training, Feedback	◔

Commercialization potential is a product of average addressable market size, solution attractiveness and market accessibility for all solutions within each displayed category. More detail on solutions is included in the Existing and Emerging Solutions chapter and the Cleaner Industry chapter of the full report.



LEGEND
Unit environmental impact potential of solutions:
● = More than 40% ○ = Less than 10%

evaluated greentech solutions across two key dimensions, environmental impact potential and commercialization potential (an aggregation of addressable market size, solution attractiveness and market accessibility dimensions). See the Solutions chapter for a description of the methodology used.

Air and water pollution solutions were found to have the greatest unit environmental impact potential, as they target specific pollutants and in many cases can achieve a removal rate of up to 90%. The commercial potential of these solutions should increase rapidly over time, in response to the improved enforcement of government regulations and a growing addressable market.

While the average unit environmental impact of energy efficiency solutions was also found to be significantly high, the analysis suggests that greater efficiency gains can be achieved through optimizing heating, power and motor systems than from enhancing the energy efficiency of other industrial equipment. Energy efficiency solutions, however, were found on average to present the greatest overall commercial potential due to their large, open markets and attractiveness to adopters conscious of the energy components of manufacturing costs.

Although solid waste management and cross-area solutions were found to have lower average unit environmental impact, they can still have notable effects across air and water pollution as well as solid waste. Their commercial potential was commonly limited due to a relatively small market size, compared to other solutions.

GREENTECH DEVELOPMENT CHALLENGES

A number of challenges complicate the ongoing development of China's Cleaner industry sector, including:

CATEGORY	DESCRIPTION
MARKET	■ Lack of awareness, support and experience to drive efficiency and adopt innovation
TECHNOLOGY	■ Solutions not always easily available and often costly and complex
FINANCING	■ Preferences for financing of state-owned enterprises over small and medium-sized enterprises ■ Government incentives not fully aligned ■ Limited range of applicable financing mechanisms
REGULATORY	■ Opaque, broad, complex and overlapping regulations ■ Limited enforcement and auditing capacity ■ Low energy prices and mild violation penalties

OPPORTUNITIES TO ACCELERATE MARKET DEVELOPMENT

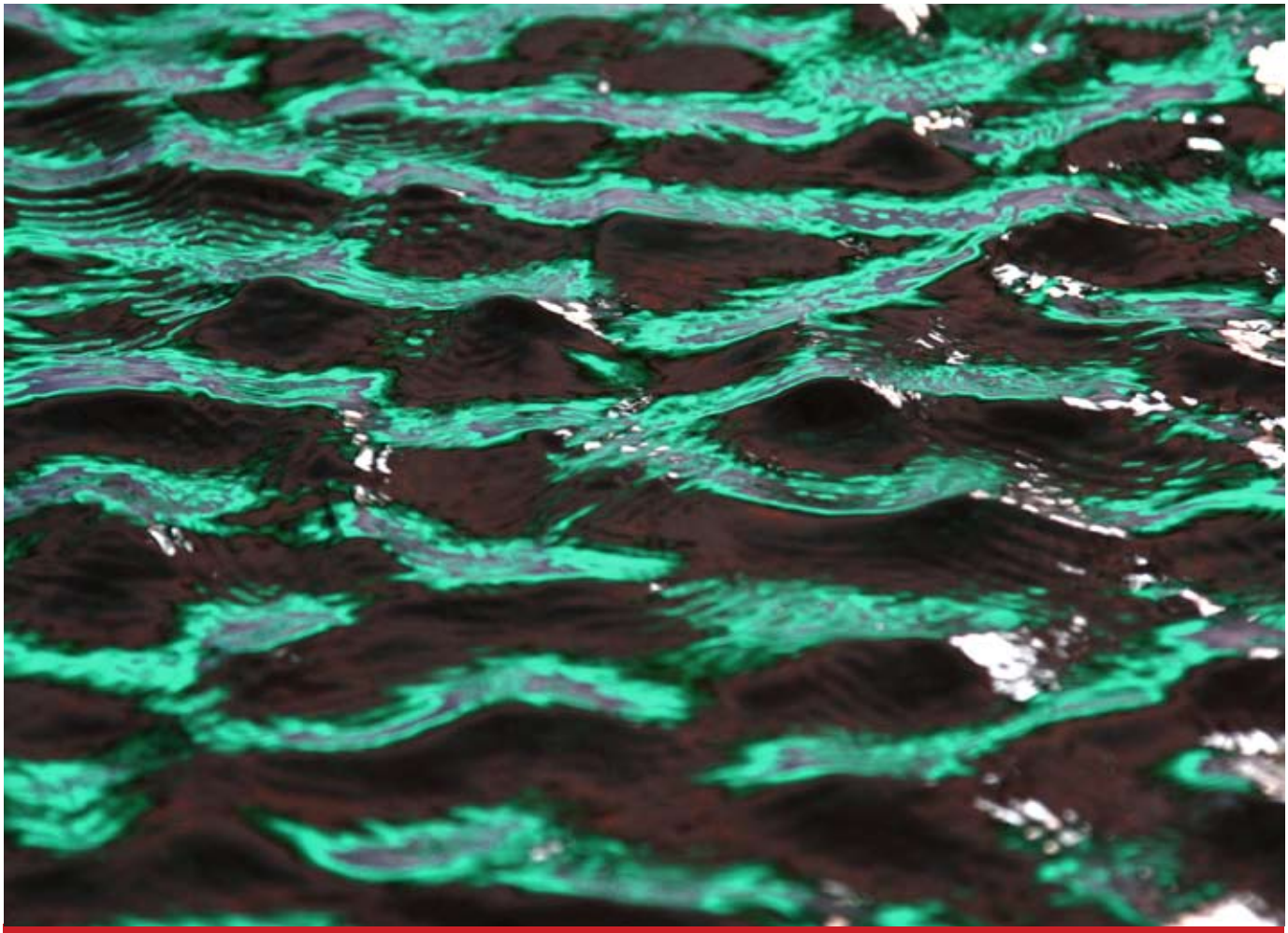
Opportunities for accelerating Cleaner Industry market development include:

Cleaner Industy sector opportunities include:

- Prioritizing demonstration projects to prove the viability of solutions
- Establishing cultures of efficiency and environmental awareness; conducting management and staff training and capacity development
- Developing and promoting innovative financing mechanisms for industrial facility upgrades
- Enabling and driving greater regulatory enforcement and compliance at all levels

A breakdown of opportunities for different classes of stakeholders is available in the full version of the report.

[1] *Energy Information Administration, International Energy Outlook 2009 (Washington DC, U.S.: United States Department of Energy, 2009), 203, 215*
[2] *International Energy Agency, Key World Energy Statistics 2008 (Paris, France: IEA, 2008), 48-57*
[3] *Hu, Xiulian et al., "Development of China Carbon Emissions Scenarios Towards 2050" (presentation given at the Asia-Pacific Initiative toward Environmentally Sound and Sustainable Society, Bonn, Germany, May 23, 2006), 5,6*
[4] *Energy Information Administration, "International Energy Annual 2006"*
[5] *Price, Lynn et al., China's Top-1000 Energy-Consuming Enterprises Program (Berkeley, California, U.S.: Lawrence Berkeley National Laboratory, 2008), 3*
[6] *中国社会科学院, "中国节能及环境政策调研报告," [China Academy of Social Sciences, "China Energy Saving and Environment Policy Survey Report"], (Beijing, China: 2008), 41-4*



SECTOR SNAPSHOT

CLEAN WATER

DEFINITION

The China Greentech Initiative defines the clean water sector as the collective sum of activities within the economic water cycle – water extraction, water treatment, water distribution, water use and wastewater treatment – with solutions including water treatment technologies, water quality measurement and monitoring and efficient point-of-use equipment.

