# Supporting Report 3

# Seizing the Opportunity of Green Development in China

# Contents

**Figures**



**Tables**

# Abbreviations

| | |
|---|---|
| BRICS | Brazil, the Russian Federation, India, China, and South Africa |
| $CO_2$ | carbon dioxide |
| FYP | Five-Year Plan |
| DRC | Development Research Center of the State Council of China |
| ETS | carbon emissions trading scheme |
| EU | European Union |
| GDP | gross domestic product |
| GHG | greenhouse gas |
| GNI | gross national income |
| IEA | International Energy Agency |
| ILO | International Labor Organization |
| KBA | key biodiversity area |
| MEP | Ministry of Environmental Protection |
| NBS | National Bureau of Statistics |
| NDRC | National Development and Reform Commission |
| NGO | non-government organization |
| $NO_2$ | nitrogen dioxide |
| NRM | natural resource management |
| OECD | Organization for Economic Co-operation and Development |
| PES | payment for ecological services |
| $PM_{10}$ | suspended particulate matter measuring 10 microns (μm) in diameter or less |
| PPP | purchasing power parity |
| PV | photo-voltaic |
| R&D | research and development |
| RD&D | research, development, and demonstration |
| $SO_2$ | sulfur dioxide |
| $SO_x$ | sulfur oxides |
| SOEs | state-owned enterprises |
| UN | United Nations |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WTO | World Trade Organization |

# Chapter One Why Green Development?

The world's development process is at a crossroad. Given the unsustainability of current economic growth in both China and the world, a new approach to development is needed. The concept of green development is such an approach. Green development can become a potentially transformative process for the economy, for society, for the environment, and for the role of government. It is an opportunity: an open door.

Green development is a pattern of development that decouples growth from heavy dependence on resource use, carbon emissions and environmental damage, and promotes growth through the creation of new green product markets, technologies, investments, and changes in consumption and conservation behavior.[1] The three key concepts in green development are that economic growth can be decoupled from rising GHG emissions and environmental degradation; that the process of "going green" can itself be a source of growth; and that "going green" is part of a virtuous circle that is mutually-reinforcing with growth. Green growth is the means by which green development is achieved.

## a. The traditional model of development is no longer feasible

Since 1978, China has been developing at an average annual growth rate of nearly 10% per year. Over just three decades, it has developed in one giant leap from a poor country into the world's second largest economy after the United States. Great changes have taken place in the quality of people's lives. If this trend continues, then by 2030 China will have attained high-income status in an unprecedented short period of time. This is considered by some as an economic miracle. But given the negative consequences of growth, it is, at best, an unfinished miracle. For various reasons, changes are needed in China's growth model.

First, China's development to date has resulted not only in past high emissions, resource consumption, and environmental destruction, but also external, social, and regional imbalances. If these imbalances are not corrected soon, then they have the potential to precipitate economic and social crises. Reforms are needed and green development forms part of those necessary reforms. As income levels increase, the Chinese people are demanding improved welfare, a cleaner environment and higher quality of life—without the recurring risks of environment-related disasters.

Second, there are still many uncertainties whether China can attain high-income status by 2030. According to projections by the DRC (Liu et al. 2011) and other research,[2] China's economic growth will slow down in the coming years, exposing yet more social and political challenges. Therefore, China needs to find new sources of growth, driven by innovation and supported by medium- and high-value added production. Green development is part of the policy approach to overcoming future risks and finding new robust sources of growth.

Third, apart from domestic conditions, changes in the international arena have also made it important for China to change its model of development. Western countries are making the transition to a more competitive form of green development. As a result, a new race towards green development is now being played out in the global economy, with significant benefits accruing to early movers. In 2009, the OECD issued a Declaration on Green Growth in which its member countries set forth a comprehensive green growth strategy. Under the EU's "Europe 2020" initiative, innovation and green growth form the core of a strategy to increase the competitiveness of European countries. For "Rio+20," the United Nations Conference on Sustainable Development to be held in Rio de Janeiro next year, green growth will be one of the main

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[1] To date, no standard definition of green development has emerged from the public and policy debate. (Huberty, Gao and Mandell, 2011).

[2] See the other supporting reports prepared as part of the China 2030 study, particularly the synthesis report.

topics of discussion. In May 2011, Germany announced that it would strive to be the first industrialized country to achieve a complete shift to clean energy. The United States has issued a 10-year clean energy strategy; South Korea has already made green economic development a part of its national strategy going forward, Brazil has aggressively merged its forward-looking policies for growth, climate change, and environmental management; and Japan is pushing for an additional 30% in energy efficiency gains, starting from its position as already being one of the most energy efficient countries in the world (**Box 1.1**).

**BOX 1.1 Three Examples of National Green Development Strategies: Germany, Korea and Japan**

Germany's New Energy Plan. In May 2011, Germany determined to close all of its nuclear plants by 2022 and to become the first industrialized country to completely shift to clean energy by increasing investment and R&D for renewable energy and energy efficiency. Presently, nuclear power provides 22 percent of Germany's electricity. To fill the gap in its energy supply after it abandons nuclear, Germany has proposed vigorous development of wind, solar, and biomass; new standards for the thermal efficiency of buildings; and the creation of a continent-wide super smart grid (which would include the import of power from sun-rich North Africa.

The Republic of Korea: a first-mover in the implementation of green growth. Born as a response to the global financial crisis of 2008, Korea's move towards green growth combines three mutually-reinforcing objectives: (i) responding to the latest economic crisis through a green stimulus, (ii) reducing its energy dependency, (iii) and rebalancing its economy towards green sectors in the long term. The financial crisis exposed Korea's reliance on imported energy as a major weakness in its growth model. Korea imports 96 percent of its energy—accounting for 2/3 of all imports. To rebalance this situation by 2030, Korea aims to decrease its energy intensity by 46 percent and increase the share of renewable energy in total primary energy from 2.4 percent in 2007 to 11 percent. Furthermore, the latest Five-Year Plan allocates 2 percent of GDP to 10 green growth strategies, each containing quantitative objectives and well defined projects. Korea aims to increase its global market share of green technology exports from 2 percent in 2009 to 10 percent by 2020.

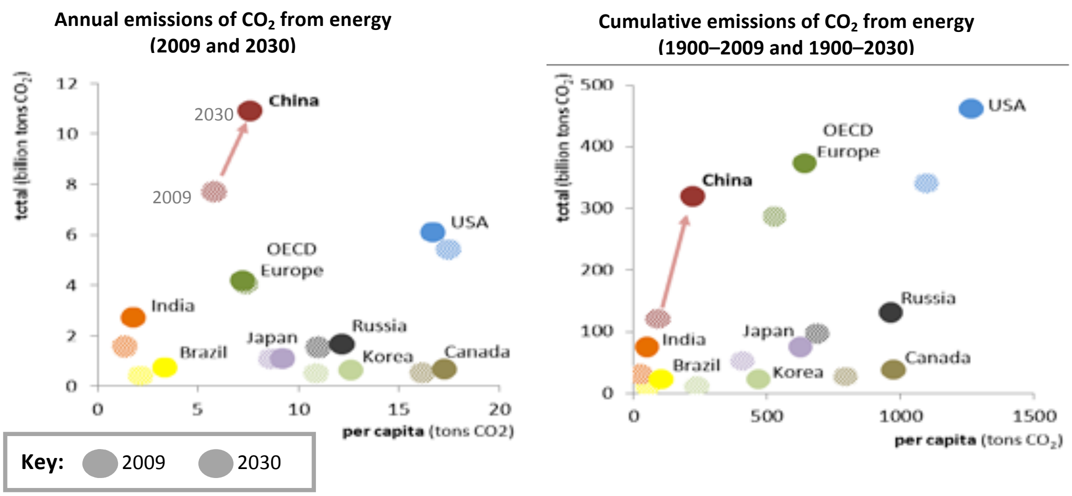
Japan's energy efficiency strategy. Japan's energy intensity decreased 26% between 1980 and 2009, and it is one of the most energy-efficient countries in the world. Nevertheless, Japan pledged to go further with its 2006 "Energy Conservation Law" by improving energy efficiency by another 30 percent by 2030 relative to 2006. The plan's implementation strategy fosters energy conservation technologies and develops a benchmarking approach to monitor energy conservation. In addition to promoting the most advanced technologies across the energy sector, the plan also introduces integrated energy consumption standards for all buildings and targets net-zero-energy houses by 2020 (and the norm nationwide by 2030). Japan's Top Runner Program, tests 21 types of appliances—ranging from vending machines and air conditioners to television sets—to determine the most efficient model, and make that model's level of efficiency the new baseline. Then, manufacturers have the obligation to achieve the new baseline within four to eight years. Japan's newest innovation is the concept of "smart community", a model city that maximizes the use of renewable energy and relies on smart grids to deal with its intermittent nature. Four large-scale pilot projects were started in 2010.

There are deep historical roots to the current transition toward green development. Developed countries, with 20% of global population, developed during a period of high fossil fuel and resource consumption. Now, the remaining 80% of the world's population also seeks to rise economically. However, if the 80% modernizes in the same way as the developed countries did—especially considering that by 2050 the global population will rise to over nine billion people—the environmental costs will become insurmountable for all countries. Therefore, the traditional model of development is no longer feasible.

