A REPORT OF THE CSIS
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China—Leader or Laggard on the Path to a Secure, Low-Carbon Energy Future?

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1 INTRODUCTION

There has been a great deal of talk about whether and how China will manage its need to provide enough energy to ensure continued economic growth while avoiding the local and global environmental impacts of its energy production and use. To listen to the political discourse, China is either a global leader on clean energy technologies and transformation or the largest source of emissions with serious, systemic local environmental degradation. How can it at once be a low-carbon leader and a laggard?

China's ability to be both lies in the pace of its current energy transformation, its size, and its willingness to put in place tough policies to try and alter its current energy trajectory. With the current energy mix, China's rapid growth and the associated environmental implications will undoubtedly wreak havoc on the global climate and local environmental conditions. Chinese policymakers recognize the unsustainable nature of their development pathway and have instituted a series of policies to steer them toward a more sustainable course. These policies have attracted staggering amounts of investment and made China the most exciting market on Earth for clean energy technology ventures.

The truth, however, is that this pathway will be difficult to journey and navigates a great deal of uncharted territory. If China manages to overcome these obstacles, it could help the rest of the global community overcome some shared challenges.

In reality, the outlook for China's future energy use is enormously complicated and does not lend itself to a simple categorization of "leader" or "laggard." This paper seeks to clarify key aspects of China's efforts to pursue a secure, low-carbon pathway and the challenges the government faces.

2 CHALLENGES OF FORMIDABLE GROWTH AND UNRELENTING DEMAND

A large population, rapid economic growth, and urbanization have made China the world's largest consumer of energy. Despite successful efforts to decrease energy consumption per unit of GDP, the country's demand for energy is projected to account for one-third of the growth in global demand in the coming decades.

Worldwide interest in China's energy sector—and the Chinese economy as a whole—is understandably strong given the dynamic growth and investment that has taken place there in recent years. The pace and scale of growth in the past decade and projections for the future are no less than staggering. Basic statistics about China's energy sector are prone to hyperbole. The world's most populated country with one of the world's largest, fastest growing economies has enormous energy needs. In just nine years, China moved from using half as much energy as the United States to surpassing it in 2009 as the largest consumer of energy on the planet. In 2009, China also became the second largest user and importer of oil, surpassing Japan. It is the world's largest producer and consumer of coal, consuming twice as much of the fossil fuel in 2009 as the United States; it has the third largest coal reserves in the world, behind the United States and Russia. Also in 2009 China was the largest producer of hydropower. It leads the world in installed biogas plants and solar hot water heaters as well.

The growth in China's energy demand has been enormous in recent years. Between 2000 and 2008, it was four times greater than the previous decade. This impressive rate is expected to continue over the next couple of decades driven by economic and social development. Once the process of urbanization and heavy industrialization slows down, the demand for energy is expected to slow down or level off.

China currently has a population of 1.3 billion people whose energy consumption is about one-third of the Organisation for Economic Co-operation and Development (OECD) average per capita consumption. Per capita income and energy consumption are uneven in China because some portions of society are still deeply impoverished with little to no access to modern energy services. The government's desire to pull some segments of society out of poverty and to increase the comfort and convenience for more affluent segments are major causes for the growth in demand. Overall, the contours of this will be shaped by economic growth, changes in the economic structure, energy and environmental policy, urbanization, demographic transformations, and technological advancements. According to the International Energy Agency (IEA), China's demand for energy is expected to grow 75 percent between 2008 and 2035. This accounts for approximately 36 percent of projected growth in energy demand around the world. It also assumes that current policies to encourage efficiency, reduce emissions, promote alternative energy sources, extend and improve electric grid operations, and achieve some degree of economic transformation are effective. By 2035 China is expected to account for 22 percent of global energy demand, up from 10 percent in 1990 and 17 percent today.

Table 2.1. China's Ranking in Top Ten Energy Statistics

Oil consumption (thousand barrels per day, 2009)	Oil production (thousand barrels per day, 2009)	Oil imports (thousand barrels per day, 2009)	Coal production (thousand short tons, 2010)	Coal consumption (thousand short tons, 2010)	Wind capacity (megawatts, 2009)	Hydro-electricity consump-tion (million tons of oil equivalent, 2010)	CO_2 emissions (million metric tons, 2009)	Primary energy consumption (million tons of oil equivalent, 2010)	Electricity consumption (billion kilowatts, 2008)	Nuclear electricity generation (kilowatt hours, 2010)
United States (18,771)	Russia (9,934)	United States (9,631)	China (3,661,272)	China (3,733,733)	United States (35,159)	China (163)	China (7,706)	China (2,432)	United States (3,906)	United States (807)
China (8,324)	Saudi Arabia (9,760)	China (4,328)	United States (1,085,281)	United States (1,048,295)	Germany (25,777)	Brazil (90)	United States (5,424.53)	United States (2,286)	China (2,833)	France (410)
Japan (4,367)	United States (9,934)	Japan (4,235)	India (626,731)	India (759,698)	China (25,104)	Canada (83)	India (1,591)	Russia (691)	Japan (1,009)	Japan (280)
India (3,110)	Iran (4,177)	Germany (2,323)	Australia (448,891)	Germany (250,695)	Spain (19,149)	United States (59)	Russia (1,556)	India (524)	Russia (844)	Russia (159)
Russia (2,740)	China (3,996)	India (2,233)	Indonesia (395,523)	Russia (227,306)	India (10,926)	Russia (38)	Japan (1,097)	Japan (501)	India (579)	South Korea (142)
Brazil (2,522)	Canada (3,294)	South Korea (2,139)	Russia (342,497)	Japan (206,909)	Italy (4,850)	Norway (27)	Germany (766)	Germany (320)	Germany (547)	Germany (133)
Germany (2,456)	Mexico (3,001)	France (1,749)	South Africa (276,148)	South Africa (201,259)	France (4,492)	India (25)	Canada (541)	Canada (317)	Canada (535)	Canada (85)
Saudi Arabia (2,438)	United Arab Emirates (2,795)	United Kingdom (1,588)	Poland (145,061)	South Korea (125,529)	United Kingdom (4,051)	Japan (19)	Iran (529)	South Korea (255)	France (447)	United Kingdom (84)
South Korea (2,185)	Brazil (2,577)	Spain (1,439)	Kazakhstan (122,207)	Poland (139,849)	Portugal (3,535)	Venezuela (17)	South Korea (528)	Brazil (254)	Brazil (405)	China (71)
Canada (2,147)	Kuwait (2,496)	Italy (1,381)	Colombia (82,573)	Australia (119,737)	Denmark (3,465)	Sweden (15)	United Kingdom (520)	France (252)	South Korea (386)	Spain (59)

Sources: U.S. Energy Information Administration; BP, *Statistical Review of World Energy 2011;* World Nuclear Association.

The scale and pace of energy consumption in China is truly difficult to appreciate. As will be discussed in future sections, small changes in the percentage of consumption or production of a specific fuel or technology can be immaterial to China's overall energy mix but enormously transformative for an industry or technology. Continued growth on a business-as-usual trajectory, however, is increasingly unsustainable without major shifts in how various fuels are consumed and a great deal of effort on the part of the government and industry within China.

A good example of this is China's continued reliance on coal for power generation. According to the 2009 *China Statistical Yearbook*, 92 percent of the country's energy came from fossil fuels. Coal had the overwhelming share at 70 percent, with oil at 18 percent and natural gas far behind at 4 percent. Even though policymakers have paid much attention and devoted some investments to alternative forms of energy in recent years, hydroelectric power, nuclear and renewable still comprise small portions of the energy mix at 8 percent. According to IEA projections, despite impressive goals to increase efficiency of coal use and to promote greater fuel diversity, overall coal consumption is expected to nearly double by 2035.[1]

Anticipating the potential negative benefits of unconstrained growth at these rates and maintaining the status quo in the current energy mix, China has enacted a suite of policies designed to increase efficiency, decrease reliance on coal and oil, and increase energy diversity by promoting nuclear, and renewable energy, and natural gas. These policies are expected to have an important impact on the energy profile. For example, IEA projects coal consumption to decline as an overall share of the energy mix from 66 percent today to 61 percent by 2035 (53 percent if you assume the government aggressively tries to reduce emissions). However, the overall volume of coal consumption is still expected to increase by half during that time period.[2] According to *BP Energy Outlook for 2030*, China accounted for 80 percent of the growth in global coal demand between 1990 and 2010, and it is expected to account for 77 percent to 2030.[3]

Continued over-reliance on coal poses a great many problems for China. Although the country's coal reserves are immense, concerns over mining safety, rising prices for domestic coal, infrastructure capacity constraints for shipping coal from the interior provinces to the energy-hungry coast, and the well-publicized local pollution concerns associated with burning such vast amounts of coal have all served as effective impetuses for Chinese policymakers to seek diversification of the energy mix, greater efficiency in the use of coal, and tighter environmental controls on coal-fired power generation.

- **Moving coal.** There are 27 provinces in China that produce coal.[4] However, most of the easily accessible coal mines and virtually all of the large ones owned by the government are concentrated in the north, which is far away from consumers along the coast. The long-distance transport, which has to be done by land, impedes the timely delivery and drives up the price of coal. China's railroad capacity is heavily dedicated to moving coal. Overland transport is constrained

1. International Energy Agency, *World Energy Outlook 2010* (Paris: International Energy Agency, 2010).
2. Ibid.
3. BP, *BP Energy Outlook for 2030* (London: BP, January 2011), http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2010_downloads/2030_energy_outlook_booklet.pdf.
4. U.S. Energy Information Administration, "China Country Analysis Brief," 2010.

also because it is used to transport such commodities as iron and aluminum that are equally essential to fueling this giant manufacturing nation.[5]

- **Mine safety.** In 2009, approximately two thousand people were killed in mine safety incidents in China, down from nearly seven thousand in 2002 alone. The government, seeking to crack down on mining accidents, set a goal of decreasing mine-related fatalities by 10 percent and ordered all coal mines to build and/or improve their underground emergency safety shelters by mid-2013.[6]
- **Local pollution.** Rapid urbanization and energy-intensive development have caused significant environmental impacts for China's urban and rural population. According to the estimates presented by the National Development and Reform Commission (NDRC), nearly 750,000 people die each year from respiratory illnesses brought on or exacerbated by poor air quality; 700 million of the rural poor have inadequate access to safe water and energy infrastructure; 190 million people in drink water that is making them sick; and the quality of the water in 40 percent of China's rivers is very low. Many rural residents still rely on traditional biomass for cooking and heating.[7] These alarming statistics drove the government to implement local pollution controls in 2005, and these pollution concerns have also driven much of the low-carbon energy policy decisions as well.[8]
- **Rising prices.** Rapid growth in demand for electric power has stretched the Chinese domestic coal industry and associated transportation infrastructure to its limits. China has become a net importer of coal, and until the shortage of thermal coal eases, coal prices have been outpacing the state-controlled electricity prices, causing economic hardship on domestic coal producers and utilities as well as widespread power shortages during the summer of 2011.

China's current energy trajectory also is concerning from an energy security perspective. As the nation's energy consumption grows, so does its position as a net importer of fuel. China is a resource-rich country that has until recently been generally self-sufficient in fueling its economic growth.

For example, it was a net exporter of oil until 1993 and of coal until 2009. Since the Chinese economy took off in recent decades, however, the country's fossil fuel consumption and reliance on imports have been rising steadily. Specifically, in 2009, it became a net importer of coal. Coal imports had been growing since 2002, especially because imported coal prices became competitive with domestic production prices.

That same year, China became the second largest net importer of oil, with roughly 4 million barrels per day (bpd) production and 8.2 million bpd consumption.[9] Although natural gas is not a

5. Bo Kong, "Assessing China's Energy Security," presented at a CSIS conference, "Implications of a Secure, Low Carbon Pathway for China," October 26, 2010.

6. Xinhua News Agency, "China's Largest Mine Safety Capsule Passes Safety Tests," *China Daily*, July 1, 2011, http://www.chinadaily.com.cn/bizchina/2011-01/07/content_11809464.htm.

7. In July 2011, National Development and Reform Commission Vice Chairman Liu Tienan said that the nation's electrification rate in 2010 was 99.6 percent and that five million people nationwide still had no access to electricity.

8. Jennifer L. Turner, "China's Green Energy and Environmental Policies," testimony given to U.S.-China Economic and Security Review Commission, April 8, 2010, http://www.uscc.gov/hearings/2010hearings/written_testimonies/10_04_08_wrt/10_04_08_turner_statement.pdf.

9. EIA, "China Country Analysis Brief," 2010.

major energy source in China, its share in the country's consumption mix is increasing, and so is its dependence on natural gas imports. Natural gas consumption for 2009 was 12 percent higher than 2008, and China imported more than 140 billion cubic feet of liquefied natural gas (LNG) to fill the gap.[10]

Fossil energy dependence has negative environmental consequences on both the production and consumption side. Coal-mining operations in the north require a large amount of water, while coal-fired power generation and increased vehicle use have raised concerns about local air pollution, as previously mentioned. It should also be noted that massive hydropower projects are also criticized for their environmental impacts (like landslides, droughts, earthquakes, and prolonged adversarial effects on the ecology). Fossil-based energy resources also contribute to greenhouse gas emissions and the changing climate, which has become an increasing area of interest and concern for Chinese policymakers.

10. Ibid.

3 LOW-CARBON PATHWAYS
THEORY AND PRACTICE

China has embarked on a lower carbon pathway, driven by strategic goals for economic growth, but also energy security, local environmental impacts, health concerns, and natural resource development plans.

Secure low-carbon pathways identify technology and policy solutions that can reduce emissions while continuing to supply enough energy to maintain economic growth, thus providing a transition from the current energy system to one that limits the amount of greenhouse gases that are changing the climate. These pathways help policymakers, industry leaders, and other decision-makers develop a framework to use as they consider the possible choices and trade-offs necessary to meet their energy and climate goals.

Many energy analysts and modelers have spent time trying to figure out how to develop these low-carbon pathways as a way to figure out whether and how China could move its energy production and use onto a more sustainable course. Notable energy modeler Jiang Kejun of the Energy Research Institute (ERI)—part of NDRC—has outlined the possible pathways the country could follow to reach its energy and climate goals while ensuring continued economic development.[1]

It is important to note that China has been assessing the potential for developing a low-carbon energy future, determining how it would fit into other strategic goals such as economic growth, energy security, local environmental impacts, health concerns, and natural resource development plans. The government has already put in place a number of policies to improve energy efficiency, encourage diversity of energy sources, create targets for renewable energy, and set timelines for reducing carbon emissions.

The pathway laid out in Jiang's work uses a combination of assumptions—economic, structural, technological, and commercial—that provide an outlook on how different technologies and fuel sources could contribute to future energy use, at what cost, and under what time frames. He looks ahead to 2050, focusing significantly on setting the stage during the next two decades. ERI is studying these options in the context (and in cooperation with other international climate modelers) of global action to reduce emissions where China would undertake mitigation measures if developed economies aggressively undertake emission reduction.