MARKET CONTEXT

China's population growth and economic development will continue to drive significant increases in demand for clean water, which is projected to grow to 654 billion cubic meters in 2030, a 47% increase over 1980.[1,2] China's need to meet this growing demand will inevitably place more pressure on existing fresh water supplies.

With per capita water resources equivalent to only one-fourth of the world average, China faces severe water challenges. North China's water resources, a mere 11% of those in South China (on a per capita basis), are particularly stressed.[3]

Water pollution further diminishes China's usable water resources. China's industrial and domestic water users discharge 50+ billion tons of wastewater into the country's natural water bodies each year.[4] As much as 70% of China's rivers, lakes and reservoirs are seriously impacted by water pollution.[5]

The annual cost of China's water scarcity (i.e. imbalance between availability and demand), due to pollution and depletion of groundwater is estimated at 147 billion yuan (US$21.8 billion), almost 1% of China's annual economic output.[6]

China's insufficient water infrastructure coverage, particularly in rural areas, exacerbates scarcity and pollution and contributes to health problems among the population. China is rapidly building up its water infrastructure, but existing supply, sewerage and wastewater treatment infrastructure, particularly in rural areas, leaves a significant portion of the population underserved.

CHINA'S REGULATORY RESPONSE

China's government has a number of targets aimed at creating a harmonious, water saving society. For example, to address pollution, it aims to reduce chemical oxygen demand (COD, a measure of water pollution) by 10% by 2010.[7] To enhance the availability of supply, China is currently building a vast South-to-North Water Diversion project to support water needs in northern and western China. To improve water efficiency it plans to reduce water consumption by 60% per unit of GDP by 2020 through a variety of measures such as deployment of efficient irrigation systems, a reduction of average municipal pipeline leakage to within 15% and an increase of 10-20% of the portion of reused municipal wastewater.[8]

China's political system has a number of national, sub-national, local and cross-administrative regulatory agencies sharing responsibility for oversight of the water sector. These agencies have recently launched a range of initiatives to regulate and enforce water-related matters, including the introduction of specific laws, State Council regulations, ministerial regulations, local authority measures and other proactive policies.

While China has made solid efforts in recent years to develop its water quality standards to international levels, there are remaining regional differences in compliance levels throughout the country. Although national water quality data is not easily accessible, Chinese and international efforts continue to benchmark water utility performance so as to better understand China's true water situation.

The Chinese government continues to allocate substantial capital to the development of China's water industries. In its 11th Five-Year Guidelines (2006-2010), the Chinese government projected that its total investment in its water sector would amount to almost one trillion yuan.[9] The economic stimulus plans China promulgated in late 2008 allocated an additional 20 billion yuan to rural water conservation projects.[10] These decisive public investments in the water sector are expected to continue with 1.7 billion yuan already allocated to the construction of groundwater monitoring wells during the 12th Five-Year Guideline (2011-15).[11]

EXISTING AND EMERGING GREENTECH SOLUTIONS

As described in the Existing and Emerging Solutions chapter, the China Greentech Initiative evaluated greentech solutions across two key dimensions, environmental impact potential and commercialization potential (an aggregation of addressable market size, solution attractiveness and market accessibility). See the Solutions chapter for a more complete description of the methodology used.

China's increasingly pressing water scarcity drove the high average unit environmetal impact potential of both efficiency and multi-use solutions, while multi-use solutions' ability to also address China's pollution issues further supported high average environmental impact potential. These solutions also received high average scores for commercialization potential, due to the range of environ mental benefits they deliver, and their relatively unrestrictd and accessible makes. Future water price appreciation should drive the commercial potential of efficiency solutions.

Multi-use water solutions have, on average, a larger environmental impact rating than other types of water solutions, as they commonly address both pollution and scarcity issues. These solutions also received high average scores for commercialization potential, due to the range of environmental benefits they deliver, and their relatively unrestricted and accessible markets. Future water price appreciation should drive the increasing commercial potential of efficiency solutions.

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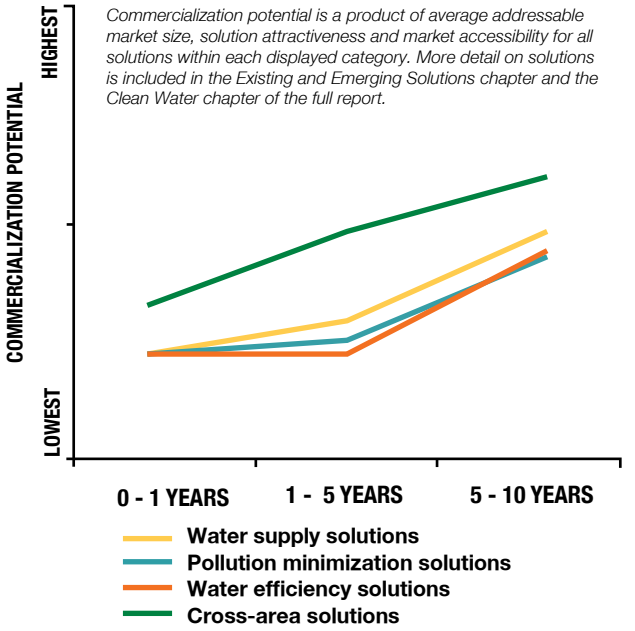
[1] Jian, Xie et al., Addressing China's Water Scarcity: Recommendations for Selected Water Resource Management Issues, (Washington, DC, U.S.: The World Bank, 2009), 23
[2] Food and Agriculture Organization of the United Nations, "AQUASTAT"
[3] Jian, Xie et al., Addressing China's Water Scarcity: Recommendations for Selected Water Resource Management Issues, (Washington, DC, U.S.: The World Bank, 2009), 11
[4] National Bureau of Statistics of China, "China Statistical Yearbook 2008"
[5] Greenpeace, "Water Pollution Has Become China's Most Urgent Environmental Problem Today," July 24, 2008, http://www.greenpeace.org/
[6] IGD, "The Value of Water," http://www.igd.com/ (accessed on August 25, 2009)
[7] People's Daily, "中共中央关于制定十一五规划的建议（全文）," [Full Text of the Chinese Communist Party Central Committee on the Full Development of the 11th Five-Year Plan], October 18, 2005, http://politics.people.com.cn/
[8] Ibid.
[9] "People's Daily, "Singapore International Water Week Opens Gateway to China Market," June 18, 2008, http://english.peopledaily.com.cn/
[10] Ministry of Water Resource, "China to Strengthen Rural Water Conservation with 20 Billion Yuan Plan," November, 24, 2008, http://www.mwr.gov.cn/
[11] Ministry of Water Resource, "Govt to Spend $249M on Groundwater Monitors," October, 29, 2008, http://www.mwr.gov.cn/

CLEAN WATER SOLUTIONS EVALUATION SUMMARY

SOLUTION	UNIT ENVIRONMENTAL IMPACT POTENTIAL
WATER SUPPLY SOLUTIONS	
Desalination	◑
Extraction Solutions	◔
POLLUTION MINIMIZATION SOLUTIONS	
Secondary Treatment Solutions	◑
Sludge Treatment and Disposal	◑
Tertiary Treatment Solutions	○
WATER EFFICIENCY SOLUTIONS	
Improved Irrigation	●
Low-Flow Fixtures	◑
MULTI-USE SOLUTIONS	
Advanced Distribution Materials and Components	○
Industrial Water Reuse	◕
Monitoring and Measurement Solutions	◔
Point-of-Use Solutions	◑
Primary Treatment Solutions	●

Commercialization potential is a product of average addressable market size, solution attractiveness and market accessibility for all solutions within each displayed category. More detail on solutions is included in the Existing and Emerging Solutions chapter and the Clean Water chapter of the full report.