The global climate crisis is one of the most daunting of the crises precipitated by traditional economic growth. China will be one of the countries most affected by climate change. Therefore, addressing climate change is a pressing need for China, and a matter of self-interest. There is a scientific consensus that to limit the rise in global average surface temperatures to 2°C, global carbon emissions must peak in 2020 or so followed by dramatic decline of 2% per year (UNEP, 2011a). In short, there is simply not enough "carbon space" to satisfy the emission needs of all countries if they continue to grow in the traditional mode of development.

Due to rapid economic expansion, and in spite of strong measures taken since 2006, both China's total annual and per capita emissions are increasing at a high rate. Though its per capita emissions were historically low, they are now above those of France and Spain, and its total emissions are the largest in the world (**Figure 1.1**). During the period 2006–2010, Chinese reduced the energy intensity of its economy (a close measure to carbon intensity) by 20%, through strict energy conservation and emission reduction measures, even as it maintained overall economic growth of over 10% per year. China's current commitment is to decrease its carbon emissions intensity (per unit of GDP) by 40–45% by 2020 as compared to 2005. Nonetheless, China's per capita GDP will have doubled by 2020, implying that both total and per capita emissions will continue to rise. It is clear that however global carbon budgets may be allocated via national actions and international negotiations over the next twenty years, there never be enough carbon emission space for China to copy the past industrialization model of developed countries (DRC, 2009; 2011).

**FIGURE 1.1 Emissions of $CO_2$ from energy, annually and cumulatively**




*Sources:* World Bank. Historic emissions and population data for 1950–2009 from Boden et al 2010, World Bank World Development Indicators and UN Population Division (2011). Projections of emissions for China from 2010 to 2030 from World Bank and DRC. Projections for emissions from other countries from US EIA (2011); population projections from UN Population Division (2011).

In sum, green development is being driven by harsh economic realities, changing global priorities, and growing technological possibilities (**Box 1.2**). Many of the forces operating in the rest of the world are also present in China. Chinese leadership has already shown its commitment to green, low carbon development, even though it is at the early stages of a long journey. This study focuses on how to achieve green development, not on whether it is an option.

**BOX 1.2 Green development can help resolve the dilemma of global emission reductions**

Traditional analysis shows that the benefits of climate change mitigation are global, while the costs local. This asymmetry leads to difficulties in global coordination of emission reduction. However, this analysis fails to include the broader local benefits that accrue to mitigation investments, such as greater economic efficiency and competitiveness, and local environmental co-benefits. As governments acknowledge these broader local benefits, the challenge of global emission reduction can begin to change from being a strictly zero-sum game to one with greater win-win potential.

*Source*: DRC Project Team of "Fighting Climate Change"

## b. New opportunities arise

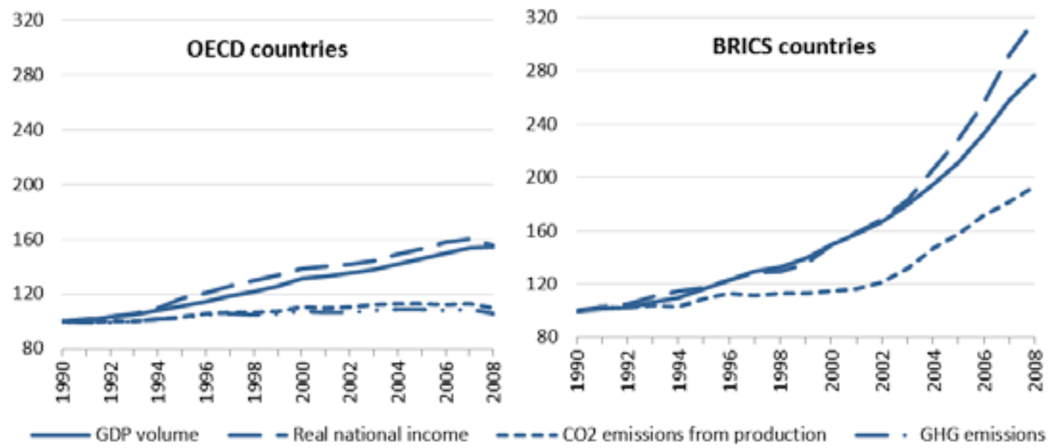
While the transition toward green development will not be easy, it will open the door to new opportunities. China's government has already clearly stated that "addressing climate change is an important opportunity to speed up economic restructuring as well as the transformation of China's mode of development and hasten forth a new industrial revolution." The 12th Five Year Plan (FYP) contains many important prerequisites for China's efforts to "go green", including completing the transition to market through private sector development and factor market reforms, increasing the share of consumption, shifting towards less emissions-intensive service industries, increasing the pace of innovation, and developing human capital. It also supports increasing R&D expenditure to 2.5 percent of GDP by 2015, among the highest levels of any country.

Transitioning to green development is critical to China's economic competitiveness in the future world economy. The core of global competition lies in technological innovation. The 12th FYP has a strong focus on seven strategic industries—environmental protection and energy efficiency, new energy, next generation information technology, biotechnology, high-end manufacturing, clean-energy vehicles, and high-tech materials—which are all leading sectors for future growth. They are mostly all "green technologies" with high value-added and export potential. Growth in these areas will make China's economical structure more competitive. Nevertheless, while technological breakthroughs are essential for green growth, the transition to green development is a much more profound process than technological changes. The transition will span manufacturing and services, construction and transport, city development and management, and energy production and consumption. This is why green development would be a significant break from China's past pattern of development, cutting across all economic and social sectors.

There is mounting global evidence that economic growth and carbon emissions and pollution have already begun to decouple. According to UNEP, the carbon intensity of the world economy ($CO_2$ emissions per unit of GDP) has dropped 23% since 1992. Since 1990, economic growth has increased faster than carbon emissions for both the developed countries and developing countries, as represented by the 5 BRICS countries, although that decoupling is much more complete in OECD countries (**Figure 1.2**). Overall, the data shows that high growth is compatible with lower carbon emissions, and that China and the other BRICS have an opportunity to compete by going further down this path.

Even though the transition to green development is a long-term process, the next 20 years are a crucial strategic period for China to seize the opportunity, gain competitive advantages, and show global leadership. It could catch up with and even surpass the United States and Europe on green measures. However, if China does not seize this opportunity, then its economy will lock into a high-emissions structure, lose competitiveness, and face much higher low carbon transition costs in the future.

**FIGURE 1.2 Decoupling economic growth from carbon emissions worldwide (index, 1990 = 1)**




*Source:* OECD 2011b.

As China positions itself to take advantage of green development opportunities, its vision can be defined by these major indicators:

- "Green" will become an important source of economic growth. The share of green products and green services in China's GDP will be among the highest in the world.
- China will become a world leader in key green technologies and business models, and be an important destination for commercializing many globally important low-carbon technologies.
- China will have made real gains in low-carbon development. The correlation between growth and carbon emissions will be significantly weakened, and carbon emissions will peak.
- China will have adopted some of the world's most stringent and most wide-reaching environmental standards, penetrating all sectors of the economy and society.
- Similarly, China will have established a resource-efficient society. Its resource efficiency through all phases of supply, consumption, and recycling will be among the highest in the world.
- China's cities will have low-carbon and smart transportation systems and buildings. They will be livable by international standards.
- The quality of air, water, and natural ecosystems will have improved dramatically. The recovery of the natural environment will significantly improve both public health and natural assets.
- Low-carbon living will become widespread and will involve all aspects of people's lives, from housing, to transportation, to food, to other consumer items.
- The risks posed by climate change will be addressed through proactive planning across all key sectors, including water, agriculture, urban, and health.

How can China turn this vision into reality? What opportunities does transition to green growth bring to China? How does going green make China more competitive? How does it become a <u>source</u> of growth? How does it improve the <u>quality</u> of China's economic growth? What advantages does China enjoy, and what obstacles? This report aims to answer some of these questions.

# Chapter Two "Green" as a Source of Growth

This chapter identifies the potential opportunities of how "green" could be a source of growth. In the past, a clean environment has too often been considered an unaffordable luxury—but green development goes far beyond the trade-off between growth and the environment. New evidence shows that the two goals—growth and a clean environment—not only may be realized simultaneously, but may be mutually reinforcing. When it comes to climate mitigation, new literature developed by researchers in the U.S. (Acemoglu, et al, in press), in Europe (Jaeger, et al, 2011) and in China (Zhang & Shi, 2011), suggests it is possible to significantly reduce emissions without reducing long-term growth.[3]

## a. How "green" contributes to growth?

Green development is primarily market-driven. The prerequisite for green development is a sound market economy in which the governmental functions to correct environmental market failures through combined policies, regulations, and investments. One can say that past unsustainable growth represents the failure of government to fulfill this role. Once these government actions are introduced, the market will respond to reduce environmental and social costs. Furthermore, high polluting, high emitting and resource-intensive products will become less competitive as their external costs are internalized. These changes in relative prices will help push resources into industries and services more consistent with green development objectives. To be specific, "green" is a source of growth in three major ways.

***Source 1: Green transformation of traditional sectors.*** A large number of existing conventional techniques and management models can not only reduce energy-use and emissions, but also improve the level of corporate profitability. Although the greening of traditional sectors may seem less dramatic and revolutionary than the development of cutting-edge new technologies, it is clear that with information and financing, many energy-efficient investments are also cost-effective and yield high economic returns. These efficiency gains are growth enhancing (Section 2.b).

***Source 2: Expansion of emerging green industries.*** Emerging green industries include solar and wind energy, together with upstream and downstream industries such as relevant equipment manufacturing and electric vehicle industries. More broadly, however, new markets and incentives, supported by innovation and research, will likely stimulate new low-carbon, resource-lite, and environmentally friendly technologies, goods, and exports. In addition, increased public awareness will help shift consumer demand towards green products (Section 2.c).