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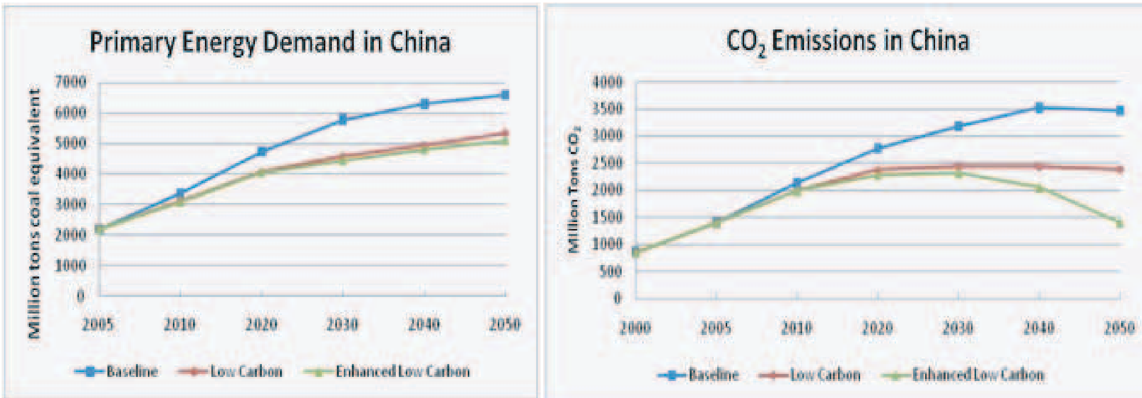
1. The CSIS Energy and National Security Program commissioned the underlying modeling work to Jiang Kejun as part of our ongoing work focused on the implications of secure, low-carbon pathways. We would like to thank the Energy Foundation for its support of this project. For more on low-carbon pathways, see CSIS reports *The Roadmap for a Secure, Low-Carbon Energy Economy: Managing Energy Security and Climate Change*, and *Asia's Response to Climate Change and Natural Disasters: Implications for an Evolving Regional Architecture*, available at http://csis.org/program/energy-and-national-security.

Figure 3.1. Energy Demand and Emissions under Three Scenarios



Source: Jiang Kejun, Energy Research Institute, NDRC.

The paper develops three low-carbon emission scenarios:

- **Baseline**. Reflects business as usual, assumes existing policies and measures will continue, and considers the government's current efforts to increase efficiency and control emissions.
- **Low-carbon**. Assumes that China will develop a lower carbon future by decreasing the share of energy-intensive industries in the economy, widely disseminating current energy efficiency technologies, and by aggressively diversifying the electricity generation mix. This scenario assumes that the energy efficiency of industries that consume high amounts of energy would reach or surpass the level of developed countries by 2020.
- **Enhanced low-carbon**. In addition to the low-carbon scenario policies and regulations, this one also includes a wider range of potential lower carbon technologies: zero-emission vehicles, low emission buildings, renewable and nuclear energy, decentralized power supply systems, and carbon capture and sequestration used with coal-fired power plants.

The differences between the three scenarios are stark. In terms of greenhouse gas emissions, the baseline scenario sees emissions peaking and leveling off after 2040. By contrast the low-carbon scenario and enhanced low-carbon scenario both peak around 2030. In 2030, carbon emissions in the low-carbon scenario will be more than 20 percent less than the baseline, and in the enhanced low-carbon scenario emissions are lowered by more than 25 percent. Looking out to 2050, the enhanced low-carbon scenario sees a precipitous and continued decline in carbon emissions, while the low-carbon scenario maintains the peak level.

In terms of the energy mix, all three scenarios see total energy demand rise through 2030; the baseline rises to 5.7 billion tons of coal equivalent, the low carbon increases to 4.6 billion tons, and the enhanced low carbon to 4.4 billion tons. The difference continues in the following decade: the 2050 figures for the low carbon and the enhanced low-carbon scenarios are still lower than the 2030 baseline. All three scenarios show China making substantial gains in energy efficiency, but in the low-carbon scenario and enhanced low-carbon scenarios, nuclear power and renewable energy see substantial gains as costs decrease.

To reach the emissions trajectories in the low-carbon and enhanced low-carbon scenarios requires an unprecedented amount of pervasive, rapid economic and technological transformation. The scenarios presented in this study also illustrate, however, that China is looking for ways to meet its energy supply concerns within a secure, sustainable, low-carbon way in tandem with its goals for encouraging continued economic development.

Several major challenges lie at the heart of this transition:

- **Structural economic transformation.** Promoting industrial and structural transformation away from a carbon-intensive economy, and driving down the cost and speeding up the dissemination of low-carbon technologies are critical elements of China's larger economic as well as climate change goals. Much of the modeling is predicated on China's ambition to achieve the level of GDP on par with that of developed countries by 2050 and the recognition that over time—as China continues to develop—the energy-intensive sectors that currently drive the country's economic growth and energy consumption will be less and less competitive. In order to successfully navigate this economic transition, the government is pursuing policies to promote structural reform and to get a head start on making its advanced industries more competitive. Although the growth of the energy-intensive sectors is expected to peak in the next five to ten years, this is a particularly complex trend to research and model; so there is a fair degree of uncertainty over how successfully China may transform its industrial structure to a less carbon-intensive one.
- **Technological progress and technology dissemination.** Certain technologies will play essential roles in reducing China's greenhouse gas emissions. The low-carbon scenarios foresee that many can be implemented in the next ten years. One area of critical importance on those fronts is clean coal technology. Advanced technologies also will play vital roles in lowering the country's overall energy intensity, and therefore, carbon intensity in the future. Jiang's low-carbon scenarios assume that China becomes one of the global leaders in these new technologies in line with the stated policy priority.
- **Meeting established and anticipated energy policy goals.** One point that emerges from the scenarios is that China has been and continues to be deeply engaged in policy-making and policy implementation at various levels of society to drive the types of transformation that meet its economic, environmental, and security goals. In fact, Jiang concludes that the policies necessary to reach the low-carbon scenario are largely in line with policies that China intends to pursue in the context of its sustainable economic development pathway (which is discussed later in this paper.) These policy goals, especially the energy efficiency ones, and efforts to expand the role of nuclear and renewable energy in the power generation mix are vital to lower carbon development.

The policy, technology, and economic goals and shifts presented in these specific low-carbon scenarios—indeed, in most if not all pathways that attempt to model severe emissions reductions over a decades-long time frame—are extremely ambitious. Over and above those concrete criteria, energy modelers and analysts also note that a fair amount of societal awareness is necessary to facilitate this type of transition. This is necessary to alter patterns of energy production and use beyond what is possible through policy, technology, or economic mechanisms. Social change is perhaps the most difficult thing to bring about, but there are several trends and drivers leading Chinese society toward these lower carbon technologies and priorities: economic opportunity from producing clean energy technologies; improved public health due to less pollution; and greater energy security brought by higher levels of energy efficiency.

It is not clear, however, that these outweigh the following factors: the need to supply modern energy services to those who still rely on traditional biomass for cooking and heating; the desire to consume more that accompanies the rising income of the residents and the migration of rural residents into cities; and the combined effect of increased labor mobility, rising prices of urban housing, and inadequate urban planning that results in increased commuting distances and energy consumption.

Promoting Low-Carbon Energy and Energy Efficiency

Within the energy sector, China has several main areas to focus on when it comes to meeting its economic and energy sustainability goals:

- Increase energy and economic efficiency;
- Promote renewable energy sources;
- Expand nuclear power generation; and
- Increase the share of natural gas in the overall energy mix.

This combination of efficiency and diversity gains speaks to all of the government's energy security, economic, and environmental goals. China has experienced great success and significant setbacks in each area.

Energy Efficiency

China almost met its goal for the Eleventh Five-Year Plan to reduce the energy intensity of the economy by 20 percent from 2005 levels by 2010. Latest estimates indicate the intensity has dropped by 19.1 percent. The Twelfth Five-Year Plan set a new target of 16 percent from 2010 levels by 2015.

China's energy efficiency goals are perhaps the most important and impactful part of its strategy to achieve more sustainable levels and types of economic growth, and to meet important environmental goals. The country has a decades-long history of the trying to manage the energy intensity of its economy through a combination of nationwide energy intensity goals supported by innovative projects and programs, government funding, and other standards and policies.

Between 1980 and 2002 China's energy intensity (total primary energy consumption per dollar of gross domestic product) improved at an average rate of 5 percent per year. These efficiency gains were driven by domestic policies and programs that incentivized greater efficiency, provided or called for the necessary up-front investment, and catalyzed interest and learning in ways to improve and promote greater levels of efficiency. During this period, energy efficiency investment accounted for between 5 percent and 12 percent of total energy investment.[2]

This efficiency trend started to reverse itself between 2002 and 2005 due to the economic growth that came with joining the World Trade Organization, the subsequent increase in trade

2. Mark D. Levine, Nan Zhou, and Lynn Price, "The Greening of the Middle Kingdom: The Story of Energy Efficiency in China," in *The Bridge*, Summer 2009.

that drove strong industrial growth, and the growth in demands for energy that accompanies a rapidly developing society in terms of personal resources consumption, built infrastructure, and migration patterns that bring more people in contact with modern energy services.[3] In 2005, China regained its focus on promoting energy efficiency and launched mandatory energy intensity reduction goals as part of the Eleventh Five-Year Plan. The target was to reduce energy intensity by 20 percent from 2005 levels by 2010.

The government employed a number of innovative programs to reach this goal. Lawrence Berkeley National Laboratories' China Energy Group conducted a study of the energy efficiency programs in the country that were the most successful and those that seemed to lag behind or whose success was difficult to determine. The report concluded that the programs that seemed most likely to meet or exceed the stated targets were the Top-1000 Energy-Consuming Enterprises Program ("Top-1000 Program" hereafter), the Ten Key Projects for Energy Savings, and the Small Plant Closure Program.

China succeeded very well in improving the energy efficiency of the power sector through closing small, inefficient thermal generation plants and using larger, more efficient units. From 2005 to 2008, energy consumption in the power sector increased about 29 percent, but the coal and emissions intensity of electricity generation fell by 7 percent and 5.1 percent respectively.[4] The power generation sector has undergone significant shifts in a short period of time with the increasing role of thermal power units that generate more than 600 megawatts (MW) and the dramatically decreasing role of those that generate less than 300 MW. This policy was particularly effective due to the combined effect of NDRC tying the efficiency requirement to the investment approval process, requiring developers to shut down less efficient plants, and the new energy efficiency-based dispatch rules being tested out in five provinces.[5] China is now operating twenty-one ultra-supercritical generation facilities with an additional twenty-four under construction, and it has become the world leader in operating and constructing these units.[6]

The least successful programs and initiatives are the ones designed to retrofit existing buildings to be more energy efficient and the efforts to transform the structure of the economy away from energy-intensive manufacturing. Building efficiency gains continue to be challenged by a range of factors including lack of proper incentives for energy efficiency design and materials, subsidized heating programs, a lack of proper reporting, data collection, and monitoring, and widespread use of energy-intensive building materials.[7] Chinese policymakers supported these policies with access to government funding to attract private investment. Over the course of the Eleventh Five-Year Plan, state investment in energy efficiency was reported to be around $19.6 billion.[8]

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3. Ibid.

4. Climate Policy Initiative at Tsinghua, *Review of Low-Carbon Development in China 2010* (Beijing: Climate Policy Initiative, Feb. 25, 2011).

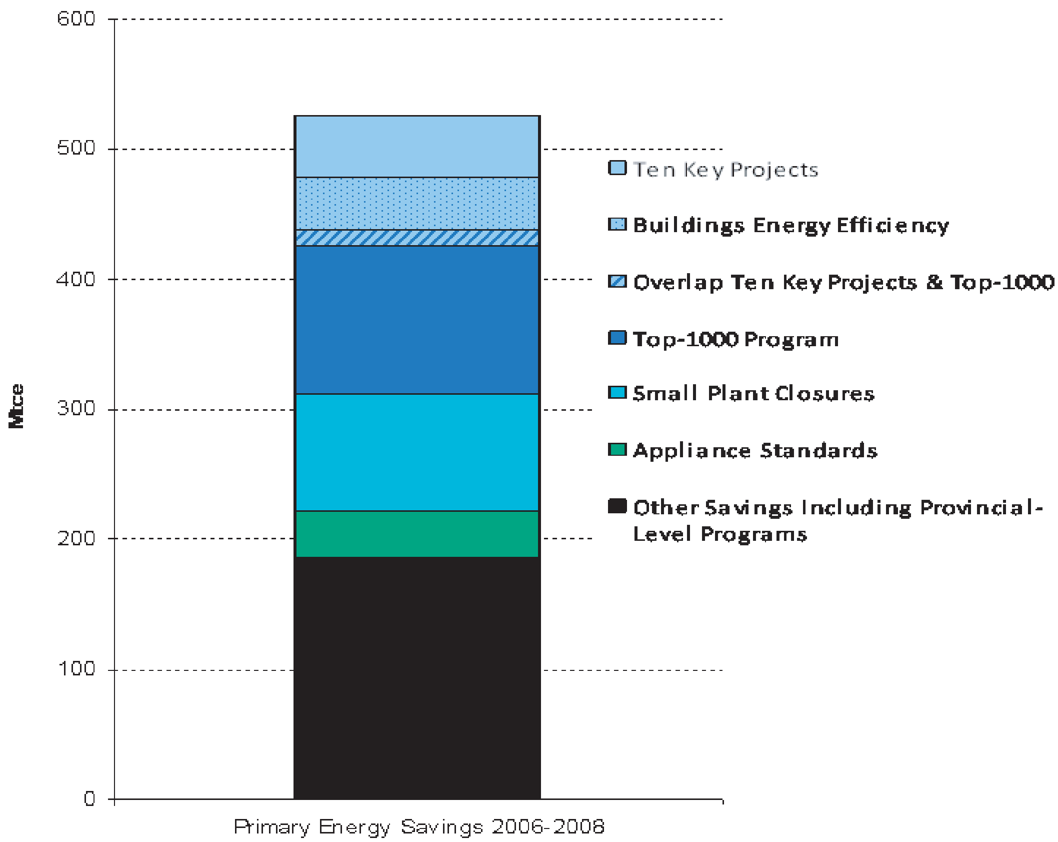
5. Conversation with Jun Tian of the Asia Development Bank, July 25, 2011.

6. Climate Policy Initiative at Tsinghua, *Review of Low-Carbon Development in China 2010*.

7. Nan Zhou, Michael A. McNeil, and Mark Levine, *Assessment of Building Energy-Saving Policies and Programs in China during the 11th Five Year Plan* (Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory, March 2011), http://china.lbl.gov/sites/china.lbl.gov/files/Assessment_of_Building_Eenry-Saving_Policies_and_Programs_in_China_During_the_11th_FYP.pdf.

8. The Climate Group, *Delivering Low Carbon Growth: A Guide to China's 12th Five Year Plan* (March 2011).

Figure 3.2. Estimated Energy Savings from Eleventh Five-Year Plan (FYP) Programs and Policies



China fell just short of its energy intensity goal and reached a reported 19.1 percent reduction by the end of 2010.[9] Given the multitude of programs and projects that the government initiated over the past five years, not to mention the programs and policies put in place by the provincial governments to support the national level policy goal, it is very difficult to assess how much energy consumption has actually been reduced. Numerous studies have suggested that the data to assess efficiency gains simply do not exist, are only released through unverifiable public statements, or are not useful in its presented form. Despite these limitations, the Lawrence Berkeley team noted in their review of progress under the Eleventh Five-Year plan that the efficiency and conservation gains were substantial, despite the difficulty of accurately measuring the success of each program, and that the success of many of these programs helped make up for the lack of progress on changing the structure of the economy.

Many of the successful programs of the last five-year plan have been continued, expanded, or complemented in the Twelfth Five-Year Plan. The energy intensity goal for this plan is slightly scaled back to a 16 percent reduction. Energy efficiency efforts over the past five years were principally aimed at reversing the trend of increasing energy intensity experienced in the early 2000s.

