The McKinsey Quarterly

CLIMATE CHANGE SPECIAL INITIATIVE

MAY 2009

China's green opportunity

China can and must achieve sustainable growth. Although the country has already charted an ambitious course to improve its energy efficiency and environment, a McKinsey study finds opportunities to do even more.

Martin Joerss, Jonathan R. Woetzel, and Haimeng Zhang

McKinsey&Company

China's rapid development over the past three decades has lifted hundreds of millions of people out of poverty and catapulted the country into the ranks of the world's largest economies. Over the next several decades, as China's economy continues to grow and the pace of urbanization accelerates, the country must not only ensure that it has sufficient and secure energy resources but also mitigate the impact such growth will have on the environment.

China must address these issues without compromising its growth or the living standards of its people. But the population's huge size and the scale of the economy have created a uniquely challenging problem. To deal with it, China's policy makers have developed an extensive body of regulations and policies to raise the energy efficiency of many sectors and thereby reduce growth's environmental consequences, including carbon emissions.

To help policy makers and business leaders identify and prioritize additional opportunities to raise energy efficiency in China and make its growth more sustainable, we undertook a study of technologies, measuring their impact on greenhouse gas emissions. We looked only at approaches that are technically feasible and likely to be commercially available no later than 2030.

Our findings indicate that by that year, the aggressive deployment of a range of new technologies—for instance, electric vehicles and new waste-management approaches—would allow China to reduce its demand for imported oil by an additional 30 to 40 percent over the energy efficiency goals already identified. The country also could stabilize coal demand at current levels. This approach would substantially improve China's already significant plans to improve energy security and reduce carbon emissions. However, these goals will require considerable capital investment. For the next two decades, China would need to spend €150 billion to €200 billion a year—on top of currently planned spending on energy efficiency—to realize the full potential of the technologies. What's more, several barriers stand in their way, including social costs (such as layoffs) and retraining. And the window of opportunity for capturing benefits is short: every building or power plant constructed without these technologies subtracts from the total energy efficiency gains they could deliver.

Adopting them will require nothing less than a "green revolution" in the generation of power, the fueling of vehicles, the management of waste, the design of buildings and cities, and the nurturing of forests and agriculture. Policy makers will have to make the decisions, but to do so they must understand the opportunities and trade-offs.

The rising challenge of sustainability

China is home to one-fifth of the world's population. In 2007, the country consumed about 2.7 billion tons[1] of standard coal equivalent[2] and emitted about 7.5 gigatons of greenhouse gases. Indeed, it has overtaken the United States as the world's top emitter. China's demand for energy—and the emissions and pollution associated with its use in industry, power generation, transport, and waste landfills—also contributes to other environmental ills. In northern China, desertification threatens arable land and grasslands. Water shortages are a growing problem across the country.

[1]Metric tons: 1 metric ton = 2,205 pounds.

[2]One kilogram of standard coal equivalent = 7,000 kilocalories.

China emits a greater proportion of greenhouse gases from its industrial sector than most other nations, developed or developing. These high levels reflect the massive industrialization China is now undergoing. Emissions from the provision of electric power and heat to commercial and residential buildings are a consequence of China's rapid urban growth and rising living standards. The country's moderate level of transport-related emissions reflects the current low penetration of motor vehicles—about 4 vehicles per 100 people in 2008, compared with almost 60 vehicles in Japan and 80 in the United States.

As China's GDP grows in tandem with urbanization, the country's emission profile will change. Long-term projections based on a consensus of leading Chinese economists suggest a 7 to 8 percent annual GDP growth rate.[3] By 2030, two-thirds of China's roughly 1.5 billion people will live in urban areas (see sidebar, "Green mind-set"). To cope with that increase, China plans to build 50,000 new high-rise residential buildings and 170 new mass-transit rail and subway systems. (By comparison, Europe has only 70.) As the economy and the cities grow, so will household incomes. Carbon emissions will rise as a result of higher consumption, including additional cars.

Suppose China made no efforts beyond what it is now doing to improve energy efficiency and diversify its fuel supply, and there were no improvements in technology. We call these admittedly unrealistic assumptions the frozen-technology scenario. Annual emissions of greenhouse gases in China would rise to 22.9 gigatons by 2030, from 6.8 gigatons in 2005. In this scenario, demand for oil would increase fourfold by 2030, requiring imports of about one billion tons a year. Demand for coal would more than triple, requiring annual imports of 3.7 billion to 4.2 billion tons.