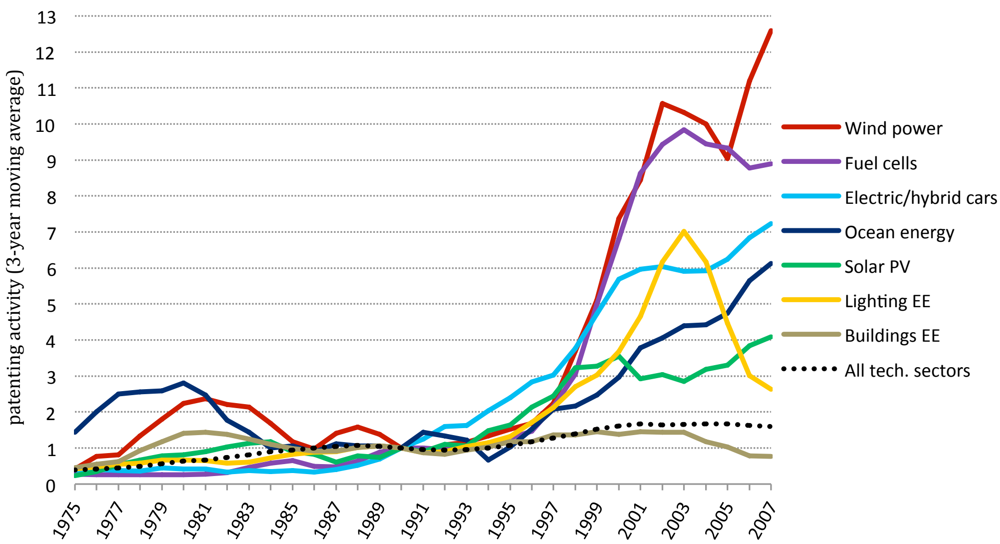
***Source 3: Expansion of the service sector.*** Services will also expand as a complement to new green product markets and changes in consumer preferences. Not only will the rising share of services in GDP help reduce the economy's carbon intensity, specialized services are likely to develop that specifically support green development. Examples of such services are ecosystem services, carbon asset management services, carbon trading, and contract energy management (Section 2.d).

Of course, whether "green" will become a dominant source of growth will depend to a great extent on future technological improvements, which are uncertain. Still, with stable green development policies, the pace of technological innovation and investment will no doubt quicken, thus increasing the possibility of technological breakthroughs. For example, between 1975 and 1997, growth in the number of patents for wind power, battery technologies, electric vehicles, marine power, solar power, and other green technologies was relatively slow. After 1997, with increased global awareness of climate change, more stringent environmental policies, and

[3] Acemoglu, et al, found that government interventions to redirect investments toward green technologies will have a short-term cost but that long term "green growth" rates will catch up to "non-green growth" rates. Growth will be unaffected overall. If immediate action is taken, then the catch-up period will be shorter. If action is delayed, the costs of intervention will be greater, and the catch-up period will be longer.

increased investment in renewable capacity coinciding with the signing of the Kyoto Protocol, the number of patents for green technologies increased dramatically (**Figure 2.1**) (OECD 2010).

**FIGURE 2.1 Index of innovation in climate change mitigation technologies (1990 = 1)**




*Notes: shows total worldwide applications in EPO PASTAT database by priority date; includes only claimed priorities (those patents for which an application is filed at additional office other than the original 'priority' office).*
*Source:* OECD 2010.

Although green development is still in an early stage and the speed of development in the future is highly uncertain, the opportunities it presents are increasingly recognized. For example, the OECD's latest Green Growth Strategy points out that "green growth has the potential to solve economic and environment problems and become a new source of growth" (OECD 2011b). According to Jaeger et al (2010), if Europe's emissions reduction target is raised from 20% to 30% by 2020, Europe's annual rate of economic growth may increase by up to 0.6%, generating 6 million new jobs may, and boosting investment as a share of GDP from 18% to 22%. Beyond these economy-wide benefits, additional sector-specific benefits may also accrue (**Box 2.1**).

**BOX 2.1 Further Sectoral Benefits of Green Development**

Beyond the above three reasons for why green development contributes to growth, the implementation of green development policies brings several further sectoral benefits that are growth inducing:

- Rapid growth of energy consumption has strained China's domestic supplies of electricity, raised coal prices, and made it increasingly dependent on imported energy. With unchanged policies, China may have to import 75 percent of its oil (making it the world's largest oil importer) and 50 percent of its natural gas by 2030. Alternative energy sector policies will dramatically reduce this import dependence.
- The efficient use and better governance of land will help reduce urban congestion and sprawl.
- Agricultural output will be enhanced by reducing the degradation of land and water.
- Infrastructure constraints, particularly for handling coal, will be eased, and infrastructure investment requirements reduced.
- By anticipating climate impacts on agriculture, low-lying coastal areas, and areas vulnerable to extreme weather events, green development will reduce climate-related risks, and improve investor and consumer confidence.

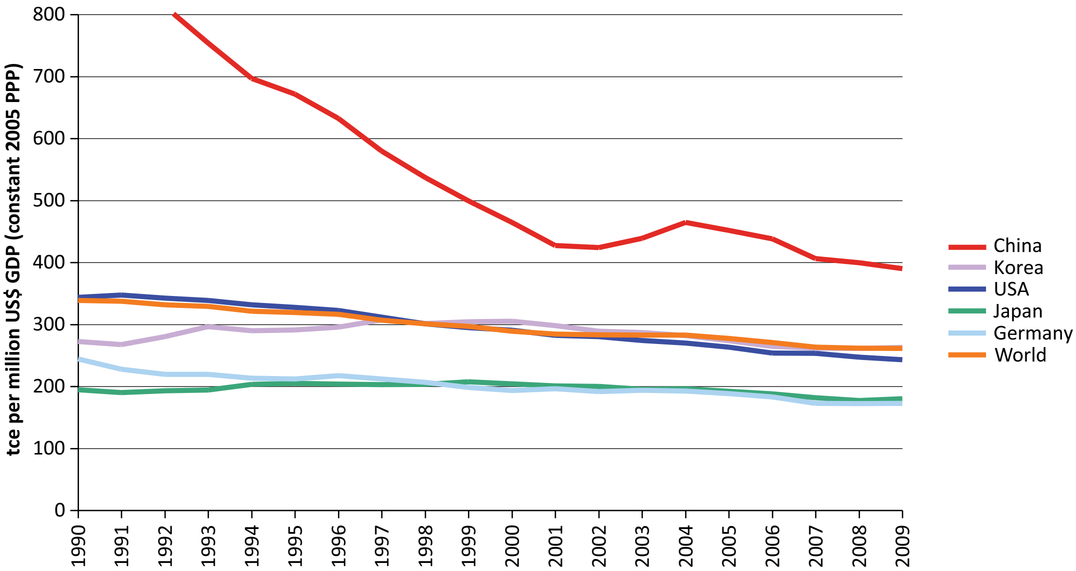
All of these measures will support growth through reduced costs, improved certainty, and the reduced need for risk management options.

*Source*: World Bank analysis (see Annex)

## b. Source 1: Green transformation of traditional sectors

Despite the unprecedented progress China has made in reducing the energy intensity of its economy over the past three decades, a large gap between China and the high-income countries remains (**Figure 2.2**). The energy intensity of China's GDP, measured in terms of primary energy consumed per unit of output, was equal to 390 tons of coal equivalent (tce) per million US$ of output in 2009 (constant 2005 PPP). By comparison, the primary energy intensity of Germany's economy was 167 tce per million US$.[4]

**FIGURE 2.2 Energy intensity of GDP, 1990–2009 (energy used per unit of GDP)**




*Source:* IEA 2011.

Whereas some new green technologies cost, many other technology and management changes that can help narrow the gap between China and the high-income countries already pay for themselves through lowered energy and input costs. Policies and investments to improve efficiency, by increasing returns for investments in green technologies and products, will immediately add to growth. For example, according to estimates by McKinsey & Company, installing LEDs for lighting in buildings could generate US$25 billion in financial savings per year by 2030 compared to business as usual (measured in 2009 US$). Improving passive heating and cooling in buildings through design modifications could provide another US$6 billion. Industry is the largest sectoral user of energy, accounting for about 72% of primary energy demand in 2008 (NBS 2010), and many efficiency gains can be found there. All together, the potential for direct savings through efficiency gains in China could be as high as US$65 billion per year by 2030, if the full technical and economic potential of these no-regret options can be realized.[5]