9. People's Republic of China, Twelfth Five-Year Plan (2011), http://www.chinanews.com/gn/2011/03-16/2909913.shtml.

Table 3.1. Recent Key Energy Policies Supporting China's 20 Percent Intensity Reduction Goal

Energy policies	Date effective	Responsible agency
Medium- and Long-Term Plan for Energy Conservation	2005	NDRC
Renewable Energy Law	2005	—
Government Procurement Program	2005	NDRC and Ministry of Finance (MOF)
National Energy Efficient Design Standard for Public Buildings	2005	Ministry of Construction (MOC)
Eleventh Five-Year Plan	2006	NDRC
State Council Decision on Strengthening Energy Conservation	2006	State Council
Revised Consumption Tax for Larger, Energy-Inefficient Vehicles	2006	MOF and State Administration of Taxation
Reduced Export Tax Rebates for Many Low-Value Added but High Energy-Consuming Products	2006	MOF
Top-1000 Energy Consuming Enterprise Program	2006	NDRC
Green Purchasing Program	2006	Ministry of Environmental Protection (MEP) and MOF
Revision of Energy Conservation Law	2007	National People's Congress and NDRC
Allocation of Funding on Energy Efficiency and Pollution Abatement	2007	MOF and NDRC
China Energy Technology Policy Outline 2006	2007	NDRC and Ministry of Science and Technology
Government Procurement Program	2007	NDRC and MOF
National Phase III Vehicle Emission Standards	2007	—
Interim Administrative Method for Incentive Funds for Heating and Metering, and Energy Efficiency Retrofit for Existing Residential Buildings in China's Northern Heating Area	2007	MOF
Lower Corporate Income Tax (Preferential Tax Treatment for Investment in Energy Savings and Environmentally Friendly Projects and Equipment)	2008	NDRC
Allocation of Funding on Energy Efficiency and Pollution Abatement	2008	MOF and NDRC
Appliance Standards and Labeling	Various years	General Administration of Quality Supervision, Inspection and Quarantine

Source: Mark D. Levine, Nan Zhou, and Lynn Price, "The Greening of the Middle Kingdom: The Story of Energy Efficiency in China."

As a result a great deal of inefficiency could be wrung out of the system with relative ease and a positive return on investment. These opportunities still exist. The challenge now, however, is to lay the groundwork for future energy intensity improvements that requires the government to pay attention to economic transformation and to introduce new, more expensive technologies.

NDRC is expected to release a special energy conservation plan later this year, which is expected to add more detail about how new and old programs will be implemented.

Renewable Energy

China's renewable energy targets, policies, and access to cheap financing have driven a remarkable growth in manufacturing prowess and capacity. The renewable energy boom, however, is far from perfect and includes a great many growing pains due to its speed and scale.

China's growth in renewable energy is extremely impressive, even though total energy use of renewable energy is on a much smaller scale than the consumption of coal, oil, or nuclear. Each type of renewable energy—hydro, wind, solar, and biomass—included in this discussion has encountered its own kind of success and shortcomings. Despite setbacks, China has remained committed to revising policies, investments, and regulations to ensure that the share of renewable energy in the mix continues to grow and that it cultivates a long-term competitive advantage in the clean energy technology sector.

According to the China Electricity Council, in 2010 the nation's total cumulative generating capacity stood at 962 gigawatts (GW).[10] On an installed capacity basis, thermal power generation occupies the largest share at approximately 75 percent (706.63 GW); coal is second with 650.11 GW, and gas is third with 26.68 GW.

Renewable energy occupies a small but growing share of China's energy mix. In 2010, renewable energy made up slightly more than 25 percent of the installed electric power supply. The vast majority of this came from hydropower at 22 percent with all other renewables accounting for more than 3 percent. That year China was also the world's largest consumer of renewable energy. It is the largest manufacturer of a great many renewable energy technologies such as wind turbines, solar photovoltaic cells (PVs), and solar hot water heaters. It also should be noted that China is increasing its use of these technologies to the GW scale, on par with other conventional thermal and nuclear power generating facilities.

The nation has invested much of its renewable energy resources in the electric power sector over the past several years. With a nearly 10 percent annual average growth rate in demand for electric power during the past decade, China's focus has been on promoting adequate generation to meet the needs of a growing society. The demand has slowed in recent years; the rate has only grown around 5 percent in the past two years, and it is expected to keep this base for the next two.

Due to security, local pollution, economic competitiveness, and climate change concerns, the government has sought to increase its share of nonhydrocarbon-based fuels in its electric power mix through policy and financial and regulatory incentives. The results of these incentives combined with strong growth in demand have been enormously successful so far in attracting foreign and domestic investment and building renewable power generation, but reforms and improvements are still necessary.

10. China Electricity Council, *Fast Annual Report,* www.cec.org.cn.

In the Eleventh Five-Year Plan, China did not include a specific percentage target for renewable energy. It did include various other goals, including the following: promoting the production and consumption of renewable energy and raising its share of primary energy; building thirty 100 Megawatt (MW)-class wind farms to form several large wind power bases; and getting enough wind- and biomass-based power connected to the grid to potentially generate 5 GW and 5.5 GW respectively by 2010.[11]

The Twelfth Five-Year Plan includes a target of 11.4 percent of total energy use from nonfossil sources by 2015 and 15 percent by 2020.

Policy, Financing, and Technology

Over the past half decade or so, China has witnessed increasing support for renewable energy in terms of policy support, financing, and technology. The foundation for the renewable energy policy is the Renewable Energy Law of 2006, which set out a framework for preferential pricing, development planning, and technical support for deploying renewable energy in China. It included things like mandatory purchase and connection provisions, and favorable tariffs for wind, biomass, and solar. The government not only requires utilities to purchase the renewable energy but also mandates that large power producers must have at least 3 percent of their installed capacity from renewable plants (excludes large-scale hydro) by 2010.

In 2007, the Medium Term Development Plan for Renewable Energy set out a goal for nonfossil-based energy to contribute 10 percent of the total energy mix by 2010 and 15 percent by 2020 (includes hydro and nuclear). The plans also set goals for specific nonhydro renewable energy goals for grid-connected electricity and for large producers specifically. Rapid growth in renewable power generation—particularly the wind sector—caused China to revise some of these goals as part of the economic stimulus plans in 2009. The goals for wind rose from 30 GW to 150 GW by 2020, and for solar, they went from 1.8 GW to 20 GW. As of 2010, solar and wind generating capacity were 0.3 GW and 43 GW respectively (of this only (31.4 GW is connected to the grid). There are rumors, however, that these goals will be revised yet again because of very optimistic estimates about the growth potential for wind as well as the need to place a greater emphasis on solar in the event of a slower nuclear build-up in the wake of the Japanese nuclear disaster. HSBC and the Global Wind Energy Council both estimate China will meet or exceed 200 GW of wind by 2020.[12]

Building Renewable Energy Capacity: Hydro, Wind, and Solar

Overview of electricity generation capacity and production in China and associated targets (current figures are for 2009 unless otherwise stated):[13]

Hydro. Hydropower makes up 22 percent of China's installed capacity. In 2010, the government added 16 GW of new capacity, the largest amount of any region in the world.[14] China is the largest holder of hydropower generating capacity also, with nearly 45,000 projects and more than 200 GW. Hydropower is one of the cheapest options for meeting the nation's power generation needs

11. Conversation with Jun Tian of the Asian Development Bank, July 25, 2011.
12. The Climate Group, *Delivering Low Carbon Growth: A Guide to China's 12th Five Year Plan*.
13. Kat Cheung, *Integration of Renewables: Status and Challenges in China Working Paper* (Paris: International Energy Agency, 2011), 8.
14. "Renewables 2011: Global Status Report," Renewable Energy Policy Network for the 21st Century (REN21), Chapter 1, Global Market Overview, 25.

and renewable energy goals because it is cheaper to build on a per MW basis here than anywhere else in the world and provides a cheaper source of electricity than coal.[15]

Under the Twelfth Five-Year Plan, China has committed to start building 120 GW of hydro capacity. Recently, however, hydropower has been a source of growing controversy in the face of widespread droughts and flooding. In the summer of 2011, droughts and floods were attributed to the government's mismanagement of some of the nation's largest hydropower facilities and major rivers, leading to a backlash against launching any additional large hydropower projects.

Wind. Wind power has experienced a great deal of growth over the past decade due to increased policy and financial support along with technological and cost improvements. By the end of 2010, the amount of wind capacity installed around the world was 195 GW (compared with 18 GW in 2000); 36 GW was added in 2010 alone. China added 17 GW of capacity in 2010.

The country has enormous potential for wind power. Capacity reportedly doubled each year from 2005 to 2008. Current expansion plans include a goal of adding 90 GW by 2015 (5 GW offshore) and 150 GW by 2020.[16] In 2009, China had around 25.8 GW installed and several major wind developments in the pipeline (estimates for end of 2010 are around 42 GW).[17] Notable among these projects are large, centrally planned "wind bases" located across six provinces and totaling more than 120 GW of proposed capacity.[18] These will generate approximately more than 10 GW each and will be located in dozens of locations with very high wind power capacity.

China's rapid expansion moved it into first place as the world's largest holder of wind capacity, surpassing the United States as of 2010. However, such growth brings challenges and controversies. Between 10 percent and 33 percent of the wind power capacity is not yet connected to the grid.[19] Because many turbines are located in the wind-rich north and northwest, they are far away from demand centers. In addition, there is a time lag or excessive expense without proper incentives to get connected to the grid. Estimates state that nearly 75 percent of unconnected wind capacity is in these remote northern locations.

Another problem stems from how the grid is operated (see further discussion below), and the regulations that govern how and when wind power can and should be connected. The system of incentives has not always led utilities to purchase power from wind farms even when they are producing. The Renewable Energy Law asked operators to buy all the grid-connected renewable energy power produced within their region, but only after the law was amended in 2010 were they "obliged" to buy a minimum amount.

On the utility side, there was a great deal of concern that the quality of wind power technologies varied greatly across the spectrum. In March 2010, the National Energy Administration announced it was drafting standards for wind farm connection that enable the power generated from the farms to be better integrated into the grid. Many people in the industry believe these standards are strict and that they will require some operators to upgrade equipment.[20]

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15. "2011 China Investment Guide: The World's Best Hydro Returns," http://blogs.forbes.com/russellflannery/2011/02/08/2011-china-investment-guide-the-worlds-best-hydro-returns/.

16. The Climate Group, *Delivering Low Carbon Growth: A Guide to China's 12th Five Year Plan*, 21.

17. Mark Fulton, "12th Five Year Plan—Chinese Leadership Towards A Low Carbon Economy," Deutsche Bank/DB Climate Change Advisors, April 2011.

18. American Council on Renewable Energy, *US-China Quarterly Market Review*, Winter 2011.

19. Ibid.

20. Kat Cheung, *Integration of Renewables: Status and Challenges in China Working Paper*, 8.

There is growing awareness in China that much of the existing wind energy capacity is being wasted. According to the State Energy Regulatory Commission, 2.8 billion kilowatt hours (KWH) was wasted during the first half of 2010 due to a lack of connectivity. State Grid Corp. subsequently announced its intention to invest in grid upgrades and capacity extensions.

Despite these difficulties, China is now home to the largest wind market in the world. One of the strongest financial incentives for investors in the wind sector is the feed-in tariff established in 2009 that guarantees purchase of wind generation at a given price. Chinese companies now occupy an increasingly large share of the wind turbine market, and they are expanding into manufacturing sophisticated, larger turbines.

Solar. China currently leads the world in manufacturing PV cells and also has the largest number of solar hot water heaters. The two main drivers for promoting solar power are to build up the nonfossil portion of the energy mix and to provide support for a burgeoning solar industry. Solar currently supplies less than 1 percent of China's electricity and will likely continue to make up a small share of the power mix despite rapid growth in the past few years. In 2010 solar installations have increased by almost 200 percent (to reach an estimated 450 MW of incremental solar) due to new support mechanisms and a focus on building national solar generation capacity.[21] China had only 3 percent of global solar generating capacity last year, yet it produced more than half of the PV equipment installed.[22]

As was noted above, solar has its own proportion of the renewable energy generation goals laid out in the renewable energy law. The National Energy Administration of China has set a goal of 5 GW of PV capacity by 2016 and is in the process of considering a target of 20 GW by 2020. In order to more explicitly drive domestic consumption of solar, the government implemented a number of key policies, the most notable among them being the national concessionary bidding for large-scale solar PV projects, the Building Integrated Solar PV Program, and the Golden Sun Program.

Golden Sun was launched in 2009 to install more than 500 MW of PV modules between 2009 and 2011, and to support demonstration of key technologies in the industry. As of March 2011, 294 projects that together generate 642 MW have been approved.[23] The program offers subsidies for 50 percent to 60 percent of the installation and transmission for commercial building and large-scale on-grid PV applications and 70 percent in remote, off-grid applications.[24] The subsidy was divided by application and by province with each province allowed to permit projects with a total capacity of up to 20 MW.[25] The program was recently extended beyond its 2012 end date and revised to include at least another 1,000 MW.[26]

In 2010 China instituted the Building Integrated Solar PV Program (BIPV), which offers incentives and grants for upfront project costs to facilitate the installation of solar panels on rooftops

21. Kathy Weiss, vice president for federal government affairs, First Solar, "China's Solar Initiative—First Solar Experience" (presentation of Energy and Environment Study Institute/World Resources Institute to congressional briefing), April 5, 2011, http://files.eesi.org/weiss_040511.pdf.

22. American Council on Renewable Energy, *US-China Quarterly Market Review*.

23. Thilo Grua, Molin Huo, and Karsten Neuhoff, *Survey of Photovoltaic Industry and Policy in Germany and China* (San Francisco: Climate Policy Initiative, March 2011).

24. IEA, *World Energy Outlook 2010*, 48.

25. ChinaFAQS, "Solar Energy" (fact sheet), May 24, 2010.

26. American Council on Renewable Energy, *US-China Quarterly Market Review*.

and building projects that integrate solar panels into overall building design. So far, 91 MW of solar generation has been constructed under the program, but the subsidy is set to decrease annually.

Similar to the large wind farm projects initiated by the national government, China is now on track to build several significant solar wind farms and large-scale applications. The first round of bids in 2009 yielded one 10 MW solar project, and the second round in 2010 yielded thirteen more that totaled around 280 MW across six western provinces. Industry had anticipated two or three more rounds of bidding before the government established a national feed-in tariff structure similar to one used in the wind sector.[27]

China's solar policies under the Golden Sun Program have recently come under fire for their unintended and adverse effects. In many cases, solar companies are being accused of offering lower costs for equipment in order to win bids. This has reportedly resulted in poor quality equipment being installed and projects that are not economical. The government stated that any company found to be using faulty equipment or undervaluing costs in bid rounds would be prosecuted.[28]

In practice, the impacts of the Golden Sun and BIPV programs have been limited by the fact that disbursement of subsidy does not guarantee actual installation or vouch for the quality of the product; there is no built-in incentive to encourage cost reduction, and the deployment scale is limited by government subsidy, suitable only for small-scale demonstration.[29] Nearly half of the projects are run by small- to medium-size Chinese companies that are not ultimately able to support the projects for the future without some sort of feed-in tariff or price support for selling the excess electricity output back to the grid system.

Support for solar power expansion will continue to be driven by renewable energy goals set on the national level that are then interpreted and adopted by specific provinces and companies, solar-specific goals, and incentives targeted at solar. It is also expected to be a featured technology in the 100 New Energy Demonstration City projects.[30]

In mid-2011 the government announced the creation of a solar feed-in-tariff that would pay solar producers a fee per kilowatt hour for power sold into the grid. Many of the details are still unknown, and so is the tariff's overall effectiveness in making projects that were previously thought to be uneconomic, more profitable. It does, however, signal the Chinese government's intention to support the solar industry and growth of the sector in much the same way it did previously for wind.