LEGEND: Unit environmental impact potental of solutions:
● = More than 40% ○ = Less than 10%

GREENTECH DEVELOPMENT CHALLENGES

A number of challenges complicate the development of Clean Water sector in China, including:

CHALLENGES	DESCRIPTION
MARKET	■ Underdeveloped water markets combined with limited nationwide benchmarking hinder the commercialization of clean water solutions
TECHNOLOGY	■ Limited customization to China's unique water conditions or to potential adopter cost-tolerance levels
FINANCING	■ Low water tariffs, coupled with inadequate public and private financing and incentives, limit the availability of capital for investments in solutions
REGULATORY	■ Less than optimal regulatory planning and coordination, coupled with regional differences in enforcement of regulations, slow the development of the water markets

OPPORTUNITIES TO ACCELERATE MARKET DEVELOPMENT

There are several opportunities for market stakeholders to accelerate the development of China's Clean Water. Three of the key opportunities highlighted by the China Greentech Initiative include:

- Customize water solutions to the unique needs of China's water market
- Improve financial planning for the establishment and operation of water infrastructure
- Support value chain partnerships between public and private sector financers, solutions providers, operators and other key market participants

A breakdown of opportunities for different classes of stakeholders is available in the full version of the report.

[12] *Ministry of Water Resource, "China to Strengthen Rural Water Conservation with 20 Billion Yuan Plan", http://www.mwr.gov.cn/ (accessed on February 29, 2009)*
[13] *Ministry of Water Resource, "Govt to spend $249 m on Groundwater Monitors", http://www.mwr.gov.cn/ (accessed on February 29, 2009)*

PATH FORWARD

This report is a starting point for defining and framing China's greentech issues, challenges and opportunities, recognizing that these markets will continue to evolve rapidly.

THE CHINA GREENTECH REPORT 2009 provides an overall picture of China's greentech markets, challenges and opportunities as of the middle of 2009. As discussed, China's market requirements for greentech solutions are tremendous. Stakeholders have clear opportunities to accelerate market development and create a more environmentally sustainable China as illustrated by the key findings from the report:

- China's greentech markets encompass a wide range of sectors, segments and distinct solutions
- China has transformed dramatically over the last three decades into a colossal and resilient economy, but at significant environmental costs
- While China is likely to continue its rapid economic development, it is expected to do so in an environmentally sustainable way
- China has already laid the foundation for greentech market growth, and the first signs of this green transformation are promising
- Regulators have taken concrete steps to address its environmental issues and support the development of greentech markets
- China's greentech markets are also influenced by international policy principles, agreements and relationships, with China proactively engaging in dialogues related to global climate change and other environmental issues
- While many green technologies, products and services are still being developed, a great number already exist and are available in China today
- These greentech solutions hold the potential to mitigate the impact of economic development on China's natural environment and offer attractive commercial opportunities for both providers and adopters
- Twelve overall challenges remain to be addressed; four areas: market, technology, financing and regulatory
- Solution adopters, solution providers, financial investors, government regulators and other stakeholders have clear opportunities to address these challenges in an open source collaborative model, accelerating China's greentech markets and achieving the vision of an environmentally sustainable China

Intended to be a starting point that defines and frames market issues and opportunities, the Initiative recognizes that the report doesn't answer every question that market participants have. Given the broad scope of greentech markets in China, the country's immense scale and the intense speed at which regulatory, end user, competitive and technology markets are changing, certain aspects of this report will become dated relatively quickly.

Important questions that remain to be answered include evaluations of competing green technologies' functionalities and cost curves, assessments of emerging business models, strategies for addressing intellectual property and technology transfer concerns, reviews of alternative financing and partnership models, the impact of the Copenhagen climate change agreement on China, and many others.

Readers of *The China Greentech Report™ 2009* are invited to join the conversation by visiting www.china-greentech.com. The Initiative's website allows people to:

- Download electronic copies of the *Executive Overview*, full report and individual sector chapters
- Order printed versions of the report
- Access additional content developed by the Initiative
- Participate in interactive discussion forums to create, uncover and promote greentech solutions for an environmentally sustainable China and the world

The China Greentech Initiative looks forward to welcoming readers to its extended community. Suggestions on improving the content in this report are also welcome at feedback@china-greentech.com.

ACKNOWLEDGMENTS

Hundreds of individuals from more than 80 leading technology and services companies, entrepreneurs, investors, NGOs and policy advisors provided input to *The China Greentech Report 2009*. The logos of these organizations are presented on the front and inside covers, and a complete listing of partners and strategic advisors is included on the last page of the report. This report is only possible because of the support and direction provided from these organizations and their people.

THE CHINA GREENTECH INITIATIVE also recognizes and profusely thanks the many talented professionals who became part of its core and extended teams over the past year. Driven by their passion for greentech opportunities in China, these team members demonstrated their willingness to tackle huge objectives and meet unrealistic deadlines while delivering the highest quality deliverables. They've worked countless late hours, sacrificed many weekends, mastered new skills, juggled competing priorities and flexibly addressed problems identified along the way. These professionals and their affiliation (when not employed directly by the Initiative) are acknowledged below.

RESEARCH TEAM

Randall S. Hancock, co-Managing Director of the Initiative and CEO of MangoStrategy, LLC, led the research team and the writing of this report. Hermes Sun (孙兆庆) directed the research team onsite from Beijing. Constantin Crachilov and Gary Sharkey (PwC) co-wrote much of this report and each managed multiple research teams. Annabell Chartres (PwC), Ana Lin T. Chiong (MangoStrategy), Michael Li (李明), Sherry Li (李晓丽, PIM), Erica Yu (郁晓菲, PIM) and Jasmine Zhang (张金莉, PwC) managed individual sector teams. Core analysts with the Initiative for the duration were Joy Bian (卞玉娟), Angela Fan (范羽), Helen He (何晓彦) and Rachel Xiao (肖凝).

Others joined the research team at specific points in the project, many as volunteers. These extended team members included Anna S. Abarro (MangoStrategy), Renyi Ang, Aaron Arfman (Hao Capital), Brianna Buck (U.S. Foreign Commercial Service), Manuel Lionel R. Basilio (MangoStrategy), Zhao Chao (PIM), Annie Chen (PIM), Kevin Ching (U.S. Foreign Commercial Service), Xin Chen (陈歆, PwC), Siobhan Das Bachran (American Chamber of Commerce in Shanghai), Mei Ping Doery (李美萍, PwC), Bienvenido E. Esmero (MangoStrategy), Nicki Fung (冯斯琦, PwC) Lydia He (PIM), Yusha Hu (Fulbright Scholar at Tsinghua University), Jennifer Jin (Dow Corning), Rei Kobayashi, Rose Ann S.C. Laurel (MangoStrategy), Geoffrey Lewis (Fulbright Scholar at Tsinghua University), Jennifer Li (李宁, PwC), Ray Li (RCC China), Lina Li (李莉娜, Peking University), Lewis Liu (刘杰, PwC), Feng Lei Ma (马逢蕾, Peking University), Giuseppe N. Parente (MangoStrategy), Lilian Pu (濮国立, PwC), Manuel Rincon-Cruz (Harvard University), Randy Ruan (阮春浩, Corning), Tobias Robinson (PwC), Garret Stiles, Steve Teng (Harvard University), Bianca Wang (王白羽, Climate Change Capital), Claudia Wang (王晴, PwC), Wilson Wang (王吉涛, PwC), Rachel Wasser, Paul C. Watson, Yang Yang (杨阳, PwC), Jessie Yu (喻方, PwC) and Steve Zhou (周尤, PwC).

PARTNER OUTREACH TEAM

Ellen G. Carberry, co-Managing Director of the Initiative and a Partner with Hao Capital, led the partner outreach and government relations team. Craig Adams, Christian Bedard, Cindy Jiang (姜新燕) and Tom Ward (PIM) were the principals responsible for developing and managing relationships with the Initiative's partners and strategic advisors. Together, they complimented one another to achieve a broad representation and significant participation of companies and non-profit organizations from diverse industries, geographies and roles. Craig Adams, with assistance from James Dougherty, contributed significantly to managing the

ACKNOWLEDGMENTS

Initiative's marketing and communications activities. Jason Hu (于经东) provided tremendous administrative support across all facets of the Initiative. In addition, the American Chamber of Commerce in Shanghai (AmCham Shanghai) also contributed to the partner outreach activities.