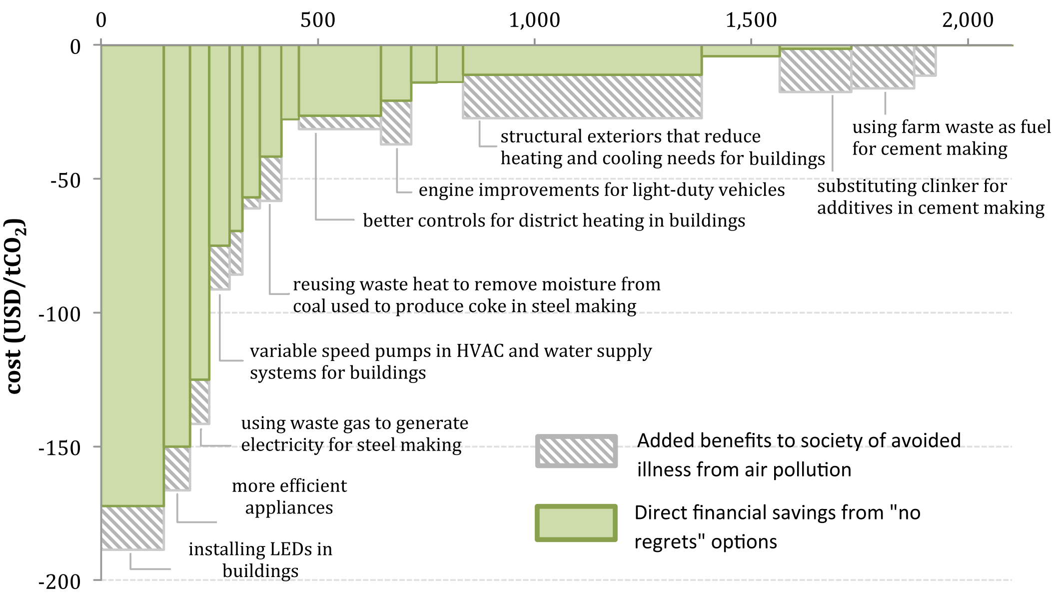
The direct benefits of these "no-regrets" options are to reduce the amount of fossil fuels burned per unit of economic activity. However, they often have additional "co-benefits" that add

[4]The difference in energy intensity is due to more than energy efficiency. It is also due, for example, to output mix and relative prices. But the opportunity for further declines in China is clear.

[5]These estimates of cost savings are drawn from detailed work done by McKinsey & Co on technologies for $CO_2$ abatement in China (McKinsey 2009). The McKinsey cost estimates are often considered an upper bound on the annual cost savings to be achieved, for the reason that while they include potential technological gains, they do not include all transaction costs associated with implementing those technological gains.

further value to the economy, such as (a) improving local air quality and thus reducing the incidence of respiratory illness associated with air pollution; (b) reducing infrastructure constraints in related sectors, such as transport and water; and (c) reducing import dependence. In other words, cost-effective energy efficiency and renewable energy investments offer triple-win ("win-win-win") outcomes by trimming production costs, mitigating emissions of greenhouse gases, and improving public health risks in various sectors. The potential for no-regrets measures to contribute to both the quantity and quality of growth is illustrated in **Figure 2.3**. This figure shows the emissions reduction potential and levelized cost of certain energy efficiency technologies in 2030, as estimated for China by McKinsey & Co., but adjusted to reflect the social value of these co-benefits. The value of these health-related co-benefits is US$20 billion per year in 2030, on top of the direct savings of US$65 billion per year (see Chapter 3 for more details).

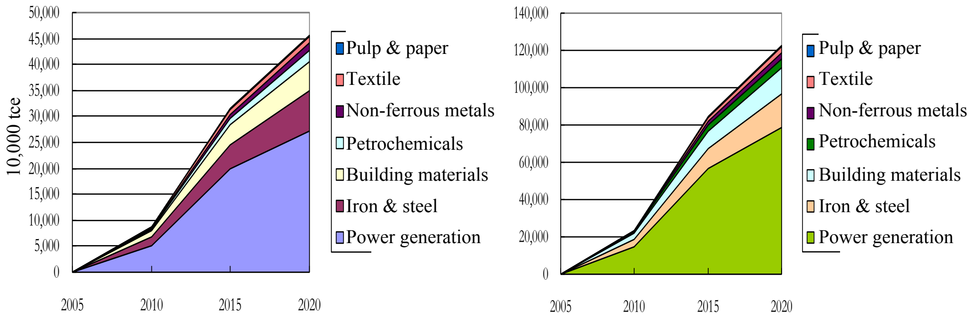
**FIGURE 2.3** **No Regrets Options for reducing $CO_2$ emissions in China, 2030**




*Sources:* World Bank calculations, based on McKinsey 2009, Ho & Jorgenson 2003, Cao Jing et al 2009, NBS 2008 and 2009, Liu X.L. et al 2011, and Matus et al 2011.

Feng F., et al (2011) estimates that there are presently several hundred mature energy-saving technologies available to but not fully deployed by China's high energy-consumption industries. The analysis shows that if energy-intensive industrial sectors applied widely, by 2020, 79 of these major technologies, the accumulated energy savings would be 456 million tce (with a corresponding reduction in $CO_2$ emissions of 1.2 billion $tCO_2$) (**Figure 2.4**). If all existing and emerging energy efficiency technologies available for energy-intensive industrial sectors were applied by 2020, the accumulated energy savings capacity would be 650–750 million tce (with corresponding reductions in $CO_2$ of 1.7–1.9 billion $tCO_2$). More detailed examples of the cement and iron & steel sectors are given in **Box 2.2**.

**FIGURE 2.4 Energy Savings (left) and $CO_2$ Emissions Reductions (right) Achieved by Deploying 79 Efficiency Technologies in Heavy Industry, 2005–2020**




*Source:* Feng F. et al (forthcoming).

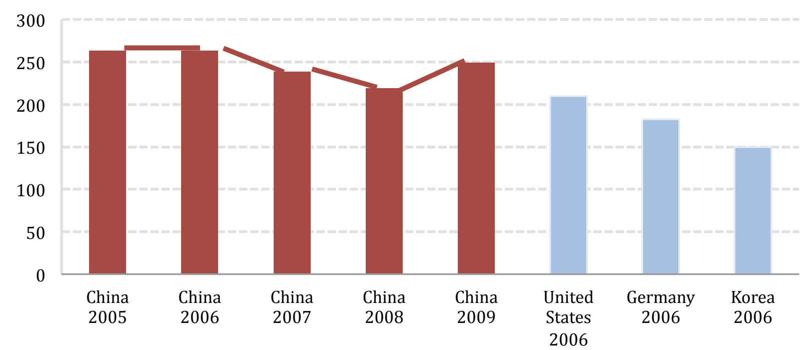
**BOX 2.2 Detailed Analysis of Two Industries: Cement and Iron & Steel**

Driven by an unprecedented construction boom over the past decade, China's iron & steel and cement sectors accounted for nearly one-fourth of the country's total energy consumption in 2009. As the construction boom is expected to last well into the 2020s, demand will continue to grow (Zhou N. et al 2011; Fridley et al 2011). By 2030, the tonnage of coal consumed to make steel and cement could reach 926 million tons per year, an increase of 276 million tons (42%) over 2008 (NBS 2010; Zeng X.M. 2010; and Zhou N. et al 2011).

Chinese cement makers have made impressive strides by reducing the energy intensity of production by 30% between 1998 and 2009. While now more efficient than the US and comparable with Europe, China is still 30% above the energy efficiency level set by the world's best practice cement technologies.

China's iron & steel industry has farther to go to reach the efficiency levels of industry leaders (Figure 2.5). By deploying the best available technologies, it could save more than 100 million tons of coal per year (IEA 2010b).

**FIGURE 2.5 Trends in Chinese iron & steel energy intensity compared to industry leaders (tons coal equivalent per million US$ output, 2009 PPP)**




*Sources:* World Bank, based on IEA World Energy Balances, NBS 2009 and 2010, and UNIDO INDSTAT

Combined, the iron & steel and cement industries could achieve average net savings of US$9.9 billion per year between 2008 and 2030 by using a basket of technologies that are already available on the market. This estimate includes net incremental capital, operating and maintenance costs. Cost savings may be even greater depending on future energy prices. Energy-saving technologies also contribute to growth by reducing the burden of pollution-caused illness. The additional benefits to society due to reduced pollution amount to US$1.2 billion per year over the same period (see Chapter 3 for more details on welfare benefits of avoided pollution).

## c. Source 2: Expansion of emerging green industries

Emerging industries are green if they are low emitting and low polluting. The most concrete example of emerging industries are clean energy, and some such as solar power, wind power, biomass, and hydropower have already been commercialized on a large scale. China's seven targeted strategic industries, as mentioned above, are environmental protection and energy efficiency, new energy, next generation information technology, biotechnology, high-end manufacturing, clean-energy vehicles, and high-tech materials. Globally, business opportunities in many of these sectors, including clean-energy vehicles and clean energy are shifting toward the developing countries.

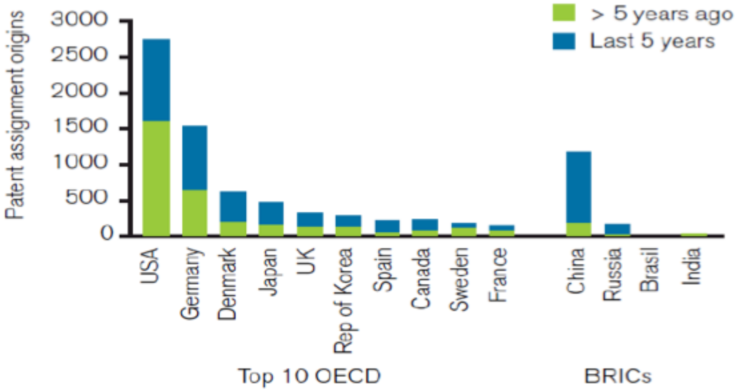
China is now the world leader in renewable energy investment, surpassing all other countries (Pew 2011). The wind power industry alone could account for over US$25 billion per year in investment, assuming 20 gigawatts installed per year. Furthermore, if the State Council targets are met, the contribution of emerging green industries to China's GDP will be 15% by 2020.