The frozen-technology scenario was developed to serve as a hypothetical baseline. Actual emissions will probably be far lower because China is improving its energy efficiency and reducing consumption of carbon-intensive sources of energy and emissions. For the past two decades, the country's carbon efficiency has gone up by 4.9 percent a year, largely through higher industrial productivity.[4] The government has set a goal of reducing the country's energy intensity by 20 percent during the current five-year plan.[5] The measures now envisioned include adopting stricter, high-efficiency building codes and higher fuel efficiency standards for vehicles, shuttering subscale capacity in energy-intensive sectors, and stepping up investments in renewable energy.

We estimate that China's current efforts and recently enacted policies could reduce the country's energy intensity by 17 percent during every five-year interval from 2005 to 2030. Under what we call the policy scenario, China would emit 14.5 gigatons of carbon emissions annually by 2030. The gains in energy efficiency would come largely in the industrial sector (through lower energy intensity and better waste recovery) and in the generation of power (through increased use of nuclear and renewable energy and improvements in coal-power efficiency). More energy-efficient new buildings and better fuel efficiency in car fleets would help as well. These improvements would also reduce the need for imported energy—by 30 percent for oil and 85 percent for coal.

[3] In this report, 7.8 percent is used as long-term GDP growth rate for China.

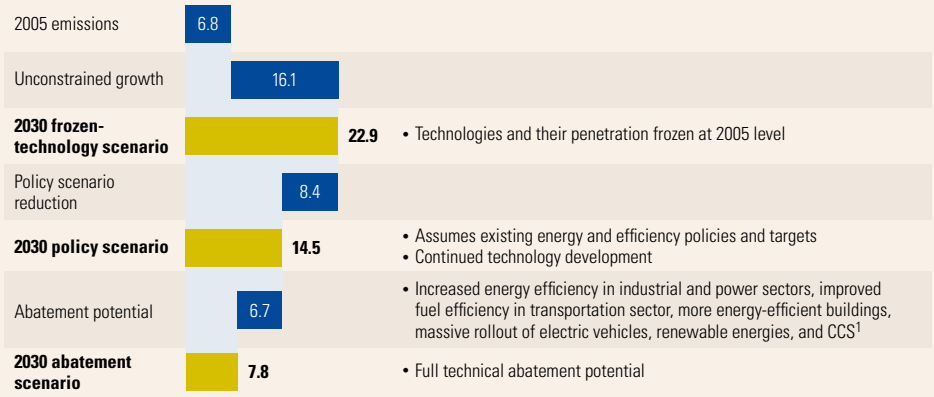
[4] Carbon efficiency measures the amount of GDP produced per unit of greenhouse gas emissions.

[5] Energy intensity, which measures the energy efficiency of a nation's economy, is calculated as units of energy per unit of GDP.

Exhibit 1

Three scenarios

Greenhouse gas emissions, metric gigatons of carbon dioxide equivalent



[1] Carbon capture and storage.

To achieve these gains, the government will have to make a significant effort, rigorously enforcing policies and providing incentives for investments in energy efficiency across sectors.

A green revolution

China has set ambitious goals for improving its energy efficiency. Yet we found additional opportunities (Exhibit 1), including even greater use of technologies or policies that China has already committed itself to pursuing, such as building additional nuclear power plants and planting forests. Other opportunities involve current and emerging technologies, such as electric vehicles, new semiconductor-manufacturing equipment that's better at controlling fluorocarbon emissions, and the use of agricultural waste as a fuel for co-firing with coal (to reduce coal consumption) in cement kilns.

We identified five major categories of energy efficiency and greenhouse gas–abatement opportunities that China could implement between now and 2030. If China pursued them successfully,

Green mind-set

By rethinking approaches to urban planning and encouraging small behavioral changes among consumers, China could reap additional savings in energy consumption and a 10 percent reduction in emissions of greenhouse gases, on top of the abatement potential from implementing greener technologies. Dense urban areas, with larger numbers of high-rise buildings, are 10 to 15 percent more energy efficient than urban neighborhoods dominated by low-rise buildings. Cities planned for greater density can also take advantage of public-transport options that cut the use of private cars. We estimate that the abatement potential of increased urban density is 300 million tons of greenhouse gases a year.