China's push to drive PV manufacturing and exports has transformed the industry. The combination of strong demand and high prices in the European Union and United States, and an influx of polysilicon into the market have helped Chinese manufacturers lower the cost of PV goods.[31]

China has recently experienced an oversupply in solar manufacturing. Combined with tighter efficiency standards on polysilicon production and an absence of a major expansion in domestic demand to absorb this, the solar industry is likely to experience some consolidation.

27. Kathy Weiss, "China's Solar Initiative—First Solar Experience."

28. Yuan Ying, "Burned by the Sun," *China Dialogue,* April 14, 2011, http://www.chinadialogue.net/article/show/single/en/4232.

29. Conversation with Jun Tien, Asia Development Bank, July 25, 2011.

30. Kathy Weiss, "China's Solar Initiative—First Solar Experience."

31. Bloomberg New Energy Finance, *Joined at the hip: the US-China clean energy relationship*, May 17, 2011.

2011 Power Shortages: Back to the Future?

Over the last several years summer power shortages have been much more frequent than Chinese officials would like and are likely to persist absent some long-term structural and price reforms. In 2004 China experienced widespread and disruptive power shortages driven by a lack of power-generating capacity to meet rapidly growing demand. Despite bringing on records amounts of new capacity since then, the country once again experienced widespread power shortages in the summer of 2011. Unlike the last major power crisis, these shortages were driven by pricing, profitability, and drought issues, not an overall lack of capacity.

China began experiencing nationwide power shortages earlier in the year due in large part to the distinctive structure of the energy sector. Four main factors have contributed to blackouts. First, market-driven coal prices have resulted in high demand prices from miners, leaving power producers unable to pay the soaring costs—despite government calls for favorable prices. Second, high coal prices, coupled with capped electricity tariffs, have resulted in many utilities operating at a significant loss with no incentive to continue to generate power. Third, nationwide droughts have led to a meaningful reduction in hydropower and a loss in transport of coal that is destined for eastern China's many coal-fired power plants. And fourth, poor power infrastructure and few inter-regional transmission lines have prevented provinces in drought-affected areas from importing power from neighboring provinces. Adjustments to electricity prices, tariffs, and infrastructure would positively affect the current Chinese power shortage, amending problems that have plagued the country since 2004.

As China continues to import coal, gas, and oil from regional markets—and as its own domestic resources become more expensive to produce because they are from low-carbon energy sources or conventional energy sources that are increasingly difficult to access and transport—policymakers will come under increasing pressure to reform electricity pricing despite the risk of negative public opinion and higher levels of inflation. Establishing a market-based pricing mechanism for steam coal and electricity is a more fundamental, effective solution than the current practice of raising electricity prices whenever deemed appropriate.

Looking ahead China may experience power shortages due to a lack of investment. The government has invested more in renewable power than in thermal power over the past two years. Average generation hours of wind and solar is 2,000 hours per annum, far less than 5,000 to 5,500 hours of coal and more than 7,000 hours shorter than nuclear power. There is a misalignment between the level of financial investment and possible power output. Taking too many investments from fossil-based generation to renewable may cause unintended consequences in the near future, such as power shortages.

Table 3.2. Summary of Ongoing Initiatives to Increase Renewable Penetration in the Electric Power Sector

Generation	Building more flexibility in the generation mix (e.g. adding hydro, gas, and pumped hydro stations).
Transmission	Building cross-region ultrahigh voltage lines to expand balancing area and potentially form a national grid.
Interconnection	Strengthening the receiving end by connecting regional grids.
Demand Side Management (DSM)	Developing options such as electric vehicles using peak-valley electricity pricing more, and demonstrating smart grids.
Storage	Adding storage options such as pumped hydro and potentially EVS.
Policies and Standards	Setting targets and national technical standards. Revising and implementing renewable energy law. Moving toward more DSM and preferential dispatching.
Forecasting	Improving accuracy of wind forecast, especially one day ahead and four hours forecast.

Source: Kat Cheung, *Integration of Renewables: Status and Challenges in China Working Paper*, 27; comments from Jun Tian, Asia Development Bank, July 25, 2011.

Grid Challenges

The challenge of utilizing higher levels of renewable energy in the electric power sector is not unique to China, but it has posed a range of obstacles that speak to the technical, regulatory, and financial architecture of the electric power system.

The grid infrastructure is run by four companies—two of which are large—that manage the transmission and distribution infrastructure. The wind generation sources are not near demand centers, and there is a transmission build-out delay relative to the rate of wind generating capacity coming online. Grid companies lack proper incentives to connect the renewable generation capacity, and there is a concern about the quality and standards of certain wind generation assets. Even where wind resources are connected, grid operators are not always able or willing to use that power.

The grid system is relatively inflexible in structure and function. The regions are not well connected, and that limits the ability of grid operators to shift loads when power generation is high in one region and needs to find a demand outlet. Within regions and provinces, 80 percent of electricity trading is governed by long-term contracts with quantities and pricing decisions set on a yearly basis.[32] This makes the system even less flexible in terms of transferring load from intermittent sources to reach demand centers.

Some of the difficulties have to do with the way China's electric power market is structured. NDRC sets electricity prices, and China effectively has no electricity spot and wholesale spot markets. Utilities therefore have no incentive to dispatch spare units during a supply crunch, and consumers have less incentive to save electricity than they would if electricity prices were allowed to rise (though electricity prices are already high relative to residential income).

32. Kat Cheung, *Integration of Renewables: Status and Challenges in China Working Paper*.

Recognizing the limitations that China's grid management and capacity have on the upward potential of renewable power integration, the government has enacted a number of measures to alleviate these challenges (see summary table below).

These measures aside, the nonmarket-oriented characteristics of China's electricity market and some unintended/unforeseen consequences of other energy and environmental policies have complicated China's ability to resolve some of the challenges of incorporating higher levels of renewable energy onto the grid. For example, closing small coal-fired power generation facilities actually diminished some of the most logical infrastructure that could be turned into supporting intermittent wind generation. And that poses challenges to increasing the amount of renewable energy in the grid. China's electricity system is rigid and lacks the kind of flexibility in pricing, dispatch, and balancing that would accommodate higher levels of renewable energy. Long-term price and quantity contracts for electricity trading, government mandates, fixed electricity prices, independent management of separate grid structures, and the diminishing number of small plants that would be more acceptable for balancing purposes are all obstacles.

The government's efforts to overcome these barriers have been largely top-down, directed measures that can give the market and investors a great deal of certainty but lack the type of flexibility and adaptability of a market-based system.[33] China's reluctance to adopt a more market-oriented approach lies in the need to provide stable, affordable access to electricity for the purposes of constant economic growth.

Nuclear

Despite a reported slowdown in nuclear capacity expansion in the wake of Fukushima, China is still on track to build more new nuclear capacity than any other country in the world. In so doing, the government hopes to demonstrate its capabilities to participate in the entire spectrum of nuclear business and, perhaps eventually, export Chinese nuclear technology.

Nuclear energy fits squarely in China's secure, low-carbon pathways. As a technologically proven and economically viable source of electricity, nuclear energy—along with such renewable energy sources as hydro and wind—plays a central role in China's plan to diversify its electricity generation mix. Efforts to reduce the energy and carbon intensity of the current economic system render nuclear energy to be a beneficiary of strong political, policy, and financial supports.

China relies on nuclear power for 1 to 2 percent of its electricity generation today. It has fourteen reactors in operation, representing a total capacity of a little more than 10 gigawatt electric.[34] For a country whose civilian nuclear program took off only in the middle of last decade, China has a remarkably ambitious plan for its nuclear sector. Under the Medium and Long Term Nuclear Power Development Plan of 2007, it is to achieve the installed capacity of 40 GW by 2020.[35] Currently, there are twenty-six new reactors under construction and fifty-six planned—roughly 40 percent of the world's total capacity currently under construction.[36] Out of thirteen construction projects that started around the world last year, eight were in China.[37]

33. Kat Cheung, *Integration of Renewables: Status and Challenges in China Working Paper*, 27.

34. World Nuclear Association, "Nuclear Power in China," September, 2011, http://www.world-nuclear.org/info/inf63.html.

35. Ibid.

36. Ibid.

37. "Nuclear construction builds up," *World Nuclear News*, Jan. 4, 2011.

According to the World Nuclear Association, 150 additional new units are proposed in China alone. While the initial target of 40 GW was itself significant, the government has since then increased the target to be 70 to 80 GW by 2020, 200 GW by 2030, and 400 to 500 GW by 2050.[38]

Policy, Financing, and Technology

China's policy toward nuclear power is to expand its role in the current energy mix while simultaneously building and demonstrating the capability to participate in the entire spectrum of nuclear business and eventually developing and, perhaps, exporting next generation nuclear technologies.

The nuclear sector enjoys strong political commitment and policy support that have enabled the remarkable pace of expansion we see today. The country's first nuclear power plant was approved in 1982, and the construction started in the mid-1980s. By then, the leadership came to recognize the viability of nuclear power as a supplement to coal and hydro.[39] China's concerted expansion of its nuclear sector began with the Tenth Five-Year Plan (2001-'05), which incorporated the construction of eight reactors.[40] The mandated 20 percent reduction of energy intensity per GDP annually under the Eleventh Five-Year Plan (2006-'10) gave significant momentum to the growth of nuclear energy. By the end of the Twelfth Five-Year Plan (2011-'15), an additional 25 GW is planned to become operational and an additional 45 GW by the end of the Thirteenth Five-Year Plan.[41]

To further illuminate China's concerted push for nuclear power, the government announced that it would develop two industrial parks in 2010 that would focus on developing the nuclear power equipment manufacturing industry; nuclear training and education; applied nuclear science industries (medical, agricultural, radiation detection, and tracing); and on promoting the nuclear industry.[42] Launched in March 2010 by the China National Nuclear Corp. (CNNC), the industrial park would give those enterprises in the park the priority for bidding quota and specific purchasing with the company, as well as offer bidding training.[43] In addition, China will reportedly spend approximately $175 billion over the next ten years on developing the 130 square-kilometer Haiyan Nuclear City.[44]

The government policy initiatives and expansion targets are thoroughly matched by the level of planned investment in the sector. CNNC plans on investing a total of 500 billion renminbi (RMB) by the end of 2015 and a total of 800 billion by the end of 2020.[45] The investment through 2015 is expected to help stimulate 2 trillion RMB worth of related investments in the nuclear power sector.[46] Chinese nuclear manufacturers are also orchestrating a large-scale fundraising drive. Several CNNC subsidiaries are planning to list on major regional stock exchanges, along with

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38. World Nuclear Association, "Nuclear Power in China."

39. Bo Kong, "Civil Nuclear Energy Development in China and U.S.-China Nuclear Cooperation," presentation at Brookings Institution seminar, Washington, D.C., Sept. 17, 2010.

40. World Nuclear Association, "Nuclear Power in China."

41. Ibid.

42. "Construction of Chinese 'Nuclear City' to start," *World Nuclear News*, Aug. 16, 2010, http://www.world-nuclear-news.org/NN-Construction_of_Chinese_Nuclear_City_to_start_soon-1608104.html.

43. Ibid.

44. Ibid.

45. "CNNC Plans 500B Yuan Investment in Nuclear Power," *Capital Vue*, Sept. 19, 2010, http://www.capitalvue.com/home/CE-news/inset/@10063/post/1218296.

46. Ibid.

other state-owned nuclear and construction companies.[47] Meanwhile, one government agency estimates that the country needs roughly 1 trillion RMB ($151 billion) in new investment by 2020, not counting the units that are already under construction.[48]

China's nuclear energy policy has four key elements: 1) the emphasis on pressurized power reactors (PWRs) for the near future; 2) the indigenous assembly, fabrication, and supply of nuclear fuels; 3) maximizing domestic manufacturing of plants and equipment; and 4) becoming self-reliant on design and project management.[49] Chinese reactor technologies have been based on designs from France, Canada, and Russia. While CPR-1000 and AP-1000 (both PWRs) dominate their construction plans, industry observers note that PWRs are expected to level off at 200 GW in about 2040 and fast reactors will increase in 2020 to at least 200 GW by 2050 and 1,400 GW by 2100.[50]

A key endeavor in the Chinese nuclear industry today is to build Generation III plants on its own based on the lessons learned from the construction of Westinghouse's advance third-generation AP-1000 reactors at Sanmen and Haiyang.[51] Another technology endeavor has been closing the fuel cycle. According to news reports in January 2011, some technological breakthrough in its reprocessing program was made at a CNNC factory.[52]

Challenges

The Chinese are investing heavily in nuclear technology research and development and manufacturing that are commensurate with the political push for the expansion of civilian nuclear power. Meanwhile, the institutional capacity has yet to receive a similar level of investment—in terms of political commitment, policy support, and capital investment. And that has caused concerns.

Among the capacity concerns are the fragmentation of governance, lack of regulatory independence, shortage of regulatory personnel, and the absence of atomic law. For example, the regulatory body—the NNSA—currently resides under the China Atomic Energy Authority although it reports directly to the State Council.[53] The State Council Research Office, which makes independent policy recommendations to the council, notes that "the independence of regulatory authorities is not enough," and recommends that the NNSA be directly under the State Council Bureau.[54]

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47. CNNC had planned on listing its subsidiary, CNNC Nuclear Power Co., in the first half of 2011; at the time of this report, it had not done so. Another subsidiary of CNNC, CNNC International Ltd., has been listed on the Hong Kong Stock Exchange. China Nuclear Engineering Construction Corp., a major rival to CNNC, is eyeing the capital market in Shanghai for a listing in 2011. Additionally, State Nuclear Power Technology Corp., which is mainly involved in the development of third-generation nuclear power technology in China, plans to list its shares in 2012. The company also plans on increasing its registered capital from 4 billion RMB ($597 million) to 10 billion RMB through a capital injection, and it plans to set up a financial services arm in 2010 to enter the financial sector.

48. "Maintain Nuclear Perspective, China told" *World Nuclear News,* Jan. 11, 2011.

49. World Nuclear Association, "Nuclear Power in China."

50. Ibid.

51. Ibid. In November 2010, approximately 75,000 documents about these first four reactors were transferred from Westinghouse to the Chinese. The Sanmen and Haiyang projects were agreed upon in February 2007, and construction started in 2009. The projects appear to be proceeding well. The Sanmen Unit 1 is expected to go on-line in November 2013 and the Haiyang Unit 1 in May 2014.

52. Zhou Yan, "Nuclear Fuel Feat to Solve Uranium Shortage," *China Daily*, Jan. 4, 2011.

53. "Maintain Nuclear Perspective, China told," *World Nuclear News*.

54. Ibid.

Also, senior officials from the NNSA and the National Energy Administration have identified the inadequate training for professional staff and quality control as concerns, saying that China is "short of specialized talent and also short of experience."[55] For example, it has been suggested that the NNSA would require more than four times the current levels of staffing to provide adequate level of safety oversight.[56] The human resource shortage is a concern in the operational side, too. China currently has six leading universities that train nuclear specialists.[57] In 2004, 750 students entered universities to pursue the study in nuclear-related fields.[58] According to the China Atomic Energy Agency, 25,000 additional nuclear experts are needed by 2020.[59]

Despite China's efforts to become self-sufficient in the most aspects of the fuel cycle, it still relies on foreign suppliers for all stages—e.g., uranium mining, conversion, enrichment, and fabrication services. The country's known uranium resources are approximately 100,000 tonnes-uranium (TU), and its production level of about 840 tonnes/year supplies enough for about 4,000 megawatts electric.[60] As China rapidly increases the number of new reactors, the dependence on uranium imports is expected to rise even though the exploration and plans for new mines have increased significantly since 2000.[61] The supply security of uranium will remain an important consideration if nuclear energy is to successfully transform China into a secure, low-carbon economy.