PROJECT MANAGEMENT

Annabell Chartres (PwC) served as the project manager for the Initiative, in addition to the research role noted earlier. Thanks to her organizational skills and tireless commitment, she made it possible to manage successfully the Initiative's enormous complexity.

REPORT PRODUCTION

Several individuals from AmCham Shanghai played critical roles in the production of the report – Siobhan Das Bachran, in addition to overseeing the Chamber's overall participation in the Initiative, coordinated the overall production effort. Katie Howe edited and managed the editorial process. David Basmajian, along with other Chamber staff, provided additional support. Marianne Kaulima was responsible for the report's design and layout. Julius Mak, a Shanghai based photographer, provided all of the images used in this report at no cost to the Initiative. Scribes of the Orient provided the Chinese translation for the online version and print production was executed by Snap Printing, Shanghai.

NOTABLE OTHERS

Finally, while it is impossible to name the hundreds of other individuals from the partner and strategic advisor group who've assisted in so many ways, a few people stand out for special recognition.

Ruth Dobson (PwC), who managed PricewaterhouseCoopers' participation in the Initiative, provided detailed feedback on all facets of the research, procured additional research support when needed, ensured availability of meeting facilities, participated in sector working sessions, hosted team parties and much more. Other members of PricewaterhouseCoopers' leadership team who contributed greatly to the Initiative include Nora Wu (顾宜), Martin Foley, Cynara Tan (陈细丽) and Allan Zhang (张鉴钧).

Other individuals made significant contributions to the founding of the Initiative when it was just a vision, including Charles Liu (刘扬声), Simon Eckersley and Elaine Wong (Hao Capital), Steve Bertamini (former CEO of GE North Asia and China), Peter Marrs (Dell), Bryan Larson (U.S. Foreign Commercial Service) and Gary Rieschel (Qiming Ventures). Brenda Lei Foster (AmCham Shanghai) and its Environmental Committee, led by including Tom McCawley (Owens-Corning), Charles McElwee (Squire, Sanders and Dempsey) and Matt Targett (Bayer), who saw the potential of broadening the Initiative to include seven working sector teams.

In July 2008, Frans Greidanus (Philips Asia) became the Initiative's first European partner, and in the same month, Beijing Capital (北京首创) became the first Chinese state-owned enterprise to join. Tina Ju (KPCB China) hosted CEOs of Initiative partners at a private reception with former U.S. Vice President Al Gore. David Nieh (Shui On Development, 瑞安房地产) hosted discussion dinners for the Initiative's research team in Shanghai. Steve Wittrig and Li Zheng (Tsinghua-BP Clean Energy Center, 清华-BP清洁能源中心) dedicated hours of their time on weekends and contributed a steady stream of secondary research.

GLOSSARY

TERM	DEFINITION
Advanced aircraft	Aircraft that are more fuel efficient and produce less emissions than conventional models used in China.
Advanced coal mining equipment	Coal mining equipment that is more energy efficient and enables higher extraction rates than conventional equipment.
Advanced diesel internal combustion engine (ICE) vehicles	Vehicles with diesel ICE that are more fuel efficient and produce less emissions than conventional models used in China.
Advanced diesel locomotives	Diesel locomotives that are more fuel efficient and produce less emissions than conventional models used in China.
Advanced envelopes	Includes insulation, windows, roofing and other passive solutions either installed more accurately than China's market convention or combined with active systems such as moisture or temperature sensors to enable reduced heat gain or loss.
Advanced gasoline internal combustion engine (ICE) vehicles	Vehicles with gasoline ICE that are more fuel efficient and produce less emissions than conventional models used in China.
Advanced metering infrastructures (AMI)	Integrated systems that measure, collect, store and analyze utility usage. Some of which include electricity, gas or water; a broader concept than AMR-IP based solutions.
Advanced recycling fees	Fees paid upon the purchase of new electric or electronic equipment and are used to finance the recycling of electric and electronic equipment waste.
Advanced ships	Ships that are more fuel efficient and produce less emissions than conventional models used in China.
Aeration	Wastewater treatment application in which water is passed through air. The subsequent increase in the water's oxygen content assists bacteria in the clean-up process.
Amine treatments	Also called amine gas sweetening (a desulfurization technique) is a process that removes hydrogen sulfide and carbon dioxide from natural gas.
Amorphous silicon thin film photovoltaic cells (a-Si PV)	Type of thin film solar cells based on amorphous silicon chemical compound.
Anaerobic digestion	Series of processes in which microorganisms break down biodegradable material in the absence of oxygen. Application is widely used to treat wastewater sludge and organic waste. It reduces the emission of landfill gas and produces a methane and carbon dioxide-rich biogas suitable for energy production.
Balance of plant	Optimization of a plant's equipment aimed at maximizing energy, water efficiency, as well as minimizing pollution and waste.
Basic industries	Collection of enterprises that produce the refined basic materials necessary for manufacturing consumer goods and that use raw materials from extractive industry.
Batteries	Combination of electrochemical cells that store electricity.
Battery electric vehicles (BEV)	Vehicles that completely rely on electricity storage batteries as a power source and are driven by electric motors.

Battery storage	Electrochemical cells that can be used to store energy. They are able to be charged using electricity and then discharged to produce electricity.
Biochemicals	Chemicals that are naturally existing and occur without artificial aid.
Biodiesel	Non-petroleum-based diesel fuel that utilizes either vegetable oil or animal fat.
Bioethanol	Ethyl alcohol (an alternative to gasoline) is produced from certain agricultural crops through a microbial sugar fermentation process.
Biofuels	Solid, liquid or gaseous fuels derived from biological materials (e.g. sugar cane or feedstock). Biodiesel and bioethanol are the most common types of biofuels used in automobiles.
Biogas	Type of biofuel that is produced by the breakdown of organic matter via fermentation, producing mainly carbon dioxide and methane, or the gasification of wood matter, producing nitrogen and hydrogen.
Bioheat	Fuel comprised of a blend of heating oil and biofuel used mainly for home heating applications.
Biological flocculation	Process where pollutants in water are concentrated together in the form of flakes, which are used in the purification of drinking water and treatment of sewage.
Biological wastewater treatments	Treatment methods that usually seek to reduce the organic and nutrient content (notably nitrogen and phosphorus) of wastewater.
Biomass	Renewable energy source comprised of living or recently dead biological material (plant or animal matter) that can be converted into fuel.
Biomass co-firing	Process that generates power plant electricity by simultaneously burning biomass with coal.
Biomass combustion	Burning of biomass to generate power plant electricity.
Biosphere	Term used to describe the entire global ecological system and the relationship of its inhabitants.
Building energy intensity	Measurement of a building's energy efficiency calculated as units of energy per square meter.
Building integrated heat and power	Combination of heating and power generation solutions that could be integrated into a building. Some of which include solar photovoltaic cells, wind turbines and solar water heaters.
Building integrated photovoltaics (BIPV)	Application of solar photovoltaic materials, whether crystalline or thin-film, into actual building structures. This normally replaces conventional building materials in parts of the building envelope such as the roof, skylights or facades.
Build-operate-transfer (BOT)	Arrangement wherein the government awards a franchise license to a private sector company (including foreign companies) for a certain period of time. This in turn permits the construction and operation of a specific public infrastructure project, which is eventually transferred to the government free of charge when the concession period expires.
Bus rapid transit (BRT)	An efficient bus system resulting from improvements in infrastructure, vehicles, and schedules.