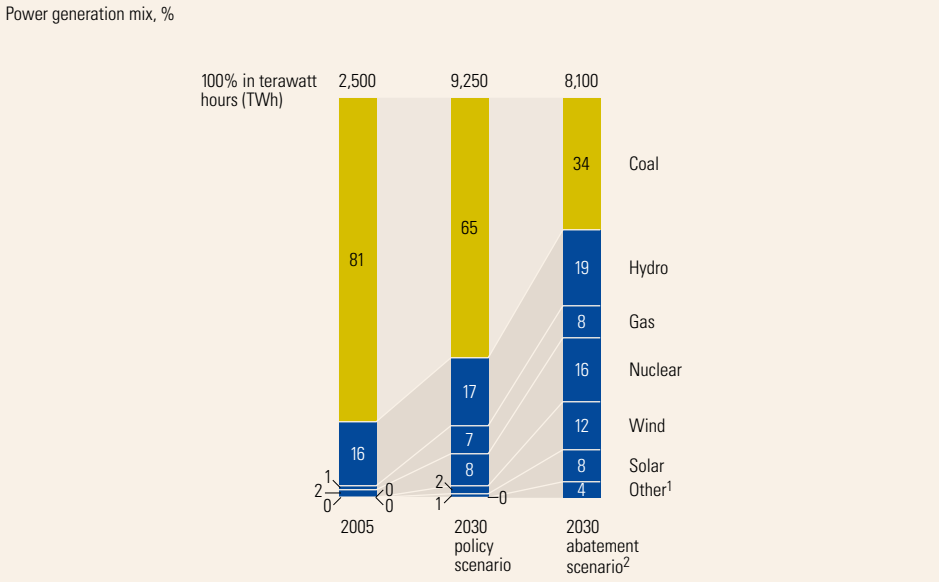
Chinese consumers use less energy than their counterparts in developed countries do, but the government could encourage them to be even more energy efficient. They could eliminate 400 million tons of greenhouse gases annually, for instance, by setting room thermostats slightly lower, buying more fuel-efficient cars, making greater use of mass transportation, and forming car pools.

it could reduce its dependence on imported oil by up to 30 percent more than the 30 percent reduction it currently hopes to achieve. The country could also stabilize coal demand at current levels, substantially reducing the proportion of electric power generated by using this fossil fuel, to 34 percent by 2030, down from 80 percent today. These efforts could enable China to hold its greenhouse gas emissions to roughly eight gigatons by 2030—roughly 10 percent higher than 2005 levels—without hindering growth.

This would amount to nothing less than a green revolution in China. Let's look in detail at each of the five categories of opportunities.

Exhibit 2

Green power in China



[1]Includes geothermal, coal bed methane, landfill gas, municipal solid waste, and biomass.
[2]Figures do not sum to total, because of rounding.

Source: Expert interviews; McKinsey analysis

Green power

As manufacturers ramp up the production of equipment for solar and wind power, the cost of implementing these technologies will decline. By 2030, China could generate 8 percent of its energy through solar and 12 percent though wind (compared with nearly nothing in each category today), and the proportion of electricity generated by nuclear power could rise to 16 percent, from 2 percent; by hydropower to 19 percent, from 16 percent; and by natural gas to 8 percent, from 1 percent (Exhibit 2).

China is the world's largest exporter of photovoltaic solar panels, and we think it will hold that position for some time. The cost of the equipment used in China's photovoltaic solar-power installations should fall almost 80 percent by 2030, given the country's (and the world's)

projected photovoltaic capacity and this sector's historical learning rate (cost reductions gained through experience as production volumes rise). As the technology improves, solar-power generating costs will fall to €0.045 per kilowatt-hour in 2030, making it just 50 percent more costly than coal rather than five times, as it is today.

Similarly, China could have an installed nuclear capacity of 182 gigawatts by 2030, an increase of 74 gigawatts over the policy scenario's goal. China manufactures 70 percent of the equipment necessary for nuclear plants, and the cost for this equipment has been falling. If the country develops nuclear power to the fullest extent, by 2030 carbon emissions could fall by 470 million tons, at a cost of €3 per ton.

By 2030, carbon capture and storage could abate 730 megatons of greenhouse gas emissions from China's most important fuel source, coal, at a cost of over €60 a ton. This technology is very expensive, but more than 25 percent of China's coal-based power plants—both new and retrofitted—could be equipped with it by that year.