In the immediate aftermath of Japan's Fukushima nuclear power plant accident, the Chinese government suspended the approval of new nuclear projects on March 16 until safety reviews could be conducted. In May, officials announced the government's intent to upgrade the emergency procedures for nuclear power plants.[62] As part of that, the nuclear and radioactive safety management department under the MEPM noted the need to improve coordination among government departments.[63] Officials there said that back-up power supplies, flood control facilities, and exterior walls of reactors were some of the things that needed immediate attention and upgrades.[64] The ministry's 2011 budget plan includes 150 million RMB on nuclear and radiation safety supervision and control, and technology assessment.[65]

Additionally, the Fukushima accident may provide some impetus for serious examination and debate on the safety of the plants built along earthquake fault lines as well as their regulatory regime as a whole. However, it is too early to know what effect, if any, the accident may have on the fundamental course of China's ambitious civilian nuclear program.

Another key challenge relates to the efficacy of China's emphasis on building older-design reactors. Roughly half of the units under construction and many on order are Generation II or II-plus design reactors like CNP-1000 and CPR-1000. While the design itself may not be deficient, much advancement has been made in the newer generation reactors (i.e., Generation III or III-

55. Aizhu Chen, "China's Nuclear Sector Faces Shortages of Specialists," Reuters, Sept. 20, 2010, http://af.reuters.com/article/energyOilNews/idAFTOE68J04920100920.

56. Ibid.

57. Ibid.

58. Bo Kong, "Civil Nuclear Energy Development in China and U.S.-China Nuclear Cooperation."

59. Ibid.

60. World Nuclear Association, "China's Nuclear Fuel Cycle," July 28, 2011.

61. Ibid.

62. United Press International "China to boost nuclear safety standards," May 9, 2011.

63. Ibid.

64. Ibid.

65. Yan Wang, "China's Environmental Watchdog," Xinhua News Agency, May 14, 2011, http://news.xinhuanet.com/english2010/china/2011-05/14/c_13874717.htm.

plus) that are being developed, built and sold by suppliers from other parts of Asia and the west. The newer generation reactors have a greater emphasis on the passive safety systems, for example, that utilize physical phenomena such as gravity, as opposed to engineered components (or electrical or mechanical operations). Because nuclear power plants generally operate for forty to sixty years, building an older-generation reactor today would severely limit China from taking advantage of advanced reactors that are available in the marketplace today or for much of this century.

Natural Gas

Perhaps the most underutilized conventional energy source in China, natural gas is expected to experience a precipitous increase in the energy mix during the coming years, and policymakers are pushing hard to access all the sources of natural gas they can find. To do so they will need to overcome key economic and infrastructure challenges.

Natural gas makes up a small portion (approximately 3.8 percent) of China's total energy mix. Industrial users take up about 45 percent of current consumption, but the impressive growth in demand is expected to come from industrial, residential, and power consumers.

Gas also contributes a small portion to the nation's electric power mix. Thermal power—which includes coal, oil, and gas—makes up 75 percent of China's electric power use; of that used in 2009, 95.2 percent came from coal and the contribution of oil and gas were 0.6 and 0.2 percent respectively.[66] China consumed approximately 3,075 billion cubic feet (bcf) of gas in 2009, up 12 percent over the year before. Gas production in 2009 stood at 2,929 bcf (up 8 percent from 2008) with imported gas making up the difference between domestic production and consumption.

Over the next couple of decades, the demand for gas is expected to increase as a result of government policies to promote the fuel and strong growth in demand for energy. The Twelfth Five-Year Plan sets a goal for gas to make up 8.3 percent of China's total primary consumption by 2015. Despite this ambitious aim, it is worth noting that the government set a goal of 5.3 percent of the total energy mix to come from gas by 2010 but was unable to meet it. Even before the plan targets were announced, IEA forecast global natural gas demand to grow 44 percent by 2035, with China accounting for one-fifth of that growth. According to IEA calculations, China's demand will grow by 6 percent per year. The U.S. Energy Information Administration (EIA) also forecast significant gas demand for China with a 5 percent per year growth rate to reach a tripling of demand by 2035.

At this rate, China will likely have to rely on increased domestic production and expanded imports. It has approximately 107 trillion cubic feet (tcf) of proven gas reserves, but significant new estimates are emerging for unconventional natural gas resource bases such as coal bed methane (CBM) and shale gas as resources are reevaluated in light of new technologies and processes. Estimates are that China has 350 tcf of recoverable CBM reserves although only 6 tcf are currently proven. In 2009, around 8 percent of current gas production came from CBM, although this was less than one-third of the total CBM production. By 2030, estimates done by FACTS Global Energy show that CBM use could be as high as 4 to 5 billion cubic feet per day (bcf/d) or 8 to 10 percent of projected gas demand.

There is also significant optimism over the potential of sizable shale gas production in China. A recent resource estimate conducted by Advanced Resources International Inc. on behalf of EIA

66. Climate Policy Initiative at Tsinghua, *Review of Low Carbon Development In China: 2010 Report*.

put China's recoverable resources from the two most prospective basins at 1,275 tcf.[67] CNPC's own shale gas reserve estimates are 1,060 tcf. Unlike CBM development, shale gas exploration is just now beginning; so the public information on shale (gas) formations (size, quality, commerciality, etc.) is quite limited, and all conclusions drawn from it are tentative at best. Given the immaturity of these shale gas developments, it will be several years if not longer before production is expected to reach any significant level.[68] Current shale gas production currently stands below 300 bcf a year.[69]

China is working to secure increased imports of natural gas via pipelines from neighboring regions and also through LNG imports. It became a net importer of gas in 2007. Two years later the nation began importing gas from Central Asia via the 1,130-mile-long Central Asia Gas Pipeline; this brings gas from Turkmenistan, Uzbekistan, and Kazakhstan at about 200 bcf a year.[70] China is negotiating with entities in that region for additional supplies from Central Asia, and it is also working on two major pipeline deals with Russia and one with Burma (Myanmar).

China is also a growing force within Asia Pacific gas markets. According to FACTS Global Energy, the country will represent one-third of regional gas demand by 2030 (up from about one fifth of the market today).[71] It currently operates three LNG import terminals and imports gas from Australia, Malaysia, and Indonesia and has a long-term contact with Qatar. China has four more LNG import facilities under construction and even more currently undergoing government approval. In recent years China has experienced stiff competition for long-term gas contracts from other Asian gas importers like Japan and the Republic of Korea.

The rising reliance on fossil fuel imports exposes China to transport-related security challenges. On the international front, it is heavily dependent on sea-lanes such as the Strait of Malacca, for oil and gas imports. As the link between the Indian Ocean and the South China Sea and Pacific Ocean, the strait is the shortest sea route for Persian Gulf suppliers. More than 50,000 vessels or roughly half of the world's fleet travel through here each year.[72] At its narrowest point, the strait is only 1.7 miles wide, thus creating a natural bottleneck that sets the scene for collisions, grounding, or oil spills.[73] Tankers also face a constant threat of thefts and hijackings during the passage.[74] In 2009, 3.1 million barrels per day, or 77 percent of Chinese crude oil imports went through the Strait of Malacca. The volume is forecast to rise to 3.5 million bpd by 2015.[75]

One of the main drivers for investing in pipelines and LNG facilities in recent years is to reduce China's dependence on maritime supply routes for fossil fuel imports from the Middle

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67. EIA, *World Shale Gas Resources: An Initial Assessment of 14 Regions Outside of the United States* (Washington, DC: U.S. Department oft Energy, April 2011, http://www.eia.gov/analysis/studies/worldshalegas/pdf/fullreport.pdf.
68. Ibid.
69. EIA, "China Country Analysis Brief," 2010.
70. Ibid.
71. FACTS Global Energy, *FGE Gas Databook: Asia Pacific Natural Gas & LNG—Annual Update,* Gas Insights Issue #17013 (June 2011).
72. EIA, "Country Analysis Brief: World Oil Transit Chokepoints" (February 2011), http://www.eia.doe.gov/cabs/World_Oil_Transit_Chokepoints/Full.html.
73. Ibid.
74. Ibid.
75. IEA, "Overseas activities of China's oil companies are demystified in new report" (press release), Feb. 17, 2011, http://www.iea.org/index_info.asp?id=1816.

East and Africa. In 2006, it inaugurated its first transnational oil pipeline that carries 200,000 bpd of Kazakh and Russian oil over 620 miles.[76] China is involved also in the Eastern Siberia-Pacific Ocean Pipeline (ESPO) project, which became operational in 2011 and delivers Russian oil to the Chinese border, and in the $2.9 billion project with Burma that entails parallel oil and gas pipelines that by design bypass the Strait of Malacca.[77] Moreover, the Central Asian Gas Pipeline, which is China's first import natural gas pipeline, began operations in December 2009, carrying natural gas imports from Turkmenistan, Uzbekistan, and Kazakhstan. Several natural gas pipeline projects are currently proposed, and they may expand the natural gas imports from Russia and Burma. Additionally, in light of China's drive to speed up its LNG imports after just completing one LNG re-gasification in mid-2011, four more terminals are under construction, two new terminals are approved, and a few additional facilities proposed—all in addition to three terminals that are already in operation.[78]

China has a number of goals on both the production and consumption sides of its gas ledger. On the consumption side, policymakers have set a goal to boost natural gas as a share of total energy mix to 10 percent by 2030; for shale gas, the goal is to discover 35 tcf of recoverable shale gas resources by 2020.[79]

Challenges

The main challenges to increasing the use of gas use are related to economics and infrastructure. On the economic side, despite rising coal prices, gas is still more expensive than coal and traditionally a preferred fuel for utilities.

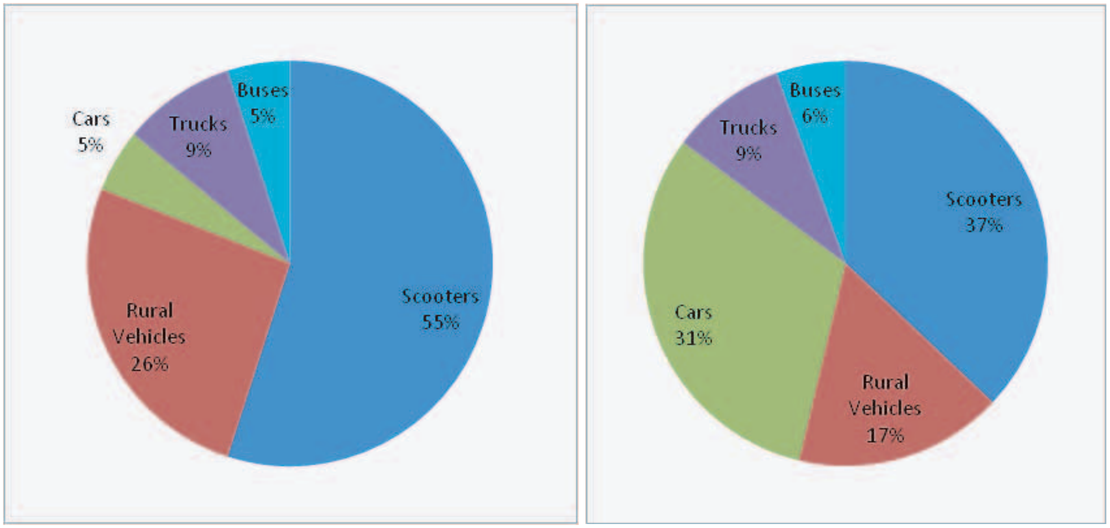
Natural gas prices are also regulated at the retail level; rates are different depending on the end-use consumption sector and have typically been well below market prices. In 2009 NDRC linked domestic gas prices to the international price, and by mid-2010 onshore wellhead gas prices rose by 25 percent. Several cities have passed the costs on to consumers in certain sectors.[80]

The emergence of large potential sources of unconventional gas in China has also thrown a wrinkle into price negotiations surrounding some of the gas import infrastructure projects.

The natural gas sector is also challenged by an incomplete, fragmented distribution network. China currently has about 21,000 miles of natural gas pipelines, and the government plans to build 14,400 miles of new pipeline between 2009 and 2015 in addition to connecting some of the regional distribution networks.[81] There are also significant capacity expansion plans for some of the major gas pipelines that move gas from resource-rich parts of the country to demand centers. For example, the West-East Pipeline is 2,500 miles long and currently brings gas from the western provinces and Central Asia to consumption centers in the east. Its capacity stands at 424 bcf a year, and there are plans to increase that to 600 bcf a year.[82] In addition, several other west-east pipelines are under way—massive infrastructure projects that cost billions of dollars.

76. EIA, "China Country Analysis Brief," 2010.
77. Ibid.
78. Kang Wu, "China's Oil and Gas Sector Developments and Market Dynamics," presented at CSIS, Oct. 27, 2010).
79. EIA, "China Country Analysis Brief," 2010.
80. Ibid.
81. Ibid.
82. Ibid.

Figure 3.3. Comparison of China Vehicle Fleet, 2000 versus 2010



Source: Argonne National Laboratory, *Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO_2 Emissions through 2050,* December 2006.

Transportation Alternatives

China's growing demand for vehicles is a great source of concern for urban planners, environmentalists, and those worried about relying too much on imported oil. To combat these concerns, the government has launched a great many initiatives to offer alternatives to personally owned vehicles as a primary mode of transportation. It has also increased vehicle efficiency standards, and hopes to lead the way in a move toward electric vehicles.

Transportation demand growth in China has surpassed all expectations in the last several years. It accounts for only 8 percent of the total energy consumption; in 2009, it accounted for 40 percent of oil consumption.

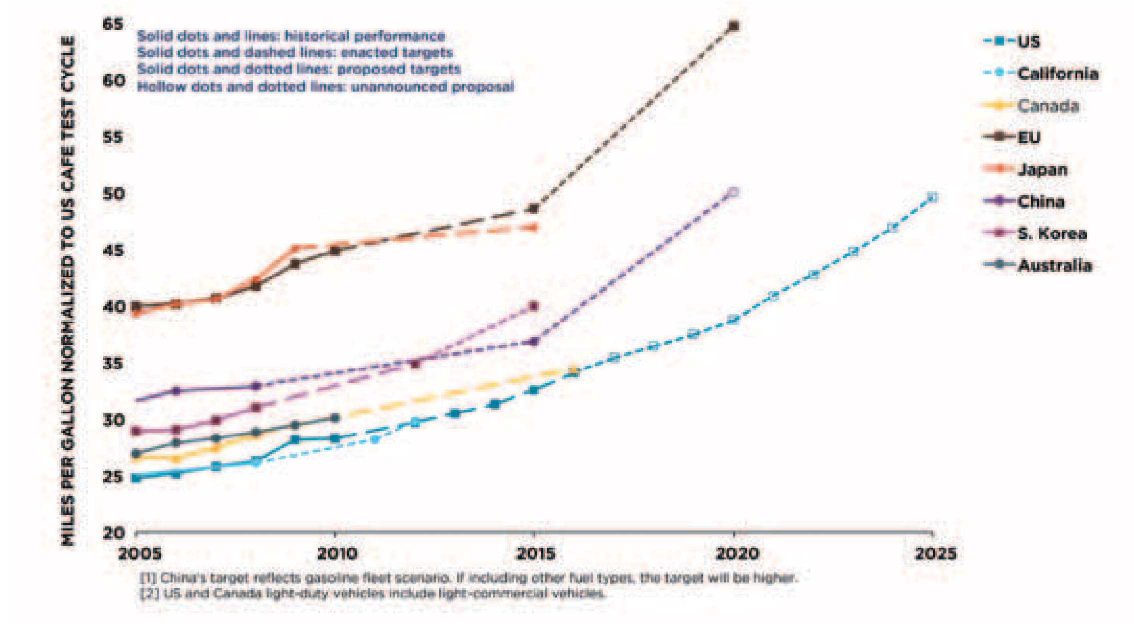
Between 2000 and 2010, the number of cars in China was projected to increase six-fold; instead it grew by a factor of twenty.[83] Today the nation has nearly 270 million motor vehicles and is the largest vehicle market in the world. Even with lower GDP growth estimates, China's demand for vehicles is expected to continue to grow due to large-scale migration to cities and increasing interest in vehicle ownership in rural areas. By 2020, there could be nearly four hundred million vehicles on Chinese roads, and estimates for 2030 project that to hit between six hundred million to one billion vehicles as possible future outcomes.[84] To be clear, these figures include scooters and motorbikes that comprise a large share in the total fleet, as shown below.