Cadmium telluride thin film photovoltaic cells (CdTe PV)	Type of thin film solar cells based on the cadmium telluride chemical compound.
Capture and use of coal mine ventilation air methane	Process of capturing and then using the methane that is contained in the exhaust air from underground coal mines.
Carbon capture and sequestration (CCS)	System that captures carbon dioxide from fossil fuel, either prior to or after combustion, and sequesters it for long-term storage underground.
Carbon dioxide equivalent (CDE)	For a given amount of greenhouse gas, it is the amount of carbon dioxide (CO_2) with the same global warming potential (GWP), assuming it remains in the atmosphere for 100 years. For example, the GWP of nitrous oxide is 320 times that of CO_2, thus one ton nitrogen oxide equals 320 tons CDE.
Carbon monoxide (CO)	Odorless, colorless, poisonous gas produced by the incomplete burning of fossil fuels (e.g., gasoline, oil, natural gas). Produced primarily by vehicles and industrial processes.
Cassava bioethanol	Bioethanol produced from cassava crop.
Cellulosic bioethanol	Bioethanol produced from wood, grasses or other plants.
Centralized energy generation model	Energy is generated in large-scale centralized power plants and distributed to the end user via the power grid.
Certified emission reductions (CER)	Refers to carbon and/or climate credits issued by the Clean Development Mechanism. CERs are utilized by participating countries (and projects) in order to comply with established emission limitation targets. They can be temporary or permanent depending on the duration of its benefits, and can be acquired or traded on the market.
Chemical wastewater treatments	Treatment methods that use substances such as chlorine, ozone or hydrogen peroxide to remove pollutants.
CIGS thin film photovoltaic cells (CIGS PV)	Type of thin film solar cells, based on the copper irridium gallium selenide chemical compound.
Circulating fluidized bed combustion (CFBC)	Combustion application that uses fluidized beds, which is a device that causes the solid components of a fluid to act like a liquid. It then suspends solid fuel over streams of hot air during the combustion process thereby resulting in more efficient chemical reactions.
Civil heat	Burning of biomass to generate heat to be used for civil purposes.
Clean Development Mechanism (CDM)	Mechanism by which countries that are signatories to the Kyoto Protocol can invest in emission reduction projects in developing countries instead of implementing similar projects in-country.
Cleaner aircraft fuels	Aircraft fuels that produce considerably less air emissions than conventional aircraft fuels while delivering equal or better performance.
Cleaner ship fuels	Ship fuels that produce considerably less air emissions than conventional ship fuels while delivering equal or better performance.
Coal bed methane (CBM)	Methane originating in coal seams in a near liquid state that is drained from surface boreholes before mining takes place
Coal blending	Process of combining various types of pulverized coal to take advantage of their different combustion and emission properties.

Coal briquettes	Small rectangular blocks of compressed coal used in limited industrial applications, primarily smaller scale chemical plants and blast furnaces. Utilization of briquettes can reduce emission resulting from combustion.
Coal liquefaction	Process that converts coal into liquid fuels.
Coal mine methane (CMM)	Methane contained in gases captured in a working coal mine by methane drainage systems.
Coal screening and scrubbing	Processes that reduces impurities (such as ash or sulfur) contained in coal prior to burning, normally at or close to the coal mine.
Coal water slurry	Coal-based liquid fuel consisting of fine coal particles suspended in water. It consists of 55-70% of fine dispersed coal particles and 30-45% of water.
Coal water slurry technology	Technology and application that transforms coal water slurry into a viable energy product. The use of slurry saves substantial amounts of heavy oil in the electricity generating process and emits fewer pollutants.
Coke	Dense, almost completely pure form of carbon that burns at very high temperatures. Used in a variety of industrial applications, including steel production.
Combined cycle	A technique, employed by power producing plants or engines, that uses more than one thermodynamic cycle so as to further utilize waste heat generated from initial combustion.
Combined heat and power (CHP)	System that simultaneously generates electricity and usable heat by capturing heat that would normally be lost.
Commissioning and efficient operations	Assuring that all systems in a building are installed, tested, operated and maintained as originally intended.
Composite materials cables	Transmission and distribution line cables made from compostive materials that are specifically engineered to reduce losses.
Compost	Biodegration or decay of organic matter, such as agricultural and food waste. Compost, a high quality fertilizer, is the main byproduct of the process.
Compressed air energy storage (CAES)	System that can store energy by compressing air in a compartment, such as airtight underground cavern, and then generate electricity by releasing the air from storage through a combustion turbine.
Compressed natural gas (CNG)	Fossil fuel substitute for gasoline, diesel or propane made by compressing natural gas and stored in special compressed gas cylinders.
Concentrating photovoltaics (CPV)	Devices that concentrate sunlight onto photovoltaic surfaces to produce electricity.
Concentrating solar power (CSP)	Whereas concentrated photovoltaic uses photovoltaic surfaces to generate electricity, CSP uses lenses or mirrors and tracking systems to concentrate a large area of sunlight into a small beam. The heat produced by the small beam of light will then be used to generate electricity.
Control systems	Systems that monitor and control the behavior of other devices or systems to ensure optimal operation of the wind turbine.

Conversion efficiency

Ratio between input and output after an energy is converted from one form to another. The calculation of this ratio also figures in the usefulness of the output amount. Specifically for photovoltaic cells, conversion efficiency is the proportion of sunlight energy that the cell converts to electrical energy.

Conversion technologies

Devices that convert electricity received from a set of wind turbines to the standard required by the power grid before feeding the electricity onto the grid.

Copper rotor motors (CRM)

Motor technologies that offer increased electrical energy efficiency, lower operating temperature, extended motor life and reduced weight and size.

Crystalline silicon photovoltaic cells (cSi PV)

Type of solar cell made from a single crystal or a polycrystalline slice of silicon; it was the first type to be widely commercialized.

Cylinder deactivation

Automobile engine technology that can reduce fuel consumption and emission of an engine during light load operation by keeping the intake and exhaust valves closed for a particular cylinder.

De-dusting

Process designed to remove particulate matter created in the power generation process. Electrostatic precipitators create an electric field that essentially captures particulates; up to 99% of particulates in gas can be captured in this way.

Desalination

Process that removes salt and other minerals from saline water (such as sea water) in order to make it suitable for human consumption or irrigation.

Diesel oxidation catalysts (DOC)

Designed to oxidize carbon monoxide, gas phase hydrocarbons and the sulfur component of diesel particulate matter thereby creating carbon dioxide and water. Has been shown to reduce emission by up to 50%.

Diesel particulate filters (DPF)

Filters that use silicon carbide blocks in the exhaust systems of locomotives to trap particulate matter. Can reduce emission by up to 80%.

Digital substations

Automated and computerized substations that provide greater transparency, higher reliability and efficiency of operations.

Dimethyl ether (CH_3OCH_3)

Considered a clean burning hydrocarbon fuel, CH_3OCH_3 is produced by the gasification of coal or natural gas. Considered to have potential as a synthetic biofuel.

Discharge rate

Rate at which pollutants or other materials are emitted into the environment, i.e. the amount of solid, liquid or gaseous material emitted over a period of time.

Disinfection

Process that involves the removal of pathogenic organisms from water via the use of chlorine and ultraviolet light, among other applications.

Distributed generation

Small-scale power generation technologies (typically in the range of 3 kW to 10,000 kW) used to provide an alternative to or an enhancement of the traditional electric power system. Power generation is achieved on-or-off-grid, as opposed to large-scale centralized power plants.

Distribution materials and components

Pipes, valves and nozzles that are used to transport water, primarily between treatment plants and usage points.