Green transport

Cars and trucks are a relatively minor source of greenhouse gas emissions in China, but that's about to change. By 2030, it could replace the United States as the nation with the most vehicles—over 330 million of them. Let's assume that internal-combustion engines have by then become as fuel efficient as possible at a reasonable price. Still, China will have to rely on imports for 75 percent of its oil.

Our policy scenario estimates for energy efficiency from the adoption of electrified vehicles are conservative. Suppose, however, that China began to adopt them widely starting in 2015 and ramped up the rate of adoption to 100 percent of new vehicles by 2020. Our analysis shows that demand for imported oil might fall 30 to 40 percent. China could emerge as a global leader in this industry by leveraging the country's low-cost labor supply, its fast-growing vehicle market, its success in rechargeable-battery technology, and its substantial investments (both made and committed) in R&D for electrified transport.

From 2016 through 2030, capital investments of over €70 billion a year would be needed for an extensive rollout of electrified vehicles and for the recharging infrastructure China will need to accommodate them.

Green industry

The steel, chemical, cement, coal mining, and waste-management sectors play a crucial role in China's economic development. All of them also use significant amounts of energy: they accounted for about one-third of total consumption and 44 percent of carbon emissions in 2005 and are also a major source of air and water pollution. China is shutting down or consolidating subscale, inefficient facilities in each of these sectors, has set energy-reduction targets for their largest enterprises, and is adopting global best practices in production. These and other government energy-saving efforts in the industrial sector could save 450 million tons of standard coal equivalent a year by 2030.

New quality standards for cement, introduced in 2008, set higher specifications for clinker (the primary material in it) and stricter definitions for clinker substitute. We expect such measures

to cut the use of cement in concrete by 10 percent, cutting the cement industry's emissions proportionately. Similarly, China is setting standards to reduce the energy used in burning waste and in recovering and reusing coal-bed methane—standards that would reduce the emissions from those activities. Such policy scenario efforts would allow China to reduce emissions in these sectors to 4.8 gigatons by 2030.

China has ample opportunity to reduce each segment's emissions below those envisioned in the policy scenario: new technologies and process improvements could abate an additional 1.6 gigatons of greenhouse gas emissions. The cement industry, for instance, could use agricultural waste as an alternative fuel for co-firing with coal in kilns. In steel making, thin-strip direct casting (casting and rolling in a single step) could substantially reduce energy use and emissions.

The challenges of implementing new technologies include limited talent and funds for investment. The skilled technicians and engineers needed are scarce in China, and because its universities don't teach some of the required skills (such as systems engineering), these limitations will persist. In certain sectors, the opportunity cost of investment in energy efficiency is high; in others, the total returns seem too low. Executives also dislike the idea of shutting down plants to improve them or of accepting the losses associated with introducing novel technologies or processes. To pursue the additional efficiency and abatement opportunities, the government will have to address these hurdles.

Green buildings

China's rapid urbanization will continue for several decades. Apartment houses, office buildings, and commercial centers are proliferating to accommodate this massive migration and economic development. In the frozen-technology scenario, total emissions from energy consumption in the buildings sector will rise from 1.1 gigatons of greenhouse gases in 2005 to 5.1 gigatons by 2030. Policy scenario moves to address the growth of the sector's energy use and emissions could reduce them to 3.2 gigatons by 2030. We estimate that implementing the full range of practical technologies would cut emissions to 1.6 gigatons annually.

Total floor space (including residential and commercial) will more than double in China, from 42 billion square meters in 2005 to 91 billion in 2030. Rising income levels are pushing up energy use as households buy more appliances and air conditioners. To address these issues, the government is setting targets so that more heat for urban buildings comes from relatively energy-efficient sources, such as natural gas and combined heat and power plants, rather than coal and diesel. Over time, natural gas will replace coal (or coal gas) for cooking and for heating water in many areas. The government is also imposing strict new energy-efficiency rules for building codes, enforcing firm energy-efficiency ratings for appliances, and rolling out subsidies to encourage the shift to more efficient lighting.

Beyond these government-directed efforts, the opportunities include replacing low-efficiency community boiler systems in northern China with large network district-heating systems[6] and retrofitting commercial buildings with automated systems and pumps to regulate heating, ventilation, and air conditioning more efficiently. China can also apply to new buildings the principles of "passive design": reducing the energy used for heating and cooling by designing

[6] Coal plants that heat water and channel it to buildings.

insulation, ventilation, and the use of natural light and shade at the same time. Older buildings can be retrofitted with energy-saving materials such as insulation and replacement windows.