The types of vehicles owned in China have also changed dramatically over the last decade. In 2000, cars only made up about 5 percent of the fleet, while scooter and rural vehicles (popular because they faced less stringent regulations) made up 55 and 26 percent respectively. A combination

83. Deborah Gordon and Yuhan Zhang, *Driving Force: Energy and Climate Strategies for China's Motorization* (Washington, DC: Carnegie Endowment for International Peace, April 14, 2011), http://www.carnegieendowment.org/files/driving_force.pdf.

84. Ibid.

Figure 3.4. Comparison of Actual and Projected Corporate Average Fuel Economy for New Passenger Vehicles



Source: Data for Fuel Economy Standards and GHG Standards, November 2009, http://www.theicct.org/documents/ICCT_PVStd_Nov09_(Data_Sheet).xls.

of increased income levels, urbanization, and government policies that encourage car ownership, caused car purchases to skyrocket from four million in 2000 to nineteen million in 2005.[85]

China is also in the process of building up the necessary infrastructure to support these vehicles. In 1999, China only had 6,258 kilometers of highway. Today, it has 65,000 kilometers of highway and 3.7 million kilometers of paved roads; it is expected to surpass the United States as the having the world's most extensive highway system by 2012.[86]

China has focused on controlling energy consumption growth in the transportation sector in several key ways: vehicle efficiency, mass transit infrastructure, driving limitations, and promoting alternative vehicles and fuels. It has begun to pull back on or revise some of its incentive programs for vehicle purchasing. In addition, to fight local pollution and safety and gridlock concerns, some major cities have instituted strict driving rules that include lottery systems for new vehicle purchases, driving restriction days, and proposed congestion charges and higher parking fees.[87] In Beijing, driving restrictions and mass transit systems are reportedly having a positive effect, with the average duration of traffic jams being cut back from three hours and fifty-five minutes last year to one hour and forty-five minutes this year.[88]

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85. Ibid.

86. Ibid. The United States has 75,000 kilometers of highway, but this system is largely though to be built out while China is still building.

87. The Beijing vehicle lottery limited new vehicle registration for 2011 to 240,000, a third as many as in 2010. Xinhua News Agency, "Car purchase lottery starts in Beijing," Jan. 27, 2011, http://www.china.org.cn/business/2011-01/27/content_21826885.htm.

88. Xinhua News Agency, "Car purchase lottery starts in Beijing"; "Shenzhen Looking At Congestion Charges," *People's Daily*, March 8, 2011, http://www.chinacartimes.com/2011/03/08/shenzhen-looking-at-congestion-charges/.

China has implemented fuel efficiency standards for a wide range of vehicle classes. Passenger vehicle fuel economy standards are already more stringent than those of the United States, Canada, and Australia—but not Japan or the European Union. According to a recent study done by the International Council on Clean Transportation (ICCT) in support of the China's MEP, vehicle emissions and efficiency standards have had a positive impact in terms of reducing negative health effects from local air pollution to the tune of $25 billion in avoided health costs in 2010 alone.[89]

The government has also placed a great deal of emphasis on public transportation options especially in rapidly modernizing cities. In the next five years, China is expected to extend new rapid rail access to every city with more than 500,000 people.[90] The Twelfth Five-Year Plan also includes new transit systems for up to sixteen cities and targets to improve existing subway and light-rail systems.[91]

89. Freda Fung, Hui He, Benjamin Sharpe, Fatumata Kamakate, and Kate Blumberg, *Overview of China's Vehicle Emission Control Program: Past Success and Future Prospects* (Washington, DC: International Council on Clean Transportation, 2010), http://www.theicct.org/pubs/chinarpt/1_executivesummary.pdf.

90. Deborah Gordon and Yuhan Zhang, *Driving Force: Energy and Climate Strategies for China's Motorization*.

91. Ibid.

4 THE EVOLVING CHINESE NOTION OF SUSTAINABILITY
POLICIES UNDER THE TWELFTH FIVE-YEAR PLAN

Overall the Twelfth Five-Year Plan the government approved in early 2011 puts forward a vision of China on a slower (though still very rapid by global standards) and more stable growth trajectory. In the energy sector it continues to emphasize promoting efficiency and conservation, and having alternative energy sources play a larger role. The plan builds upon areas of past success in terms of continuing key programs and setting economy-wide goals, but also seeks to institute structural changes in places where progress toward reaching those goals is thought to be impeded—such as upgrading or integrating the nation's electric power grids, or building more mass-transit options to alleviate demand for vehicles. It provides clear direction on the need to reduce emissions intensity. It maintains a focus on the importance of transforming the country's economy by building competitiveness in new fields that have a higher economic value than basic resource extraction or light manufacturing, including clean energy technology development. Finally, the plan seeks to implement market-based programs and reforms in an effort to catalyze harder-to-reach efficiency and low-carbon energy gains and to improve the cost-effectiveness of their policy implementation (see a summary of Twelfth Five-Year Plan provisions below). Clean energy analysts have observed that the plan is a clear indication that China intends to build on its success in the clean energy sector and continue to develop along these lines.

China had a great deal of success in some of its energy reform efforts in the Eleventh Five-Year Plan, but it also had some mishaps and hurdles. As was mentioned earlier, the government was not particularly successful in transitioning the economy away from energy-intensive industries. Moreover, policymakers scrambled to meet the energy intensity target set by the plan and as a result took rather draconian measures to shut down plants and facilities in the waning months. This caused blackouts, forced factories to shut –down, and was otherwise overly disruptive.[1]

The Twelfth Five-Year Plan reportedly continues to evolve the notion and improve the mechanisms for how China will ultimately reach its own version of sustainable growth, further solidifying policies designed to steer away from resource-intensive growth and focus on implementing more cost-effective policy mechanisms and approaches.

Rejection of the "Develop Now, Clean Up Later" Approach

Certain analysts have concluded that the Twelfth Five-Year Plan is the most important clean energy signal to come from the Chinese government since the Renewable Energy Law of 2006 and perhaps the clearest articulation of China's energy and environmental priorities. This plan is also backed by considerable financing. Estimates state that the government is prepared to support

1. The Climate Group, *Delivering Low Carbon Growth: A Guide to China's 12th Five Year Plan*.

Table 4.1. Provisions Included in China's Twelfth Five-Year Plan

Sector	Goals
Carbon intensity	Reduce by 17 percent from 2010 levels by 2015.
Carbon trading	Establish a carbon trading scheme gradually, set up and improve a reporting and verification system for greenhouse gas emissions, and promote low-carbon pilot schemes.
Energy efficiency	Create electricity pricing reforms that favor efficiency, provide financial support to energy service companies, develop an energy use cap in energy-intensive industries, and allow pilot energy saving trading.
Energy intensity	Reduce by 16 percent from 2010 levels by 2015.
Forests	Increase the area of forest coverage by 12.5 million hectares and forest stock volume by 600 million cubic meters.
Grid	Build cross-region UHV transmission lines to support long-distance power transmission and grid connection for renewable power with 200,000 kilometers of power lines with capacity of more than 330 Kilovolts (KV) by 2015, roll out smart substations, promote the use of smart meters, and build electric car charging facilities.
Hydro	Start construction of additional 120 GW.
Nonfossil use share	11.4 percent of primary energy consumption by 2015.
Nuclear	Start construction of 40 GW.
Solar	Have 5 GW installed capacity by 2015.
Transport	Construct 35,000 kilometers of high-speed rail to connect every city with more than 500,000 residents.
Wind	Install at least 70 GW of new capacity.

Source: Bloomberg New Energy Finance.

clean energy initiatives to the tune of approximately $763 billion over the next decade (this figure includes nuclear energy).[2] A growing number of targets in the Twelfth Five-Year Plan focus on resource or environmental objectives (nearly one-third, according to experts at the Chinese Academy of Social Sciences).[3] In addition, for the first time the plan includes an explicit articulation of the nation's approach to addressing climate change.

Increasing Focus on Cost-Effectiveness

Part of the disagreement that arises over China's role as a leader or laggard in low-carbon pathways is the extreme difficulty of accurately measuring and assessing the success of various programs and measures. Information transparency or truthfulness aside, many policy analysts note that the way in which many Chinese energy policies are structured and implemented make it difficult to assess their performance. For example, the Top-1000 Enterprise Program is often credited as one of China's most successful energy efficiency programs. The drive to improve overall efficiency of these enterprises spans multiple fields and policies including energy audits, reporting require-

2. American Council on Renewable Energy and the Chinese Renewable Energy Industry Association, *US-China Quarterly Market Review* (Spring 2011).

3. Mark Fulton, "12th Five Year Plan—Chinese Leadership Towards A Low Carbon Economy."

Table 4.2. China's Cap and Trade Development Timeline

April 2008	Binhai New Area Development Plan creates the seeds for carbon market mechanism.
June 2008	People's Bank of China and China Investment Corp., among others, start drafting outlines of an emissions trading scheme for the country.
August 2008	Environmental exchanges are set up in Beijing, Shanghai, and Tianjin.
February 2010	The first carbon trades are executed in Beijing and Tianjin.
October 2010	The NDRC affirms the prospect of environmental taxes in the upcoming Twelfth Five-Year Plan and notes that carbon taxes are also being explored.
November 2010	A Panda Standard is formed (first voluntary carbon standard for China).
January 2011	The city of Wuxi announces a plan to map out a low-carbon strategy consistent with the concepts being formulated in the Twelfth FYP discussions.
March 2011	A summary draft of the plan includes cap and trade for the first time as a policy to be implemented on a pilot basis.

Source: Deutsche Bank Climate Change Advisors, Analysis 2011.

ments, standards, investment, and incentives. While the overall program may show signs of success, because it is evaluated in its entirety, some highly successful aspects of the program may mask highly ineffective or inefficient policy measures elsewhere.[4]

It is also difficult to measure the policies' cost-effectiveness with any accuracy. The Chinese government has spent 2 trillion RMB to 3 trillion RMB over the course of the Eleventh Five-Year Plan on energy conservation and environmental protection; McKinsey & Co. estimates that 1.3 trillion RMB was spent on energy and low-carbon development. Yet there is very little insight into how this money was spent on specific programs; nor is there a viable means of assessing how well the money was spent.[5] Moreover, many of the policies and programs were run by top-down regulatory measures that are often overly resource-intensive.

This question of cost-effectiveness has motivated policymakers to introduce elements of market mechanisms along with other policies in the Twelfth Five-Year Plan. There is an increasing awareness that significant cost and energy savings can be achieved with market signals more than top-down administrative structures. One important feature of this new focus on cost-effectiveness is China's reported desire to institute several cap-and-trade or other market-based mechanisms to curb environmental pollutants. This includes plans to institute cap-and-trade pilot programs over the 2011-'15 period. For the last several years, Chinese policymakers have discussed cap and trade and environmental taxes as possible new tools under consideration (see summary table). While limited pilot cap and trade schemes may not seem remarkable from an emissions reduction perspective, it is clearly a break with China's historical top-down approach to driving clean energy and a sign that the government is focusing on ways to make more progress and be more cost-effective.

The Twelfth Five-Year Plan serves as a guide for China's policy-making apparatus. In the coming years, central government agencies, and in turn provincial and local government agencies, will release greater details about how new targets and goals are to be achieved.

4. Climate Policy Institute at Tsinghua, *Review of Low Carbon Development in China: 2010.*
5. Ibid.

Table 4.3. Key Policy Milestones in the Next Five Years

Document	Description	Date expected
Special Energy Conservation Plan	NDRC	Late 2011
Specific Plan for Addressing Climate Change	Break down restriction indicators, including energy intensity, carbon intensity, nonfossil fuel percentage in overall energy mix, and forest coverage.	2011
Strategic Emerging Industries Development Plan	Guiding document	August 2011
Energy Efficiency and New Energy Vehicle Industry Plan	Focus on hybrid and pure electric vehicles.	2011
New Energy Industry Plan	Covers advanced nuclear power, wind, hydropower, solar, biomass, clean coal, smart grid, and distributed energy systems	Draft still under discussion
Climate Change Law	Pull together existing law, lay a legal foundation for future institutions, and standardize function of existing institutions.	Next two or three years
Energy Law	Basic law for China	Draft released in 2007, submitted to State Council in December 2010

Source: The Climate Group, *Delivering Low Carbon Growth: A Guide to China's 12th Five Year Plan*, March 2011.

5 INTERNATIONAL IMPLICATIONS

China's drive to address its own concerns over the economic, security, and environmental impacts of its energy production and use has widespread implications for countries, markets, and international dynamics around the world. Given the globally integrated and interdependent nature of energy markets, investment and trade flows, and global supply chains, it is hard for any country's energy policies and practices not to impact at least some interests beyond its borders. For a country the size of China, with its enormous energy consumption, emissions profile, level of overall investment, and projected growth in all of those areas, it is nearly impossible not to have a widespread impact and the subsequent analysis (along with praise and criticism) that comes with it. For the purposes of this study, we explore the international implications for clean energy competitiveness, energy security, and climate change.

Competitiveness

China has planted its flag on the competitive high ground it perceives in clean energy products and services. It has done so by investing in clean technology manufacturing, growing its domestic market, providing clean energy incentives, and prioritizing so-called new energy industries for further support and additional research and development.

China has explicitly stated its objective to create and maintain a competitive advantage in the area of clean energy technology. It is not alone. Several other countries and regions, such as the European Union, Japan, Korea, and United States have stated—and supported with varying levels of policy and economic clout—the notion that this type of technology represents a strategic area for economic opportunity.

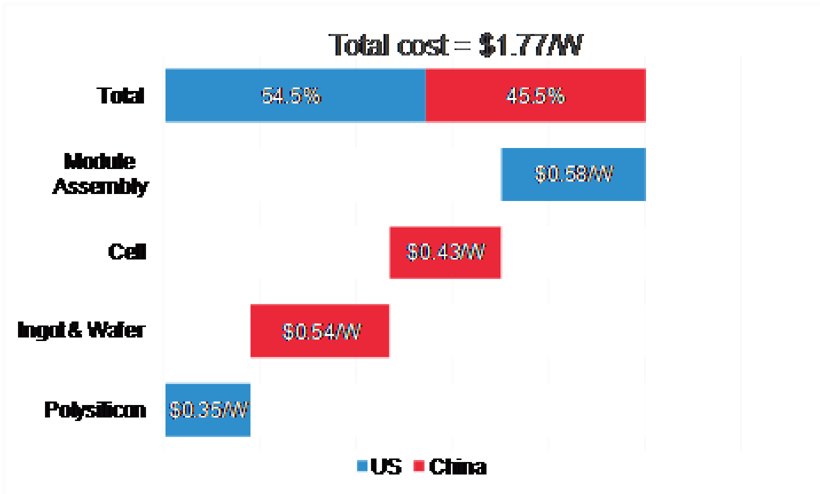
So far China has been extremely successful in some aspects of this challenge and less successful in others. It has undoubtedly succeeded in making itself a destination for clean energy investment and has emerged as a world leader in many areas of clean energy manufacturing.