Efficient motors	Electric motors that are more energy efficient than conventional models currently used in China.
Efficient processing	Processes that are energy-efficient, low-polluting, eco-friendly and leave behind little or no solid waste.
Effluent	Wastewater (treated or untreated) that comes out of sewage treatment facilities and/or industrial facilities.
Electric two wheelers (E2W)	Bikes and scooters equipped with a rechargeable battery and an electric motor used for propulsion.
Electric auto vehicle (EAV) charging systems	Systems that allow for plug-in electric vehicles to be charged using power from the grid.
Electric locomotives	Locomotives powered by an electric engine which uses an electricity source, such as an overhead line, third rail or an on-board electricity storage device, rather than fossil fuels to meet its energy requirements.
Electrical/electronic waste (e-waste)	Discarded, obsolete, broken or surplus computers, entertainment electronic devices, mobile phones, televisions, refrigerators and electronic items, whether sold, donated or discarded by their original owners.
Embodied energy	Total energy used in the manufacturing of product. An accounting method that computes the sum total of the energy necessary for the entire life cycle of a product.
Emission standards	Requirements that set specific limits to the amount of pollutants that can be released into the environment, which generally include nitrogen oxides, sulfur oxides, particulate matter, etc.
Energy intensity of GDP	Average amount of energy consumed to produce a unit of GDP.
Engineering, procurement, construction (EPC)	Project contract that includes engineering, procurement and construction.
Enhanced coal bed methane (CBM) recovery	Process of recovering additional coal bed methane from hydrocarbon-rich rocks.
Enhanced oil recovery (EOR)	Solutions that increase the amount of extractable crude oil from an oil field, such as: Gas injection, chemical injection, ultrasonic stimulation, microbial injection or thermal recovery.
Environmental management system (EMS) and IT systems	Comprehensive, systematic, documented management of an organization's environmental programs that rely on IT solutions for effective operation.
Ethanol 10 (E10)	Vehicle fuel comprised of 10% ethanol blend with gasoline that has become a standard in China. Blend can be used in standard internal combustion engines without need for modifications.
Extraction solutions	Solutions that help locate, access and extract water from underground sources.
Fabrication industries	Businesses engaged in the production of manufactured goods; excluding the generation of energy for manufacturing processes. This is in contrast to the term "manufacturing industry", which sometimes encompasses both energy generation and goods fabrication.
Fast neutron reactors	Type of nuclear reactors that can utilize nuclear wastes from thermal reactors as feedstock and operate at higher efficiencies.

F-class gas turbines

Advanced technology gas turbines, which are rotary engines that extract energy from a flow of combustion gas at thermal power plants, that are more efficient and reliable than conventional gas turbines.

Filtration

Removing solid particulate matter suspended in water by passing the water through permeable fabrics or porous layers of soil.

First generation biofuels

Fuels that use feedstock such as sugary or starchy materials that are then fermented into bioethanol. Also includes oil from seeds that can be used in biodiesel.

Flue gas denitration (De-NO_x)

System that removes nitrogen oxides from flue gas.

Flue gas desulfurization (De-SO_x)

System that removes sulfur oxides from flue gas.

Flue gas purification

Process by which flue or exhaust gases are cleaned in order to remove nitrogen oxides, soot and other particulates.

Fresnel mirrors

Solar thermal energy collectors that consist of a series of long, narrow, slightly curved mirrors that focus the light onto linear receivers positioned above the mirrors to be eventually converted into electricity.

Fuel cell vehicles (FCV)

Vehicles propelled by an electric motor using electricity generated through a chemical process within a fuel cell, which requires hydrogen fuel and oxygen from the air as feedstock.

Fuel economy standards

Standards that regulate the amount of fuel required to move the automobile over a given distance.

Fuel switching

Ability to make use of alternative fuels either by using multiple fuels simultaneously or by switching between fuels.

Gas flaring and venting

Method by which excess natural gas typically found at oil wells and refineries is burned in order to prevent the buildup of excess pressure. Flaring and venting are major contributors to greenhouse gas emission.

Gas reburning

Process designed to reduce the emission of nitrous oxides generated by natural gas boilers by injecting natural gas above the boilers' coal burners in order to "reburn" the byproducts of combustion.

Gasification

Method that extracts energy from organic materials. Carbon-based matter (e.g. coal) reacts at high temperatures with oxygen producing synthesis gas. Process can be more efficient than direct combustion of carbon material and is considered to be more environmentally sound as well.

Gasoline grades

Classification system that categorizes gasoline by octane ratings. The three types of gasoline (conventional, oxygenated, and reformulated) are further broken down into regular, midgrade and premium categories, all based on octane content.

Generators

Machines that convert one type of energy, such as kinetic or mechanical, into electrical energy.

Global warming potential (GWP)

Measure of a given pollutant's estimated contribution to global warming. Scale is relative and compares the gas in question to that of the same mass of carbon dioxide.

Green devices	Electronic devices used inside buildings (including lighting solutions, appliances and consumer electronics) that are more energy efficient than conventional alternatives.
Greenfield refineries	Refinery facilities that are built on sites that have not experienced previous development.
Greenhouse gas (GHG)	Gas in the atmosphere that absorbs and emits radiation within the thermal infrared range (including water vapor, carbon dioxide, methane, nitrous oxide, ozone and chlorofluorocarbons).
Greywater systems	Systems that focus on the reuse of water generated from domestic processes such as dish washing, laundry and bathing for either indoor use or in irrigation.
Hazardous wastes	Wastes characterized as being flammable, oxidizing, corrosive, toxic, radioactive, explosive or with the potential to threaten public health or the environment.
Heating, ventilation and air conditioning (HVAC)	Climate control system of buildings; it ensures that room temperature, humidity and air flow are adequate to sustain a comfortable living environment.
High temperature superconducting transformers	Transformers that use high temperature superconducting materials to improve efficiency and reduce losses in electrical transmission.
High voltage transmission	Movement of voltage over long distances (greater than 35,000 volts).
Horizontal-axis wind turbines (HAWT)	Most common type of turbine, with the main rotor shaft and electrical generator at the top of a tower and is usually pointed into the wind.
Hot-summer/cold-winter zone (aka transition zone)	Region in China characterized by hot, humid summers and cold, humid winters. Temperature difference between day and night is relatively little and there is usually large amount of precipitation in a year. Zone includes the whole of Hubei, Hunan, Jiangxi, Anhui, Zhejiang provinces, Shanghai, Chongqing, the eastern parts of Sichuan and Guizhou provinces, the southern parts of Henan, Jiangsu, Shanxi and Gansu provinces and the northern parts of Fujian, Guangdong and Guangxi provinces.
Hybrid electric vehicles (HEV)	Vehicles that combine an internal combustion engine with an electric motor to drive the vehicles, and rely on gasoline or diesel and electricity storage batteries as power sources.
Hybrid locomotives	Locomotives that utilize a conventional power source (typically a diesel engine) in conjunction with a rechargeable energy storage system (REES). The REES is charged using the surplus energy from the power source and/or from regenerative breaking, and can then be used to provide energy for propusion.
Improved irrigation	Irrigation solutions (such as sprinkler or drip irrigation) that use water more efficiently than China's conventional irrigation methods with equal or greater benefit to the user.
Incineration energy recovery	Waste to energy solution that generates power from the combustion of solid waste.
Industrial heat	Burning of biomass to generate heat to be used for industrial purposes.
Industrial solid wastes	Garbage, refuse, sludge and other solid materials discarded as a result of industrial operations. Commonly understood to exclude biodegradable and hazardous waste.