Such moves will exact a social cost. Higher energy-efficiency standards for heating controls and pumps could drive inefficient local players from the market. More expensive heating systems and market-driven fees for heating could make it unaffordable for lower-income Chinese unless they get subsidies. Enforcing higher building standards will drive up administrative costs. Many of the government's efforts so far haven't been very effective. Despite awareness programs and subsidies, the penetration of compact fluorescent lightbulbs (CFLs) has reached only about 10 percent a decade after the bulbs were introduced. The government hasn't banned incandescent bulbs from the market (as Australia, for instance, has) and faces an uphill battle to persuade consumers that more expensive but energy-efficient CFLs pay off in the long term.

Green ecosystem

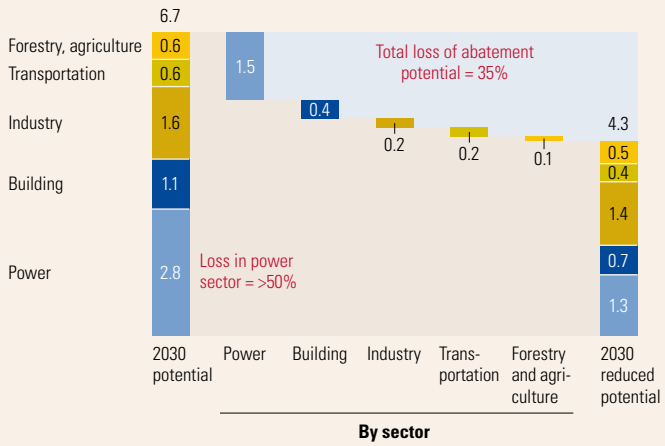
Farms and forests are carbon sinks. Although China has halted most activities that led to deforestation, virgin forests now cover only 11 percent of the country's total land area. By our estimates, government forestation and reforestation programs will raise forest coverage to 20 percent of China's total land area by 2010. China is also trying to limit grazing on grasslands (90 percent of its 400 million hectares of grassland is degraded or at risk), to introduce sustainable agriculture, and to promote the use of methane from animal manure for heating and cooking in rural areas. (Some 23 million rural families heat their homes and cook with methane.) By 2030, these policies will reduce emissions by 0.29 gigatons annually.

Additional abatement opportunities along similar lines could provide 0.64 gigatons of possible abatements by 2030. These include increasing the forest cover to 25 percent rather than 20 percent, raising more animals in enclosures rather than letting them graze on grasslands,

Exhibit 3

No time to waste

Loss of potential abatement as a result of 5-year delay in technology implementation, metric gigatons of carbon dioxide equivalent



Related articles

"What countries can do about cutting carbon emissions"

"How the world should invest in energy efficiency"

"Promoting energy efficiency in the developing world"

"Connecting climate change and economic recovery"

"Meeting the challenges of China's growing cities"

"Cleaner energy for China: An interview with the chairman of ENN Group"

and promoting agricultural practices such as conservation tillage and the use of the latest fertilizers. These opportunities could also have knock-on effects: improved land-management practices, for example, control desertification and use water supplies more productively.

To realize the full potential of the additional opportunities, China would need to start now; even waiting a few years would reduce the possibilities for raising energy efficiency and abating emissions. To capture the full abatement potential in the power-generation sector, for instance, China must start implementing by 2010 most of the measures we recommend. China builds new plants continually. Coal-fired ones brought on line next year, if not retrofitted with expensive carbon-capture technologies, will emit greenhouse gases for the next 30 to 40 years. A simple sensitivity analysis shows that postponing the implementation of cleaner power technologies for just five years would cut the abatement potential by up to 1.5 gigatons of greenhouse gases—over 50 percent of what's possible (Exhibit 3). A ten-year delay would reduce the abatement potential by 80 percent.

By starting now to embrace the technologies for a green revolution, China can create a future with greater energy security and lower energy emissions—without compromising economic growth and the living standards of its people. Q

Martin Joerss is a principal in McKinsey's Beijing office; **Jonathan Woetzel** is a director in the Shanghai office, where **Haimeng Zhang** is an associate principal.