Relentless cost reductions and technological progress in renewable energy technologies in China have exceeded expectations, mostly due to massive scaling-up of the industry. In renewable energy, the cost of both wind energy equipment and solar photovoltaic have decreased dramatically during the past 5 years (Feng & Wang, 2011). The wholesale prices of coal-fired and wind power are already very close (just under RMB 0.50 per kWh). In the case of solar PV, the price of unit modules has decreased from $23 per module in 1980 to less than $3 per module in 2010 (see US DOE 2010). Following this long-term trend, the existing gap between coal-fired and solar PV power will likely be closed by 2020. Similarly, the costs of biomass, marine power, shale gas, coal gasification, and other clean energies will continue to decrease.

The rapid progress of clean energy technologies is illustrated by the dramatic rise in the number of worldwide patent filings for wind power, solar PV, ocean energy, electric/hybrid vehicles, and lighting energy efficiency technologies. China occupies a prominent place within this global trend of innovation. The number of wind power patents granted to Chinese inventors, for example, has surged within the past 5–7 years, and transfers of wind power technologies to China from the developed countries over the past two decades have exceeded any other country (**Figures 2.6**). As China continues to absorb and innovate new green technologies—supported in part by government investment and policies—these technologies will become increasingly competitive and contribute to the country's growth in the upcoming years.

The growth of China's nascent environmental protection industry, in particular, demonstrates the important role that the state will play in promoting the growth of green sectors. Take the flue gas desulfurization (FGD) industry for example. Under the 11th Five Year Plan, the central government mandated that $SO_2$ emissions be reduced 10% nationwide compared to 2005. This target was bolstered by additional standards set by the NDRC and MEP for emissions from heavy industry. As a result, China's FGD industry has grown dramatically since 2006. Annual installations of $SO_x$ scrubbers on coal-fired power plants have increased at an average rate of 34%, even with spotty enforcement of the new standards (China Greentech Initiative 2011). By 2009, the FGD industry and other environmental protection industries, including water treatment and solid waste disposal, were valued at RMB 480 billion (CAS 2011). With stricter standards introduced under the 12th Five Year Plan, the government hopes that the environmental protection industry can grow to RMB 2 trillion by 2015 (US$295 billion) (see **Box 2.3**).

**FIGURE 2.6 Patent Assignee Origins for Wind Power Technologies**



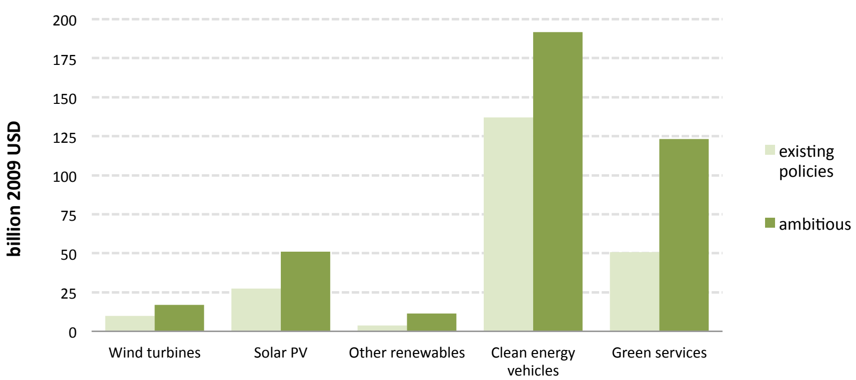

*Source:* Chatham House, 2009, cited in Feng et al 2011 (forthcoming).

**BOX 2.3 Robust growth projected for China's environmental protection industries**

In a speech in November, 2011, at the APEC Summit, President Hu Jintao announced, "Continue rapid growth is projected for China's environmental protection industry during the 12th Five Year Plan (2011–2015). By 2015, the total value of the industry may exceed RMB 2 trillion. Between 2011 and 2015, China's central government plans to invest RMB 3.1 trillion in protecting the environment, more than double what was invested over the previous 5 years. China's energy conservation and environmental protection industries are seen as major sectors for foreign investment. A flourishing demand for "green" products and services, combined with a favorable investment environment will provide a vast market and tremendous opportunity for enterprises from around the world. . . ."

Green emerging industries also create exports and jobs. By 2030, the projected exports of green technologies and services specifically related to renewable energy and clean energy (mainly electric) vehicles will rise to US$229–395 billion in export sales (**Figure 2.7**) and 4.4–7.8 million new jobs. These export sales are on the order of 6–10% of total projected exports, or 2–3% of projected GDP. Of course, this large scale-up is driven by global demand, and depends on decisive action to address climate change by the world's governments.

**FIGURE 2.7 Projected Annual Chinese Exports of Green Products and Services (2030)**




*Note: The ranges given above compare two scenarios defined by the IEA. The "existing policies" scenario is one in which the G20 countries follow through with their commitment to reduce fossil fuel subsidies, countries fulfill their Cancun Decision pledges to reduce greenhouse gas emissions, and other existing $CO_2$ mitigation policies are implemented (i.e., the "New Policies" scenario in the IEA World Energy Outlook 2010). The higher estimates correspond to the "ambitious" scenario in which countries take ambitious action to limit atmospheric concentrations of $CO_2$ from rising above 450 parts per million (i.e., the "450" scenario in the IEA World Energy Outlook 2010).*
*Source:* World Bank calculations. For details, see background paper to this study.

As a driver of growth, "green" clearly creates jobs. But "green" also implies some higher costs, industrial restrictions, and layoffs as well as government actions lead to changes in prices and production patterns. The positive impact on employment is greater the longer the time frame being considered and the wider the definition of "green jobs" being used. A recent study under the China Council of International Co-operation on Environment and Development (CCICED, 2011) estimates that government spending of RMB5.8 trillion ($91bn) on measures to save energy, protect the environment and replace polluting industries with hi-tech firms would create 10.6m jobs over the next five to ten years. In contrast, eliminating the dirtier sectors of the economy would lead to the loss of 950,000 jobs. The previous paragraph noted that 4.4–7.8 million new jobs may be created by 2030 due to increased exports of certain green technologies. Although approximate, all of these estimates confirm the notion that the net trade-offs favor green as a source of job creation (**Box 2.4**).

**BOX 2.4 The Relationship between Green Development and Employment**

Empirical research done in other countries has concluded that in the medium term, green growth will have positive but small net effect on the number of jobs in the global economy (UNEP 2011b; Martinez-Fernandez 2010; ILO 2009; Dupressoir et al 2007). Within this overall scenario, of course, some countries, such as China, will excel in creating green technology jobs. Furthermore, evidence from developed countries also suggests that those jobs that are created in the transition to green growth are often more skilled and higher paying. A recent nationwide study of green industries in the United States revealed that the median wage in these industries is 13% higher than the median wage in the overall US economy (Muro et al 2011). Another study in Germany found that implementing measures to mitigate climate change led to more job opportunities for college graduates (cited in Dupressoir et al 2007). This finding is linked to the higher component of innovation found in newer technologies as opposed to in more traditional ones.[6] In contrast, it is likely that extractive industries, utilities, marine fisheries, and some heavy manufacturing industries will likely shed jobs over the upcoming decades, primarily the result of gradually increasing energy prices, depleted natural capital (e.g. over-exploited fisheries and forests), more efficient technologies, and the automation of production processes.

## d. Expansion of the service sector

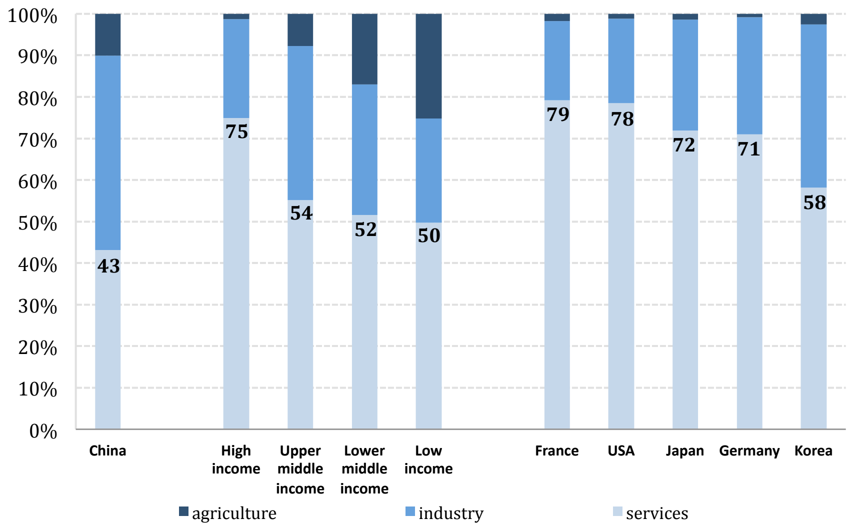
The green transformation will impact the service sector in two ways. First, it will give birth to new green service industries, such as ecosystem services, carbon asset management services, carbon trading, and contract energy management. Second, it will support the country's intended economic rebalancing away from heavy manufacturing and towards a larger service sector. Both trends are important to reducing China's carbon footprint, as its efficiency in manufacturing may soon approach, or even surpass the levels of high-income countries.

The emerging green service sector is already important. According to a trade association of energy conservation service providers in China, as of the end of 2010, the total value of China's energy conservation service industry was RMB 80 billion (US$12 billion). The industry reduced power consumption by 10.64 million tons of coal each year and reduced GHG emissions by 26.62 million tons of $CO_2$. Another important trend is that ecosystem management services are a growing industry in some poor areas of China, where farmers on marginal lands are paid to maintain the ecosystem rather than to sell wood or other crops.