Industrial symbiosis	Form of industrial organization where waste from one production process can be used as an input in producing another good, thus maximizing resource efficiency and minimizing industrial waste.
Industrial wastewater systems	Systems used at industrial sites to treat water after use prior to either reuse or release into the natural environment.
Industrial water reuse	Process whereby certain pollutants are removed from industrial wastewater so that the water can be recycled for further uses at the same site.
Influent	Water flowing into wastewater treatment plants.
Installed capacity	Theoretical production capacity of the total equipment that is installed, as opposed to the effective capacity which is the actual optimal production.
Integrated design	Approach that brings together all the stakeholders in the building process at an early stage to maximize building comfort and usability while minimizing resource use.
Integrated gasification combined cycle (IGCC)	System that turns coal into synthesis gas and removes impurities before combusting it in gas turbines; the waste heat is captured and passed to a steam turbine system for energy recovery.
Integrated rainwater collection	System that collects and stores rainwater from the rooftop of a building to be used locally.
Internal combustion engines (ICE)	Engines in which the combustion of a fuel occurs with an oxidizer in a combustion chamber. In an ICE, the expansion of the high temperature and pressure gases directly apply force to a movable component of the engine, such as the pistons or turbine blade.
IP-based automatic meter reading (AMR)	Solutions that automatically gather data from energy metering devices and transmit to a central processing facility where billing is handled and consumption patterns are analyzed.
Jathropa diesel	Biodiesel produced from jatropha crop.
Kim hotstart idle reduction systems	Systems that rely on electric and small diesel powered heating units to maintain desired engine temperatures (both coolant and lube oil) while the locomotive is shut down.
Lean manufacturing	Methodology seeking to minimize waste (non-value added activities) in manufacturing processes through the use of inventory management, preventive maintenance, product quality and flexible workforces and production facilities.
Line loss rate	Measurement of the energy lost during the transmission of electricity, a significant portion of which is thermal in nature.
Liquefied natural gas (LNG)	Natural gas temporarily converted into liquid form in order to ensure ease of storage and transport. The reduction in volume is accomplished by cooling the gas until it becomes liquid.
Liquefied petroleum gas (LPG)	Mixture of hydrocarbon gases (typically propane and butane) that are synthesized from petroleum. It is a low carbon emitting fuel source for powering appliances and vehicles.
Liquefied petroleum gas (LPG) vehicles	Vehicles that use LPG as its primary fuel. There are two types of LPG vehicles: 1. those that only utilize LPG; and 2. so called "dual fuel" autos that can use both LPG and conventional gasoline.

Liquid flow batteries	Rechargeable batteries that convert chemical energy into electricity by allowing an electrolyte containing one or more dissolved electro-active species to flow through an electrochemical cell.
Lithium ion (Li-Ion) batteries	Known for their use in consumer electronics, as well as increasingly being used in pure electric vehicles applications. Compared to nickel-metal hydride batteries, Li-Ion batteries enjoy a higher energy density, longer life cycle, more rapid charge and perform better in colder weather.
Local sourcing	Procuring and sourcing building materials within the geographical proximity of their intended use.
Low-flow fixtures	Faucets and other water use systems that use less water than conventional systems but deliver the same or greater benefit to the user.
Low-impact materials	Building materials that use less resources and produce less pollution compared to conventional building materials over their life cycle.
Maintenance	Set of inspections, repairs or modifications of individual wind turbines or wind farms to ensure optimal operation.
Medical wastes	Also known as clinical wastes, normally refers to wastes produced on healthcare premises such as hospitals, clinics, doctors offices, labs and nursing homes. They are normally bio-hazardous or infectious and may contain blood, objects contaminated in medical procedures and body parts.
Membrane bioreactor (MBR) process	Multistage waste water treatment process which combines biological waste oxidation and membrane separation in order to remove effluents.
Membrane separation	Technologies utilized to remove water vapor and carbon dioxide from natural gas.
Metallurgical coal	A higher-quality coal used in making coke. Also known as coking coal.
Methane hydrocarbons	Main atmospheric pollutants released in the process of oilfield exploitation and the production of petroleum.
Methane recovery and utilization	Technology designed to capture methane released in coal mine-related emission and utilize it in various applications. Utilization includes, among other things, injecting recovered methane into natural gas pipelines.
Microalgae diesel	Diesel produced from microalgae (photosynthetic organisms) that can be farmed in water.
Micrositing	Consideration of an array of factors related to wind flow, terrain, local power demand, environmental and land-use issues carried out during site selection for wind turbines to maximize wind farm's operational efficiency and economics.
Mixed refrigerant cycle (MRC)	Applications are used to liquefy natural gas. Considered to be an efficient and cost effective technology and used in various Chinese liquefied natural gas plants.
Modular high-temperature gas-cooled reactors (MHTGCR)	Type of nuclear reactors that are safer and have higher efficiency when compared to conventional nuclear reactors.

Monitoring and measurement solutions

Solutions that track the composition or volumes of water flows in natural water sources, water distribution systems, water treatment plants or user premises, which are often integrated with IT and or GPS technologies.

Multiple units (MU) train

Trains that rely on a series of self-propelling carriages controlled from one cabin for its propulsion, instead of locomotives.

Municipal solid wastes (MSW)

Waste materials generated by urban areas, and are typically dealt with by incineration or placement in landfills. Composting and solidification are other disposal methods.

Natural gas

Important fuel source and fertilizer component consisting primarily of methane, and is found in fossil fuels and coal beds, among other places. Considered to be the cleanest of the fossil fuels, but requires extensive processing in order to remove elements other than methane.

Natural gas combined cycle (NGCC)

Systems that generate electricity using gas turbines, and then capture waste heat to generate steam and additional electricity using a steam turbine.

Natural gas desulfurization

Broad process consisting of several applications (e.g. amine treatment or membrane adsorption) that removes sulfur from natural gas thereby purifying said gas and removing pollutants. Recovered sulfur can be used in various chemical industry applications.

Natural gas vehicles

Vehicles with motors that run primarily, if not exclusively, on natural gas.

Net zero buildings (NZB)

Buildings that draw no net energy from the grid on an annual basis. Achieved through a combination of energy efficiency and on-site generation.

Neutralization

Process in which the hazardous components of waste are eliminated, thereby rendering them benign (e.g., a corrosive acid is neutralized with a basic substance so that it is no longer corrosive, etc.).

New energy vehicles

Vehicles that are not driven by gasoline or diesel internal combustion engines, but by other power sources (storage batteries, fuel cell, solar power etc.).

Nitrogen oxide (NO_x)

Generic designation for a number of mono-nitrogen oxides, NOx is produced and released during combustion and is a chief component of smog.

Non-GHG air pollutants

Mainly sulfur oxides, nitrogen oxides, volatile organic compounds and other pollutants whose primary detrimental effects on health and environment do not stem from their global warming potential.

Offgrid / <1 MW / Horizontal

Horizontal wind turbines with under 1 MW capacity, that generate electricity to be used locally and does not require connection to the power grid.

Offgrid / <1 MW / Vertical

Vertical wind turbines with under 1 MW capacity, that generate electricity to be used locally and does not require connection to the power grid.

Oil tank automatic dehydrators

Pollution abatement devices designed to reduce oil levels in discharged wastewater via dehydration/separation. Used by filling stations and other segments of the petro-chemical industry.

Ongrid / >3 MW / Offshore

Horizontal wind turbines with capacity over 3 MW, that are located offshore and feed the generated electricity onto the power grid.

Ongrid / >3 MW / Onshore

Horizontal wind turbines with capacity over 3 MW, that are located onshore and feed the generated electricity onto the power grid.

Ongrid / 1-3 MW / Onshore

Horizontal wind turbines with capacity between 1 and 3 MW, that are located onshore and feed the generated electricity onto the power grid.

Optimized air traffic management

Set of processes designed to achieve the highest possible productivity of the air fleet and ground facilities. This is accomplished by optimizing flight planning, logistics and air traffic management, while ensuring safety and convenience and minimizing the negative impact on the environment.

Optimized waterway management

Set of processes designed to achieve the highest possible productivity of ships and related facilities (such as ports). This is accomplished by optimizing water traffic planning, logistics and traffic management, while ensuring safety and convenience and minimizing the negative impact on the environment.

Oxygen-enriched combustion

Type of combustion that uses oxygen-enriched burner to increase oxygen content in the combustion air so as to reduce energy loss and increase heating efficiency.

Parabolic dish stirling engines

Devices that concentrate sunlight at a single focal point via a parabolic dish to produce electricity, and can track the sun along two axes by automatically adjusting the direction of the dish.

Parabolic troughs

Solar thermal energy collectors that consist of a long parabolic mirror and a Dewar tube running its length at the focal point that absorbs energy from the sunlight which is converted into electricity.

Particulate matter (PM) removal systems

Systems that remove particulate matter (harmful fine particles) from flue gas.