In 2009, China became the world leader in attracting and deploying new investment for renewable and energy efficiency technologies. According to Bloomberg New Energy Finance (BNEF), China attracted $54.4 billion in third-party private capital in 2010, a 39 percent increase over the same category of financing in 2009.[1] By comparison, the second and third largest destinations for investment were Germany and the United States at $41.2 billion and $34 billion respectively.

In addition, a significant portion of clean energy investment came from the public sector. BNEF estimates China has spent $46.9 billion in economic stimulus for clean energy investments,

1. Ethan Zindler, testimony to the U.S. Senate Energy and Natural Resources Committee, March 17, 2011.

Figure 5.1. Value Breakdown by Country of Origin, Hypothetical Suntech (China) PV Module to Be Installed in the United States



Source: Bloomberg New Energy Finance.

Note: Example only; Suntech assembles the majority of its modules in China.

and the China Development Bank has committed $35.3 billion in credit facilities for solar and wind equipment manufacturers to export to key developing markets.[2]

Many Chinese companies that were little known several years ago are now global leaders both in and outside of China. In 2010 six of the top ten solar manufacturers were Chinese companies (Suntech, JA Solar, Trina Solar, Yingli, Canadian Solar, and Solarfun), and so were four of the top fifteen wind turbine manufacturers (Sinovel, Goldwind, DFSTW, and XEMC). Using a combination of second mover status (the advantage gained by not being the initial technology innovator but the second wave of companies improving upon an initial innovation), domestic demand, low-cost labor, and access to cheap financing, China has been able to drive down the cost of clean energy technology in both these sectors and become the largest manufacturer of a variety of technologies.[3]

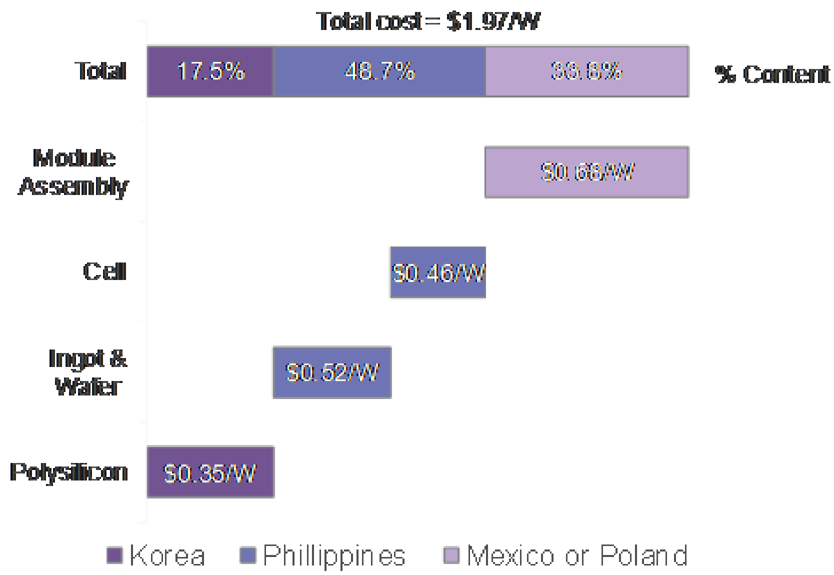
This impressive onset of activity has sparked concern in other countries, particularly the United States, that China is winning the clean technology race.[4] Some institutions invoke this competition threat in order to motivate more aggressive domestic clean energy policies and market activity. Clean energy competition has been a regular feature of political rhetoric, strategy documents, and policies in a number of countries including the United States, Korea, and Japan. On the flip side, other companies, lawmakers, and politicians point to actions China has taken that represent unfair competition practices under global trade rules and principles. The most notable example is the complaint filed by the United Steel Workers in late 2010 asserting unfair competition due to Chinese domestic content laws and other practices.

2. Ibid.

3. Bloomberg New Energy Finance, *Joined at the hip: The US-China clean energy relationship*.

4. Sources include a great deal of articles and studies such as the Breakthrough Institute's *Rising Tigers, Sleeping Giant,* and the Center for American Progress's *Helping America Win the Clean Energy Race.*

Figure 5.2. Value Breakdown by Country of Origin, Hypothetical SunPower (United States) PV Module



Source: Bloomberg New Energy Finance.

Note: Example only; SunPower has also procured silicon from U.S. producers.

The competitive dynamics in the clean energy marketplace and between China and other countries are decidedly more complex than whether one country has a leading number of turbine manufacturers. First, creating a market for clean energy technologies and services is not a zero sum game. Despite the apparent overwhelming shift in clean energy investment and activity to China, a variety of countries benefit from growing clean energy markets. The BNEF chart below shows that many Chinese PV modules include U.S. equipment while U.S. wind turbines have Chinese components. Several other countries contribute to the supply chain as well, like Korea, the Philippines, Mexico, and Poland.

In fact, Chinese policymakers are said to be frustrated by their reliance on other countries for high valued-added components and the country's role as the cheapest manufacturer. For this reason, China has established high local content rules, mandated joint ventures, and access to the latest technology in exchange for market access in some cases.[5] These methods have been extremely successful at times in giving domestic Chinese companies an expedited route to global competitiveness; high-speed rail is often-cited example of this.

In the Twelfth Five-Year Plan, China's focus on moving toward excellence in high-end energy technology is reflected in the government's decision to elevate new energy technologies as a priority for research and development investment. In Chinese policy-making, sectors that fall within this prioritized ranking are pillar industries. Nearly 70 percent of state-owned entities fall within these categories, indicating the importance China puts on their success. The plan has moved its focus from traditional pillar industries to so-called new strategic and emerging industries, which

5. Thomas M. Hout and Pankaj Ghemawat, "China vs. the World: Whose Technology Is It?" *Harvard Business Review*, December 2010.

Table 5.1. Strategic Industries Redefined

The "old" pillar industries	The "new" strategic and emerging industries
National defense	Energy saving and environmental protection
Telecom	Next generation information technology
Electricity	Biotechnology
Oil	High-end manufacturing (e.g. aeronautics, high-speed rail)
Coal	New energy (nuclear, wind, solar, biomass)
Airlines	New materials (special and high performance composites)
Marine shipping	Clean energy vehicles such as plug-in hybrid electrical vehicles (PHEVS) and electric cars

Source: Joanna Lewis, World Resource Institute/Environmental and Energy Study Institute briefing, April 5, 2011

include conservation and clean energy. This shift indicates these new industries will be supported by industrial policies and financial incentives.

China is very likely to continue to find success in becoming more competitive in a variety of industries using these methods, but foreign companies are also becoming increasingly sophisticated about how they take advantage of the exceptional growth opportunities while still protecting their competitive advantage and technological edge.

Not only are multiple countries sharing in the economic benefit created by greater demand for clean energy technologies through globally integrated supply chains, but also the size of the clean energy market is not fixed. A 2011 report that the Clean Energy Ministerial commissioned from IEA found that while clean energy technologies are making progress, especially in countries with stable incentive frameworks, fossil fuels continue to outpace them.[6] Moreover, to reach globally agreed-upon climate change goals, the market for clean energy technology should be much bigger. The report states that while renewables have shown impressive progress, their market presence needs to double by 2020 to meet global climate goals, and that the current atmosphere of fiscal austerity is causing governments to pull away from costly renewable incentive programs. In addition, one hundred large-scale carbon capture and sequestration projects are needed by 2020.

Therefore, countries that create incentives for clean energy technologies, in essence, grow the market and the size of the opportunity for those goods and services. Many of the articles and studies advocating a shift to clean energy fueled-economic growth state that a combination of policies to create competitive advantage in these technologies and grow their markets is the key to winning the clean energy race. The counter to this argument is that protectionist measures lessen the overall efficiency of the global market for these goods and services, and in so doing, they actually stifle growth. Moreover, these protectionist policies are ultimately ineffective because countries cannot create competitive advantages on things like manufacturing when other countries have a natural advantage. Other arguments state that this economic opportunity is being subsidized by government policy, and therefore it is an unsustainable subsidized industry.[7]

6. IEA, *Clean energy Progress Report* (Paris: OECD/IEA, 2011).

7. Bjorn Lomborg, "Hold the Accolades on China's Green Leap Forward," *Washington Post* (April 20, 2011), http://www.washingtonpost.com/opinions/hold-the-accolades-on-chinas-green-leap-forward/2011/04/19/AFLdZMEE_story.html.

Clean energy competition with China is an issue at the convergence of two other much larger issues dealing with the innovation cycle and the introduction of new low-carbon technologies into the market. It also raises the question of whether the future of a liberalized global trading system is changing and how countries continue to provide economic growth and jobs for their citizenry.

The first theory is that the introduction of clean energy technologies and services requires both push (research, development, and deployment) and pull (tax incentives, regulations, targets) incentives. The bigger the market, the more deployment, the more costs come down, the more companies invest in improvements. This process lowers the costs and improves performance for everyone to reduce emissions, diversify energy supplies, and fuel new industry. To this end, China is making a positive contribution to the effort to drive down costs of these technologies.

The second theory is much more complicated and politically charged. When China joined the World Trade Organization (WTO), the assumption was that over time its market would become more similar to other markets already in the system and gradually become more open. Since then China has been criticized for protecting its market through currency manipulation, inadequate protection of intellectual property rights, local content rules, and other preferential treatment. In reality other countries have done much of this in the past as a matter of industrial policy, but not nearly as aggressively or to the same extent. Given the current concern over the shortcomings of the free trade system and the relative decline of developed countries' economic standing, many academics are questioning whether China's economic policies will ever be more in line with WTO principles, and, if not, what system will arise and how companies and countries should position themselves for success.

Another concern is the job creation aspect of clean energy opportunity. Indeed much of the United States's success in clean energy investment is measured in job creation (much of this is because sizable amounts of the U.S. stimulus package went to fund clean energy investments). This raises an even more difficult question about how countries can or should incentivize the job-intensive aspect of clean technology and market development or if there are specific parts of the clean energy investment cycle that have catalytic economic benefits for the broader economy.[8]

Finally, many detractors of China's clean energy advantage point to the questionable quality of the technology products and the shortcomings in the clean energy market. As was discussed earlier, many of these observations have merit. The difference in perspective is that China views this as a competitive advantage it is building, not one it already possesses. The Twelfth Five-Year Plan and near-constant pace of reviewing and revising policies that promote these technologies and energy services show that China is willing to learn from its mistakes and adjust (within the confines of certain interests) to become more successful. This persistence and commitment illustrates the optimism policymakers place on the manufacturing of clean energy products as a source of strategic advantage.

Security

Concerned about its ability to secure affordable and reliable supplies of energy, China is promoting efficiency, creating diversity of energy supplies, building strategic stocks, and investing in energy production beyond its borders.

8. Green Growth Leaders, *Shaping the Green Growth Economy*, April 2011, http://greengrowthleaders.org/wp-content/uploads/2011/04/Shaping-the-Green-Growth-Economy_report.pdf .

China's energy security concerns have implications for the world that are economic as well. At first blush, the concerns and related strategies to deal with energy security seem to have very little to do with the country's low-carbon pathway goals other than to serve as a further driver for diversification away from fossil-based energy sources. In reality, these concerns are such a significant driver of energy policy decisions and have such an enormous impact on energy markets all over the world that China's actions on energy security are impossible to ignore when evaluating the impact on the international community. China's position as a net energy importer, coupled with its projected massive energy demand needs in the coming years, pose a great deal of concern about its ability to provide affordable, reliable energy supplies. The government's energy security strategy is much too complex to be captured in the space provided here, but a brief description of a few key pillars is important for understanding the complexity of the issue and potential impacts.

Strategic Reserves

China may increasingly affect the economic security of the United States and the world. As the world's largest energy consumer, China has become a "swing consumer"—the country that affects marginal oil prices based on its ability to substantially increase consumption relatively quickly.[9] Petroleum stockholding is a widespread and coordinated practice among OECD nations that China adopted to address its energy security vulnerabilities, mainly by minimizing adversarial impacts of a possible physical disruption of crude supplies.

The national petroleum reserves, announced in the middle of the past decade, are being built in three phases. The first phase, which encompasses four aboveground tank sites, was completed and its tanks filled by April 2009.[10] The sites hold 103 million barrels, which is equivalent to 31 days of net imports or 15 days of total consumption in China.[11] The second phase, slated to hold 169 million barrels, is targeted to be complete by 2012 or 2013. Unlike the first phase, the second phase will include sites in inland provinces, with access to trans-border pipelines. The sites may also utilize underground facilities.[12] By the time the third phase is complete in 2015-'16, China will likely have 500 million barrels of crude in its national reserve.[13]

Petroleum is not the only sector in which China is considering the importance of strategic stocks. The government recently approved a proposal to create the country's first strategic reserve of coal in order to provide a buffer against any short-term supply pressure or disruption, given China's increased reliance on coal imports. Recent years have shown the vulnerability of coal supplies, specifically from Australia, whose 2010 droughts have had a large, lasting impact on the Asian coal trade. The coal stocks are reported to start at 5 mega tons (mt) in May 2012 with a rumored upward potential of 20 mt some time in the future. According to the China National Coal Association, the ten largest coal mining and power companies and eight coastal port authorities will manage strategic coal stocks. These national reserves will be complemented by recently announced building stocks within Chinese provinces.[14]

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9. Mikkal Herberg, "China's Energy Rise and the Future of U.S.-China Energy Relations," New America Foundation, June 21, 2011, 2.

10. Kang Wu, "China's Oil and Gas Sector Developments and Market Dynamics."

11. Ibid.

12. Ibid.

13. Ibid.

14. Deutsche Bank, *Commodities Weekly* April 8, 2011.

As one of the largest consumers of oil, China's decision to hold strategic stockpiles is generally viewed as a positive development for global oil security. This type of preparedness is thought to insulate the entire market of consumers in the event of an oil supply disruption. It is not clear, however, how China intends to use these strategic stocks. OECD countries have historically coordinated stock releases, as well as holding requirements, through IEA, a group with whom China has observer but not member status. Engaging China on its development and use of strategic stocks has been a major priority and area of engagement for IEA and OECD members.

Diversify Supply Sources and Investing Abroad

In recent years, China has been making equity investments in oil and gas fields abroad in the belief that physical ownership enhances the country's energy security. These activities have been carried out by the country's national oil companies (NOCs)—notably China National Petroleum Corp. (CNPC), Sinopec, and China National Offshore Corp. (CNOOC). From 1992 through 2009, NOCs invested roughly $48 billion in upstream oil and gas assets abroad, of which approximately two-thirds was spent on direct acquisitions of upstream assets.[15] In 2009 alone, they invested nearly $17 billion for direct acquisition of oil and gas assets from other companies.[16] Much of what Chinese companies produced from assets they own overseas is in Africa (49 percent) and the former Soviet Union—mainly Kazakhstan (32 percent).[17] By 2008, China's total overseas equity output, which was 140,000 bpd in 2000, reached roughly 900,000 bpd, accounting for approximately 23 percent of its total oil production.[18]

The Chinese have also been trying to diversify supply sources. In 2008, Saudi Arabia supplied 22 percent of China's total oil imports, followed by Angola's 18 percent, Iran's 13 percent and Oman's 9 percent.[19] In recent years, they have been actively pursuing bilateral oil and gas deals with countries in Africa, the former Soviet Union, and Central and South America. For example, Africa's share in China's oil import market has grown from less than 5 percent in 1994 to more than 30 percent by 2008.[20] Taking advantage of the global recession as well as the large foreign reserves in the Chinese treasury, the government spent roughly $54 billion in 2009 alone for loans to non-Middle Eastern producers, such as Russia, Kazakhstan, Brazil, and Venezuela.[21]

China's enthusiastic involvement in developing natural resources outside of the country is an enormously complicated trend with a variety of internal political, commercial, and foreign policy dynamics that are difficult to separate. Other public and private sector interests have looked at these activities with mixed views due to the pace, magnitude, and, sometimes, method of carrying out these arrangements. On one hand, these investment dollars are welcome as a source of additional barrels on the market and, hopefully as a result, a well supplied, stable oil market. On the other hand, some view China's intentions with suspicion and wonder whether or not the political deals that come with the commercial deals somehow either undermine the free market system for oil (the so-called practice of planting flags on barrels) or, on the foreign policy side, have more to do with expanding China's soft power influence to other regions of the world.