[6] At the same time, not all jobs produced by green investments are a priori "good jobs which offer adequate wages, safe working conditions, job security, reasonable career prospects, and worker rights" (UNEP et al 2008, 4). The creation of new employment opportunities through green investments may not improve the plight of informal workers in such industries as construction, waste removal, and recycling. The effect of green growth on work conditions across industries is also as yet unclear. Green growth is not a substitute for effective social protection and investments in human capital.

China's traditional service sector is lagging and has significant room to develop. In 2010, the share of services in total value added was 43%, a figure which is much lower than the average for high-income countries (73% in 2008),[7] and even lower than in most middle-income countries (56% in 2010) (World Bank 2011) (**Figure 2.8**).

**FIGURE 2.8 Services, value added, as a share of GDP (2010)**




*Notes:* ***Agriculture*** *corresponds with ISIC Rev. 3.1 divisions 1–5, covering forestry, fishing, livestock production, and the cultivation of crops;* ***industry*** *includes divisions 10–45, covering mining, manufacturing, construction, and utilities; services are defined as divisions 50–99, which cover wholesale, retail trade, transport, government, financing, professional services, education, healthcare, and real estate. Data for France and Japan are from 2009.*
*Source:* World Bank, World Development Indicators (2011).

There are several reasons why the share of services in China's economy is low. First of all, the level of government public service is very low, particularly in the lesser developed regions. Historically, the role of government has focused on facilitating economic growth more than on providing social services. Second, government over-regulation and even monopoly has restricted development of the service industry, has inhibited the flow of private capital into these sectors. This is particularly true in finance, insurance, navigation, railway, telecom, petroleum, power, education, medical services, entertainment, sports, and the arts. Third, China's export-oriented development strategy has meant that local government has been dependent on large-scale, capital-intensive industries for tax revenue, and there has been less support to the service industry. All of these reasons are weakening, thus favoring the long-term development of China's service industry.

China's service sector growth over the long term will depend on the pace of reform of government restrictions, policies favoring the knowledge industries, and consumption patterns of the rising middle class. The rising share of services in GDP will help reduce the economy's carbon intensity. According to estimates by the DRC, the energy intensity of output (value added) by secondary industries in 2009 was eight times higher than agriculture and five times that of services. Every percentage point increase in the share of services in GDP is associated with a decline in energy consumption of 1.4 percentage points.[8]

[7] Services here are defined as activities included in ISIC Rev 3.1 Divisions 50–99, excluding public administration and national defense.
[8] Of course, if reductions in China's manufacturing sector are offset by increased output in other countries, the rebalancing would have negligible effects on global emissions even as China's emissions intensity would decrease.

## e. Additional opportunities for China's under-developed regions

The green development approach can help reduce China's inter-regional inequality by helping its relatively under-developed central and western regions catch up. Although historically the east always led in economic development, since 2005, growth rates in the central and western regions have overtaken the east. However, the interior provinces should not follow the precedent of the eastern provinces by growing first and then cleaning up later. This is especially true for those central and western provinces with abundant mineral resources. Although extractive industries may have led to high GDP growth rates, the income levels of people living in these regions has not grown commensurately, and in some places the natural environment has been severely degraded.

There are several reasons why the interior provinces should avoid the conventional (and environmentally degrading) growth path of the east. First, the ecological environment of the interior provinces is relatively fragile compared to the east, and the costs of "clean-up later" would be prohibitive. Second, China's population is aging rapidly. As the surplus agricultural labor force that filled the factories of the east gradually shrinks, this will prohibit labor-intensive growth similar to that observed over past decades. Third, as China introduces more stringent energy conservation and GHG emissions reduction policies, the potential for growth from high-emissions, resource-intensive industries will be limited. The interior provinces have a strong comparative advantage in clean energy resources (Wang Yi, 2011). Fourth, with rapid expansion of cities onto increasingly scarce land, the national government has imposed stricter controls on the use of land for industry (**Box 2.5**). Thus, China's under-developed regions have a direct interest in growing green while avoiding the clean-up costs being incurred by the eastern provinces.

**BOX 2.5 China's "Main Functional Area Development Plan"**

In order to protect the environment and avoid "polluting first and cleaning up later", China's State Council launched the "Main Functional Area Development Plan" in 2010. This plan divides all of China's land area into four major types: (i) relatively affluent, industrial, urbanized areas where development should be "optimized" to solve existing environmental problems; (ii) key areas for future development; (iii) areas where development should be limited, and (iv) areas where development is prohibited. These classifications are somewhat controversial: for example, restricting the rights of different regions to development contains elements of a planned economy. Controversial aspects aside, the Plan represents stringent environmental regulation and will prevent certain regions from following the more traditional path to development. Without the Plan, local governments would likely be unable to implement such strict environmental policies. Thus, by limiting or prohibiting the development of certain regions, the Main Functional Area Development Plan will encourage these regions to take a new path to green development.

*Source:* DRC.

Because their economies are currently less-developed, many ecological environment and cultural resources of these regions have been preserved. With high-speed rail, highways, improved logistics, the internet, and other telecommunication technologies, the relationship between urban locations and economic development are changing. By capitalizing on better connectivity, the hitherto under-valued environmental resources of China's interior regions may provide economic benefits that enable them to grow in a way that does not require sacrificing their environment.

Many under-developed regions of China are now pushing to develop in new ways, including high value-added agriculture, ecotourism, cultural tourism, training and conference centers, healthcare centers, and the arts. Some of these innovations require new business models, such as franchise businesses that draw on local labor. Important opportunities exist for payments for ecosystem services as well as for installations of renewable energy. For example, farmers in some poor parts of China have already transitioned from selling timber to marketing ecosystem services to earn a living. Another example is the more complicated "big push" that is being piloted to better connect a poor county of Hunan province with the market economy (**Box 2.6**). Elsewhere in China, other examples of green development are appearing every day. Searching out different forms of green development that are suited to local conditions has great importance not only for China but for other poor countries as well.

**BOX 2.6 A "Big Push" Model for Green Growth in Poor Areas: the Case of Hunan**

Huaihua in Hunan province is endeavoring to take full advantage of improved transportation, telecommunications, and logistics networks to pursue a new strategy for economy growth. The previously undervalued intangible resources of the Wuling Mountain Area, such as its beautiful natural environment and rich cultural heritage, will provide a new source of income for local people and help promote local economic growth.

Through the coordinated efforts of government and private entrepreneurs, poor regions are making a "big push" to utilize new market mechanisms and build green economies that include conference centers, medical services, eco-tourism, and cultural tourism. A more productive division of labor is evolving, with the local population benefiting as both farmers and service providers. The slogan of this experiment, "Villages Making Life Better," suggests that villages will no longer represent poverty in China, but will be a symbol of a high quality life style. More importantly, the models are duplicable elsewhere.

*Source:* DRC.

# Chapter Three "Green" Improves the Quality of Growth

People's welfare includes such concepts as good health, quality of life, and a clean environment, in addition to income. While some of these other welfare concepts are not measured in traditional measures of GDP, they can, nevertheless, be measured. Improving the "quality of growth," implies improving some or all of these welfare measures. Even though China's current levels of environmental degradation and resource pollution, measured as a percent of gross national income, are much higher than in high-income countries, it has already made great strides. This chapter addresses the magnitude of the welfare gains that can be made through green development. It also indicates that some improvements in environmental quality are necessary investments in long-term quantity of growth benefits as well.

## a. Improving the quality of China's growth by reducing environmental degradation

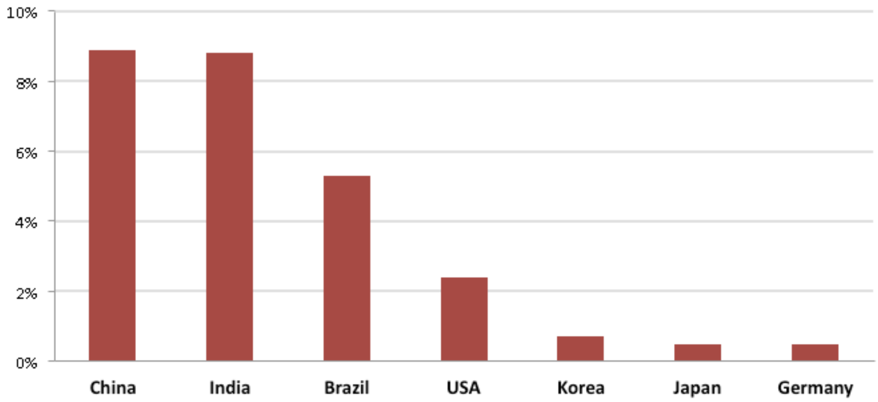
Green development will reduce China's current high costs of environmental degradation and resource depletion, which is crucial for its continued growth and well-being.[9] Under no scenario can it achieve the quality of growth that is already articulated in its 12th Five Year Plan and longer-term social and economic targets without dramatic improvement in the use and sustainability of its natural resource base. The experience of Japan shows that stringent environmental policies do not interfere with economic growth. In fact, they may even catalyze growth. Intervention-style environmental policies play an important role in this (Kobayashi 2011). This implies that economic growth and improving the quality of the environment may be mutually reinforcing.