Passive design

Building design that takes advantage of the local climate to provide some or all of the heating, cooling, lighting and ventilation needs of the occupants.

Peak load capacity

Maximum electrical load capable of being handled by transmission equipment in a given time period.

Physical wastewater treatments

Treatment methods that usually treat suspended (as opposed to dissolved) pollutants. The process often involves simply allowing suspended particles to float to the top of a container or settle at the bottom, but may also use mechanical means to assist in the settling/floating process.

Point-of-use solutions

Water monitoring or treatment solutions that are installed at the point where water is actually used (such as apartments, commercial and industrial facilities).

Power towers

Type of solar power plants that uses a tower and a high heat capacity component to receive the sunlight focused by an array of flat movable mirrors and convert it into electricity.

Pressure swing adsorption

Application that seeks to separate certain target gases from a broader mixture of gases using specialized adsorptive materials. Typically used to remove carbon dioxide and hydrogen sulfide to increase the quantity of methane, a key component of natural gas.

Pressurized fluidized bed combustion (PFBC)	Developed to further improve efficiency levels in coal-fired plants, it replaces the conventional combustion chamber of the gas turbine with a pressurized fluidized bed combustor. The end result is that the products of combustion pass through a hot gas cleaning system before entering the turbine.
Primary treatment solutions	Solutions used primarily at the sedimentation stage, where the solids are separated from the wastewater stream.
Process wastes	Wastes that result from the process of converting raw materials into final products (e.g., scrap metal, slag, mine tailings, etc.).
Process redesign	Redesign and/or systems optimization of the operation with the purpose of increasing resource use efficiency and minimizing pollution.
Pumped hydro storage	Method under which energy can be stored by pumping water into a high reservoir and then releasing it back into a lower reservoir to generate electricity when passing through power generating turbines.
Real-time information processing	Solutions that enable real-time communication between core nodes in the electric network (including customer premise) and allow to better manage demand, improve reliability and flexibility of the network.
Recycled materials	Building materials manufactured from materials that have been recycled.
Renewable energy access flexible alternating current transmission system (FACTS)	System comprised of static equipment used for alternating current transmissions that are meant to enhance controllability and increase power transfer capability of the network.
Resource service companies	Professional service companies (including Energy Service Companies) that provide project management, consulting, engineering, financing, operation and maintenance services that reduce energy and water use in buildings.
Second generation biofuels	Fuels that use special-energy non-food crops, that have the effect of not diverting food supplies away from the food chain, and waste biomass containing lignin and cellulose.
Secondary treatment solutions	Solutions that substantially remove the biological content of sewage (including derivates of human waste, food waste, soaps and detergent).
Sedimentation	Traditional water treatment method that is based on the settling of particulates at the bottom of a body of water.
Sludge	Semi-solid material left from industrial, water treatment or wastewater treatment processes.
Sludge treatment and disposal	Solutions (including dewatering, landfill storage and fertilizer conversion) that treat sludge generated from wastewater treatment in order to remove usable substances and properly dispose of residual wastes.
Smart buildings	Buildings that rely on integrated IT-based resource use measurement and monitoring, intelligent analysis of the internal environmental and performance data, and automation of connected building systems.

Smart grid networks	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). They deliver power in an efficient manner and can better integrate power from renewable sources.
Sodium-sulfur (NaS) batteries	Batteries with high energy density and high efficiency of charge/discharge that require high operating temperatures.
Solar photovoltaics (PV)	Photovoltaics (solar cells) are devices that convert light into direct current using the photoelectric effect. Solar PVs are the main technology used in China for the generation of electric solar power.
Solar water heaters (SWH)	Systems that heat water by absorbing the energy from the sun, normally consisting of solar thermal collectors, fluid systems to transport the heat and a water tank where water is heated and stored.
Solidification/stabilization (S/S)	Common method used for treatment, management and the reuse of contaminated waste (especially treated industrial hazardous waste and contaminated material). This process involves mixing Portland cement with the contaminants which results in a brick which can be reused on-site.
Standard operating procedures (SOPs)	Set of prescriptions for employees (often mandated) on how to execute specific tasks or to react to circumstances in the most efficient and effective ways.
Standard operating procedures (SOPs), training, feedback	Collection of management tools designed to improve the efficiency of employees as well as the effectiveness of the management at an industrial site.
Stop-start systems	Systems that safely stop and restart a locomotive's engine during idling operation to conserve fuel and reduce air and noise pollutions.
Subcritical power generation	Coal-fired subcritical power plants that operate at very high temperatures, resulting in much higher heat efficiencies.
Sulfur dioxide (SO_2)	By product resulting from the combustion of coal and oil containing sulfur. When combined with nitrogen dioxide, sulfur dioxide forms acid rain.
Supercapacitors	Electrochemical capacitors (tasked with storing electrical charge) that have an unusually high energy density when compared to common capacitors, typically on the order of thousands of times greater than a high capacity electrolytic capacitor.
Sustainable materials	Materials gathered in environmentally responsible ways (including recycled materials, certified wood and biodegradable plastics).
Sustainable urban planning	Urban planning that optimizes the use of the built environment, transportation system, energy, water and land, while aiming to minimize the negative impact of the community on the natural environment.
Sweet sorghum bioethanol	Bioethanol produced from sweet sorgum crop.
Tertiary treatment solutions	Solutions that provide a final treatment in order raise the effluent quality of the water before it is discharged into the receiving environment.

Thermal coal	All other coals that are not classified as metallurgical or coking coal. Coals of these type are usually low in grade and are commonly burned in power plants to generate electricity. Also known as steam coal.
Thin film	Technology that utilizes thin layers of material for electronic semiconductor and optical applications. Thin film is used in second and third generation photovoltaic technologies and often applied for building integrated applications.
Third generation biofuels	Processes that involve the production of biodiesel from algal oils. Energy derived from algae crops is substantially greater (up to 30 times) than second generation biofuel crops.
Time-of-use (TOU) pricing	Cost system wherein the price of electricity is established ahead of time and for a specific period of time, encouraging consumers to modify their consumption habits by taking price factors into consideration.
Transformers with amorphous core	Alternative transformers that are more energy-efficient and environmentally-friendly than conventional.
Ultra high voltage (UHV) transmission	Power transmission lines with voltages of 1,000 kV or higher for alternating current or 800 kV or higher for direct current. It allows power to be transmitted at greater distances with lower losses than lower voltage transmission lines.
Ultra supercritical power generation (USPG)	Coal-fired power plants that operate at very high temperatures and use advanced steam cycles in order to achieve higher heat efficiencies and less emission than conventional coal power plants.
Underground coal gasification combined cycle (UCGCC)	Process by which coal is converted into a product gas underground and then combusted aboveground to generate electricity in combustion systems that capture and utilize waste heat.
Vanadium redox batteries	Flow batteries with deep cycling life that can be mechanically refueled and has low negative environmental impact.
Vapor recovery	Process of collecting evaporating oil while it is being loaded, received or stored at filling stations. Vapor recovery is carried out via absorption, combustion, condensation or film separation.
Vertical-axis wind turbines	Type of wind turbines where the main rotor shaft runs vertically.
Waste management	Collection, transport, processing, monitoring, recycling and disposal of waste materials.
Waste oil	Used cooking oil (mainly vegetable oil and animal fat) that can be converted into fuels such as biodiesel.
Waste separation and off-take	Sorting of solid wastes at the industrial facility to assist its exchange, recycling, incineration or disposal.
Waste vegetable oil biodiesel	Biodiesel produced from waste vegetable oil.
Wastewater sulfur stripping units	Mechanisms designed to remove hydrogen sulfide and ammonia from refinery wastewater.
Water grades	System designed by China to grade water quality that uses a scale ranging from I to V+, with grades I through III fit for human consumption.
Water productivity	The ratio of goods and services produced over the volume of water required for their production; measures the efficient use of water.

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