15. Kang Wu, "China's Oil and Gas Sector Developments and Market Dynamics."
16. EIA, "China Country Analysis Brief," 2010.
17. Kang Wu, "China's Oil and Gas Sector Developments and Market Dynamics."
18. EIA, "China Country Analysis Brief," 2010.
19. Bo Kong, "Assessing China's Energy Security."
20. Ibid.
21. Ibid.

Conservation, Efficiency, and Diversity

As has been discussed throughout this report, the Chinese government has also introduced various demand-side policy measures in efforts to address its energy security vulnerabilities. First and foremost among such policy measures was its aggressive energy conservation plan under the Eleventh Five-Year Plan to reduce energy intensity per GDP by 20 percent by 2010. The conservation plans included the Top 1000 Energy-Consuming Enterprise Program and the Ten Key Projects. (See the energy efficiency section of this report for more details.)

The Chinese energy leadership has also been placing a greater emphasis on developing renewable and nuclear energy to diversify its energy mix. The government had set a policy target of increasing nonfossil energy's share in the total energy consumption to 15 percent by 2020.

Additionally, the government has been promoting green vehicles as one way of preemptively moderating a rapid rise in gasoline consumption that is expected, if not already under way, as Chinese society continues to modernize. Today, the transportation sector consumes roughly 40 percent of oil in China, but only 2 percent is used to fuel privately owned cars. However, by 2020, that segment will likely account for 10 percent of the total oil consumption by the transportation sector.[22] The oil consumption by the transport sector itself will likely rise five-fold by 2030.[23]

In order to promote green vehicles, in June 2010 the government announced subsidies of up to 60,000 RMB for fully electric vehicles as well as 50,000 RMB for plug-in hybrids in pilot cities like Shanghai, Changchun, Shenzhen, Hangzhou, and Hefei. Also, the ongoing efforts to convert public fleets to nonpetroleum-based vehicles—including compressed natural gas, biofuels, and hybrid electric vehicles—may reduce energy use by up to 1.6 quadrillion British thermal units (QBTUs) by 2025; that amount roughly equals 2 percent of China's annual energy use today.[24]

The size and pace of energy developments in China have the potential to revolutionize the technology and commercial dynamics for a great many energy sources. For this reason, how China chooses to prioritize energy conservation or nonfossil energy sources is of particular interest to other countries that seek to use those sources and companies that seek to deploy their technologies in the ever-growing Chinese market.

Climate Change

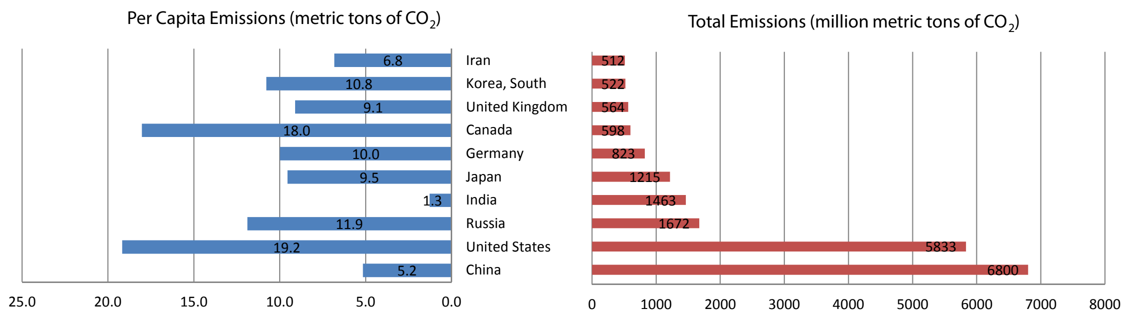
The world's largest greenhouse gas emitter has shifted its position on climate change to reflect the progress it is making at home to reduce it emissions growth rate relative to GDP. Analysts now envision a time when China's emission could peak by 2040.

China occupies a strategically and scientifically important role in climate change discussions. In the early 1990s when the global community first came together to settle on a way to deal with the global climate challenge, China was much less significant in terms of its overall size and emissions impact.

According to IEA projections, the country will account for 58 percent of the global increase in carbon dioxide emissions by 2035. Under the agency's new policy scenario that assumes China

22. China FAQs, *China's Transportation Revolution,* Nov. 2, 2009.
23. Mikkal Herberg, "China's Energy Rise and the Future of U.S.-China Energy Relations," 7.
24. China FAQs, *China's Transportation Revolution.*

Figure 5.3. Energy-Related Emissions of Top Ten Carbon Dioxide (CO_2) Emitters, 2008



Source: EIA 2011, International Energy Statistics.

reaches its stated emissions intensity reduction goals, emissions will increase by 54 percent to 10.1 gigatonnes, surpassing emissions of the entire OECD by 2035.

China plays an important and complex role in international negotiations. This role has changed and continues to evolve as the negotiations get closer to a comprehensive global agreement over the next few years.

China is the world's largest emitter of greenhouse gases, surpassing the United States in 2007, and is projected to be the world's largest emitter for the foreseeable future. It is also a large developing country with only a fraction of the per capita emissions of some major developed economies.

Over the past several years China's position on climate change has moved a great deal. Throughout the earliest periods of climate change negotiations there was a widespread belief that climate change was merely a developed country conspiracy to keep developing countries poor. As the science improved, Chinese policymakers and scientists realized that the threats posed by the more serious impacts of climate change could be very damaging for society. Even so, from the Chinese perspective, the responsibility to address climate change rested firmly with the developed countries that were responsible for historic emissions currently causing concern. Looking forward, however, the policymakers realized the country's own position as the largest current emitter required strong action.

China's position in the negotiations was to resist the calls for a greater leadership role, to firmly establish itself as part of the Group of 77 block, and defend the views and desires of other developing economies. Despite the changing views about the country's own obligations with regard to reducing emissions, Chinese negotiators were still reluctant to take on any concrete commitments. They continued to reject the notion that their country and the United States were the linchpins to coordinate global action and maintained China's alignment with the Group of 77 as defenders of developing countries.

China was once constrained by its domestic political situation; expensive emissions reductions were anathemas to economic growth, and some believed that climate change was a conspiracy to keep the country from rising. Between 2009 and 2010, however, China's position shifted. With the United States once again engaged in negotiations, the government realized the U.S. government was looking for a new framework that must make room for action from all major economies,

Table 5.2. China's Efforts to Address Climate Change

<table>
<tr><th>Legislative measures</th><th>Administrative measures</th><th>Economic measures</th></tr>
<tr><td>2002/2007 Law on Energy Conservation

2002 Law on Promotion of Clean Production

2002 Law on Prevention of Air Pollution

2002 Law on Forest

2003 Law on Environment Impact Assessment

2005 Law on Renewable Energy

2009 Resolution on Climate Change</td><td>Regulations to implement laws

Set up National Climate Change Leading Group (chaired by Premier Wen Jiabao).

Set short-term energy intensity goal in the Eleventh Five-Year Plan (20 percent below 2005 by 2010).

Set mid-term carbon intensity goal in 2009 (40 to 45 percent below 2005 by 2020).

Shut down small, inefficient coal, steel, iron, cement, aluminum, and coke plants.

Make local leaders accountable for the goal.</td><td>Adjust economic structure (increase ratio of light and tertiary industry).

Adjust energy structure (increase the ratio of nonfossil fuel in the energy mix).

Increase investment on energy efficiency and renewable energy.

Provide incentives to develop renewable energy.</td></tr>
<tr><th colspan="3">Progress to date</th></tr>
<tr><td colspan="3">Economic structure has improved slightly.

Energy efficiency has improved, and more renewable energy has been developed (9.6 percent of total energy mix in 2010).

Shut down 72 GW of inefficient coal power plants from 2005 to 2010.

Energy intensity per unit of GDP drops 19.1 percent below 2005 levels by 2010.</td></tr>
<tr><th colspan="3">Future goals</th></tr>
<tr><td colspan="3">Short-term: energy intensity reduction (16 percent), carbon intensity reduction (17 percent), nonfossil energy share in total mix (11.4 percent), forest coverage increases by 12.5 million hectares.

Mid-term: carbon intensity cuts 40 to 45 percent below 2005 by 2020, nonfossil share of total energy mix is 15 percent by 2020, forest coverage increases by 40 million hectares by 2020.</td></tr>
</table>

Source: Sun Guoshun, Chinese Embassy, World Resources Institute/Energy and Environment Study Institute briefing, April 5, 2011

including rapidly emerging developing countries. In addition, China realized that many of the actions it was taking at home were in line with the types of actions sought by the global community. Domestic pollution control, diversity of energy supplies, and the desire to become a high-tech manufacturer and eventually innovator for the clean tech sector all shifted China's domestic policies to put them in a position to be a more positive contributor to the negotiations. The combination of their domestic alignment with low-carbon policies in addition to concern about the international perception of China as spoiler in the international negotiations seem to have brought about a shift in China's negotiating stance.

To be clear, China's domestic energy policy is not driven primarily by climate change concerns, but by a desire to curb local pollution, increase efficiency, increase diversity in energy supplies, and transform the structure of the economy away from energy-intensive industries. Nevertheless, the contribution toward slower emission growth that these policies make provides a firm foundation upon which China could represent itself in the negotiations.

Indeed the country has a portfolio of domestic policies enacted to reduce emissions in an effort to combat climate change. Up until 2009, none of these policies explicitly mention climate change as a driving force. That year the Chinese legislature passed its first official resolution on climate change, which pledged to accelerate the country's efforts to tackle the problem of climate change and deal with emissions reduction. The resolution also clearly outlined and reiterated the import role for developed countries to take the lead on emissions reductions and financing for developing countries.[25] More recently the Twelfth Five-Year Plan raised the prominence of climate change as a goal by setting the first ever emission intensity targets and including an explicit section to address climate change. Recent press reports also indicate that the plan includes a hard cap on carbon emissions at 4 billion tons of coal equivalent by 2015.[26]

So how should one gauge China's role in combating climate change? By 2035, China's emissions will grow from 6.6 gigatons of energy-related CO_2 to 12.5 gigatons in 2035. It will, absent an economic collapse or major technological breakthrough, be the largest source of new emissions and among the largest historical emitters.[27]

Part of the problem is that the metric for judging the adequacy of a country's actions is slipping away. The goal of climate change negotiations and indeed globally coordinated action to mitigate the worst effects of a changing climate was to limit temperature rise to "safe levels." Scientists determined and politicians suggested that 2 degrees Celsius should be the goal and that a target of around 450 parts per million CO_2 atmospheric concentration had a relatively good chance of keeping the world in that range.

Unfortunately, the pledges put forth in the latest round of negotiations (the Cancun Agreement) do not reach that level. According to analysis that IEA conducted, dramatic, swift action would have to be taken after 2020 if society hopes to reach the 2 degree target. Such action would not only include massive amounts of investment but also the premature retirement of capital stock well before its economic or useful life in favor of low-carbon alternatives. It is hard to see how this scenario is feasible absent a major shift if the global economy, technology, or society's view of the dangers posed by climate change sometime between now and then.

The practical conclusion to draw from all of this is that the widespread view of a top-down structure, driven by a global target with national targets and timetables doled out, is not the current reality. The current negotiations include something that looks much more like the bottom-up structure proposed by the Japanese and Australians in which countries pledge to do what they can to reduce emissions and periodically reassess progress to see how well they have done and if they can do more. While the bottom-up approach is less satisfying in terms of its potential to guaran-

25. "China's legislature endorses climate change resolution" (press release), National People's Congress of the People's Republic of China, Aug. 28, 2009, http://www.npc.gov.cn/englishnpc/Special/CombatingClimateChange/2009-08/28/content_1516242.htm.

26. Xinhua News Agency, "China to Cap Energy Use At 4b Tons of Coal Equivalent By 2015," March 4, 2011, http://www.chinadaily.com.cn/bizchina/2011-03/04/content_12117508.htm.

27. IEA, *World Energy Outlook 2010*, 672-73.

tee a specific climate outcome, it is more feasible politically because it allows countries to operate within the realm of the possible. It does, however, make assessing comparability among countries much more difficult. In the case of China, it may be the world's largest emitter, but it is also investing far and away more than any other country in trying to find solutions, even partial ones.

On the other hand, as mentioned earlier, one of the main challenges to reducing emission is to bring down the cost of low-carbon energy sources. Given China's voracious energy demand and aggressive energy efficiency, renewable energy, and nuclear policies, no country in the world is doing more to drive down the cost of those technologies and make them available on a widespread basis.

Finally, it must be reiterated that China is one of the largest, most populated countries in the world. It is still a developing economy with around 21.5 million people living below the poverty line. It is emerging from its heavy industrialization period and hopes to move on to an economy with a more advanced, less energy-intensive structure. The pace and the scale at which the country is growing are truly mind-boggling. The social stability China seeks to balance while growing is precarious. All the while, the government is searching for an alternative pathway that balances sustainability notions and alleviates resource constraints associated with the 21st century. This is something no country has ever done and is extremely challenging. Given the size of China's energy consumption and dependence on fossil fuels, it is very hard to see overwhelming decarbonization on a decade-long timeframe. However compared with what many other countries plan to do or have been able to do, it is making impressive progress.

Within the context of global climate negotiations, China has an enormous leadership role to play. As governments continue to argue about the future of the Kyoto Protocol and negotiate the details of the Cancun Agreement (things like MRV, sharing technology, finance, etc.), the negotiations run the risk of falling apart or losing steam as it becomes evident that the goal of limiting warming to 2 degrees Celsius will not be met and that governments' ambitions on mitigation, financing, and adaptation will fall short. Because of China's role as the world's largest emitter and center of strength for the developing country block, it will be in a unique position to hold together the talks and ensure progress from the international framework with other leaders like the European Union, United States, and Japan.

6 CONCLUSION

China is both a leader and a laggard when it comes to secure, low-carbon pathways. As the world's largest energy consumer and one of the fastest growing and largest economies in the world, it will be influential to global energy markets and global emissions pathways no matter what path the government takes. So far, China's efforts to reduce energy intensity and increase nonfossil-based energy sources in its primary energy mix have dramatically changed the outlook for all energy sources. The solar and wind initiatives have bent the cost curves and provided a source of demand for those industries respectively. Energy intensity improvements have dramatically reduced future expectations for emissions growth and coal consumption. The nuclear program, despite a recent slowdown, is leading the world's nuclear power expansion.

Despite all the effort and investment, China's current pathway is light-years away from where scientists say the world should be headed to limit the most severe consequences of global climate change. China's projected coal, oil, and natural gas consumption are still highly influential in each of those markets, and will have consequences for globally and regionally traded energy commodities and all other countries that consume them. The nation's energy consumption and emissions pathways are so influential that wherever they lead, the world will likely follow or at least be forced to cope with the consequences of their success or failure.

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