The overall environmental benefits from green development can be substantial. At its current level of development, China's level of environmental degradation and resource depletion in China is valued at approximately 9% of GNI (gross national income), over ten times higher than corresponding levels in Korea and Japan (**Figure 3.1**).[10] A successful path of green development would cut this value, by 2030, to the much lower level of 2.7% of GNI per year (i.e., comparable to current levels in the United States)—at an estimated additional cost of 0.5–1.0% of GNI per year beyond what it is currently spending on environmental protection (see Section 3.c). While some of the benefits of this level of investment in the environment come in the form of financially viable "win-win" investments (see previous chapter and section 3.b), others would take the form of be economically viable investments in public welfare and ecological health.

[9] These costs are typically measured by valuing a country's environmental externalities, or the external costs associated with resource degradation (including pollution-related health damages, property damages, and global impacts), and resource depletion (soil erosion, deforestation, fisheries loss, biodiversity loss, water pollution, and watershed degradation).

[10] It is recognized that Figure 3.1 compares countries at different levels of development. That said, the figure is intended to illustrate the level of potential improvement that China may achieve as it rises to high income status (for details, see Table 3.1).

**FIGURE 3.1 Environmental and natural resource degradation and depletion, 2008 (% of Gross National Income)**




*Notes: Here,* ***environmental degradation*** *includes damages from $CO_2$, small particulate matter (PM10), and water pollution. Damages from $CO_2$ are estimated at $20 per ton of carbon (the unit damage in 1995 U.S. dollars) times the number of tons of carbon emitted. Damages from $PM_{10}$ are calculated as the willingness to pay to reduce the risk of illness and death attributable to particulate emissions. Damages from water pollution for China are from 2003 and are based on estimates of health damages, calculated by monetizing premature mortality from diarrheal disease and cancer associated with water pollution and morbidity from diarrheal disease associated with water pollution (following World Bank 2007).* ***Natural resource depletion*** *is the sum of net forest depletion, energy depletion, mineral depletion, and soil nutrient. Net forest depletion is unit resource rents times the excess of roundwood harvest over natural growth. Energy depletion is the ratio of the value of the stock of energy resources to the remaining reserve lifetime (capped at 25 years). It includes coal, crude oil, and natural gas. Mineral depletion is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime (capped at 25 years). It covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.* ***Soil nutrient depletion*** *data from Shi M.J. & Ma G.X. 2009.*
*Sources:* World Development Indicators 2011; World Bank (2007); Shi M.J. & Ma G.X. (2009).

China's specific environmental improvements would come from reducing reliance on fossil fuels, and achieving the lower levels of air pollution, water pollution, and resource depletion associated with high income countries (**Table 3.1**). The best way to achieve these improvements is to ensure that environmental externalities are internalized as efficiently as possible in consumption, production, and investment decisions throughout the economy. Prices of natural resources and key factors of production will need to reflect scarcity value as well as environmental costs and benefits. Green development, such as reduced reliance on fossil fuels, will improve local environmental outcomes—such as reduced air pollution, land degradation, and water contamination.

**TABLE 3.1 A Greener China**

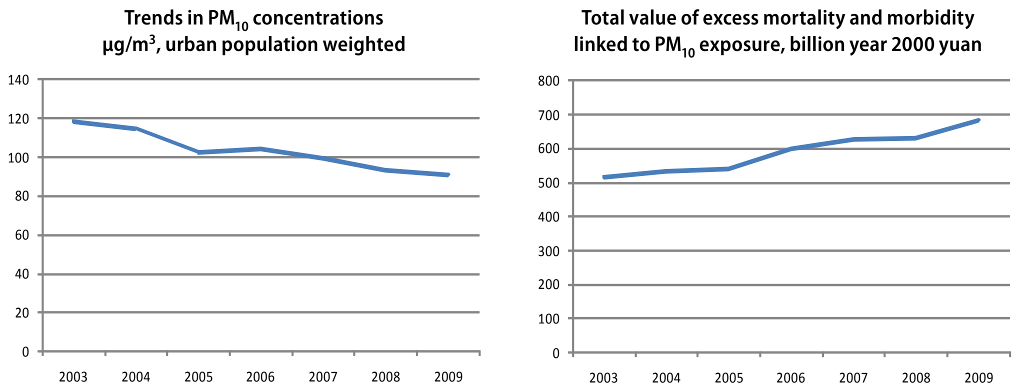
| Environmental depletion and degradation, all number are % of GNI | 2009 value | "Greener" value, reachable by 2030 | Net improvement |
|---|---|---|---|
| Energy depletion | 2.9 | 1.9 | 1.0 |
| Mineral depletion | 0.2 | 0.2 | 0.0 |
| $PM_{10}$ health damage | 2.8 | 0.1 | 2.7 |
| Air pollution material damage | 0.5 | 0.1 | 0.4 |
| Water pollution health damage | 0.5 | 0.1 | 0.4 |
| Soil nutrient depletion | 1.0 | 0.1 | 0.9 |
| Carbon dioxide damage | 1.1 | 0.2 | 0.9 |
| **Total depletion & degradation** | **9.0** | **2.7** | **6.3** |

*Source:* http://data.worldbank.org; World Bank (2007); Shi M.J. & Ma G.X. (2009); World Bank analysis.

The largest part of the projected improvement would be the economic benefits associated with human health and material damage improvements due to reduced air pollution. China currently faces one of the world's highest current and projected burdens of environmental disease linked to urban air quality (Cohen et al, 2004, and World Bank, 2007). Trends in urban air pollution are improving, but the impact on health is still extremely large, nearly 3 percent of GNI in 2009. The government has responded strongly in recent years to address the problem of air pollution. But despite improvements in urban air quality, the urban population has grown so much that the total health costs associated with air pollution, and the exposure of the population most at risk, the elderly, continue to rise (**Figure 3.2**).

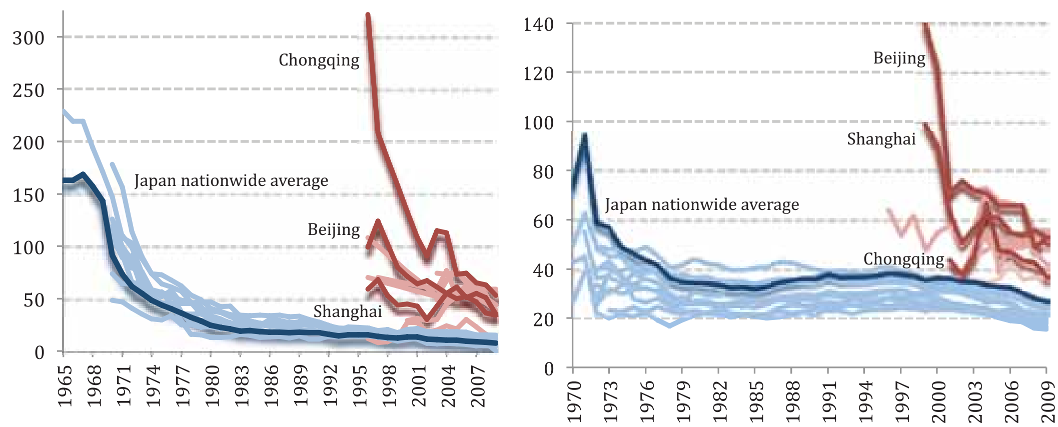
A strong commitment to dealing with concentrations of particulate matter in cities will pay large dividends in improving health and social welfare. As China continues to grow, it will be possible to dramatically reduce air pollution levels—just as Japan did starting in the mid-1960s (see **Figure 3.3**). That is when Japan's air quality and other environmental concerns reached crisis levels, and when it too was an upper middle income country. If air quality in China were brought to the level of Japan in 1980, these benefits would be valued at 3.1% of GNI. In addition, these air pollution improvements would bring large co-benefits associated with reduced use of fossil fuels, such as reduced depletion of fossil fuel resources, improved water quality, improved soil quality, and reduced $CO_2$ emissions.

**FIGURE 3.2 Urban Air Pollution Trends in China, 2003–2009**




*Source:* World Bank analysis based on China Environmental Statistical Yearbook.

**FIGURE 3.3 Average annual $SO_2$ (left) and $NO_2$ (right) concentrations observed for the 10 largest cities in Japan and China, 1970–2009 (μg/m³)**




*Notes: Includes ten largest cities in Japan by population in 1970; 10 largest cities in mainland China by downtown population in 2009 (excluding Dongguan city, Guangdong).*
*Sources:* NIES database, Japan Ministry of Environment (1989), Kawasaki Air Pollution Monitoring Center; NBS, China Environmental Statistical Yearbook, various years; city statistical yearbooks for Beijing, Tianjin, Shenzhen, Chongqing, and Nanjing, various years.

Pollutants in water and soil also affect public health both directly and through the food chain. About 40 percent of the water sampled from the major rivers in the North and Northeast is at Grade V or V+.[11] This exacerbates already critical water shortages, such as in the North and Northeast where freshwater resources are only 785 cubic meters per capita, about 200 cubic meters below the international standard for "severe water stress".[12] With the urban population growing by nearly 300 million over the next two decades, the stress on existing supplies will only increase. Cleaning up China's water supply is a clear priority (see Box 3.1).

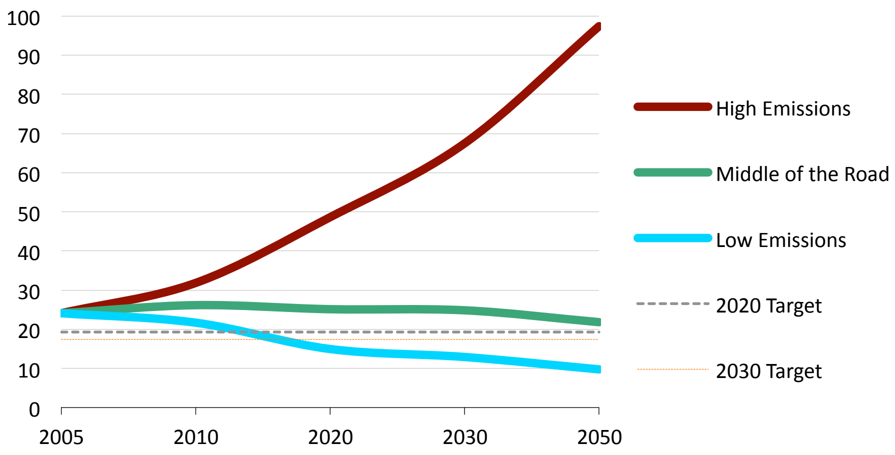
**BOX 3.1 The challenge of China's water pollution**

China's surface and groundwater supplies are low on a per capita basis, but useful supplies are much lower yet because of pollution. Although seen most vividly in pictures of an algae-chocked Lake Tai, across water-stressed North China, 40% of the rivers fall in the two worst water quality categories of class V and VI, meaning direct use would endanger health and treatment is very expensive. The government has necessary, but ambitious, targets to control pollution:

**Ministry of Environmental Protection Targets**

- By 2020: 60% of China's surface waters meet the standards for Grades I–III (compared to 57% in 2009)
- By 2030: 70% of China's surface waters meet the standards for Grades I–III
- By 2050: 80% of China's surface waters meet the standards for Grades I–III.

**FIGURE 3.4 Waste water emissions projections (COD), 2005–2050 (million tons)**




*Source:* MEP and CAE 2011.

Based on global experience, success in improving water quality will depend on a combination of aggressive regulatory monitoring and enforcement with a strong set of economic incentives. China's interventions to date have focused on industrial and municipal point-source pollution. While continuing to reduce those sources of pollution, the country will need to tackle the even more difficult problem of non-point sources.

Land degradation presents a similar problem of scarcity. Heavy use of agrochemicals, combined with pollution from cities and industry has degraded soil quality. According to the

[11] NBS 2010; MEP 2009. Grade V is defined as water only suitable for agricultural water supply and general landscaping use; and Grade V+ is water unsuitable for any use (China Environmental Water Quality Standard GB3838-2002).

[12] The national average of 1,812 cubic meters of freshwater resources available for every person in China is only one-quarter of the world average.

Ministry of Environmental Protection and Chinese Academy of Engineering, heavy metal contamination of farmland is a serious issue raising concerns that these pollutants can make their way into the food chain (MEP & CAE 2011; Zeng X.B. 2010). The presence of contaminated arable land may also restrict land availability for agriculture, which is already severely limited due to pressures from urban, industrial, and infrastructural development. Indeed, total agricultural land may drop below the amount mandated by the government as "the red line" below which self-sufficiency in grain production will be hard to maintain.

## b. Environmental co-benefits of green development

As highlighted in the previous chapter, there are investments and management improvements that are cost effective (assuming efficient markets), emissions-reducing, and pollution-reducing. These "no-regrets" cases contribute, therefore, to growth, climate mitigation and local environmental benefits. The potential cost savings of these no-regrets low-carbon investments available in China were estimated by McKinsey & Co. to be on the order of US$65 billion per year by 2030. The additional co-benefits of these investments associated with improved productivity of China's workforce, thanks to fewer cases of respiratory illnesses each year, puts additional economic gains at around US$20 billion per year. The magnitude of various other potential "win-win" strategies to improving public health is highlighted in **Table 3.2**. Of these examples, more efficient buildings that require less coal to be burned for electricity would generate the largest health-related co-benefits (as much as US$9 billion), followed by the use of additives in place of clinker in cement production (as much as US$2.7 billion).

**TABLE 3.2 Direct savings and additional co-benefits of annual reductions in $CO_2$ emissions, 2030 (million US$/year)**

| Sector | Cost Saving Abatement Option | Direct Savings from Reduced Costs | Additional Benefits from Avoided Air Pollution |
|---|---|---|---|
| Buildings | Replacing old bulbs with LEDs | 24,992 | 2,364 |
| | Appliances | 9,007 | 978 |
| | Efficient variable speed water pumps | 3,453 | 750 |
| | Water heating | 2,085 | 489 |
| | District heating controls | 1,439 | 1,125 |
| | Efficient buildings* | 6,116 | 8,967 |
| Transport | Light duty vehicles, efficient combustion engines | 5,018 | 950 |
| Industry | Combined cycle power plants (steel) | 5,630 | 745 |
| | Coal moisture control (steel) | 2,085 | 827 |
| | Utilizing or destroying coal bed methane (mining) | 751 | -- |
| | Clinker substitution (cement) | 229 | 2,669 |
| Power | Small scale hydropower | - | -- |
| Agriculture/ Forestry | Fertilizer management | 2,280 | 162 |
| | Cropland management and restoration | 1,112 | -- |
| | Methane utilization | 834 | -- |
| **TOTAL** | | **65,030** | **20,027** |

*Notes:* * Includes passive design, retrofit packages for commercial buildings, and other design improvements. US$ figures expressed in 2009 dollars. For this table, a sector-by-sector estimate was made of the local environmental co-benefits associated with energy efficiency investments. These co-benefits include the avoided costs of respiratory illnesses due to reduced air pollution, which is correlated with reduced burning of fossil fuels. For some industries, such as iron & steel and cement, most GHG emissions can be attributed to burning coal. For others, such as the transportation sector, GHG emissions come mainly from burning oil. Since certain fuels are "dirtier" than others, different types of fuel use reductions have different impacts on local ground-level air pollution. A Chinese Academy of Sciences study calculated the fuel mix used by each industry type (Liu X.L. et al 2011), and estimated how many units of coal, oil, and natural gas were saved by reducing GHG emissions with the technology options in the McKinsey marginal abatement cost curve (McKinsey 2009). Damage estimates were taken from studies done by Harvard and Tsinghua University economists (Cao J. et al 2009; Ho & Jorgenson 2003) of the marginal cost of increasing people's exposure to higher concentrations of pollutants. By summing the benefits from reduced coal, oil, and natural gas combustion for each abatement option, this study estimated the total value of avoided illness.
*Sources:* Authors based on McKinsey 2009; NBS 2008 and 2009; Ho & Jorgenson 2003; Cao Jing et al 2009; Liu and Wang 2011; Matus et al 2011.

## c. The benefits of investing in environmental protection

As China faces the challenge of reducing the degradation of its natural assets (measured as a percent of GNI), and makes targeted increases in spending on environmental protection, how much would it cost? It is clear that cleaning up China's environment requires resources; otherwise, it would have been done already.

Current annual investment in the treatment of industrial pollution in China—about 0.15–0.20% of GDP—is roughly comparable with the amount spent in several European countries each year. Considering how fast China's economy has grown over the past decade, this reflects a great effort to reduce pollution, especially point-source pollution from industry.

Overall, however, cleaning up industrial pollution is a relatively small fraction of total environmental protection expenditures by government and business in high-income European countries. When the full range of environmental protection activities defined in the European System for the Collection of Economic Information on the Environment (SERIEE) are included, high-income European countries spent about 0.3% to 1.1% of GDP more than China on environmental protection overall as a share of GDP in 2008 (**Table 3.3**).[13]

**TABLE 3.3 Total environmental protection expenditures, 2001–2009 (% GDP)**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|
| **China** | — | — | — | — | — | — | — | 1.23% | — |
| **France** | — | — | — | 2.07% | — | — | 2.16% | — | — |
| **Germany** | 1.73% | 1.70% | 1.69% | 1.70% | 1.51% | 1.62% | 1.53% | — | — |
| **Hungary** | 1.68% | 1.76% | 1.85% | 2.00% | 2.14% | 1.95% | 1.59% | 1.52% | — |
| **Italy** | — | — | — | — | — | — | — | — | — |
| **Poland** | — | 1.75% | 1.78% | 1.74% | 1.79% | 2.04% | 2.06% | 2.38% | 2.42% |
| **Portugal** | — | — | — | — | — | 1.12% | 1.25% | — | — |
| **Spain** | 1.48% | 1.55% | 1.56% | 1.54% | 1.61% | 1.69% | 1.78% | 1.83% | — |
| **Sweden** | 1.19% | 1.19% | 1.18% | 1.16% | 1.26% | 1.20% | — | — | — |
| **EU25** | 1.90% | — | — | — | — | 1.82% | — | — | — |

*Sources:* NBS 2010, MEP 2010, Eurostat 2010, Eurostat data-base, MOF 2009, SFA 2009, Wang X. et al 2010, and authors' calculations.

Over the longer-term, to improve its environmental quality, China's government expenditures related to the environment should be at least 0.5% of GDP above current levels. Any increased environmental expenditure in China would include increased spending on both pollution abatement and on efforts to protect and restore the health of its ecosystems. Although China is already spending RMB 83.7 billion (US$ 12.0 billion) each year on tree planting programs to combat soil loss, flooding, and desertification, the cost-effectiveness of these programs can be improved by setting targets based on ecosystem health rather than acres of forest planted. It can also direct more investment to relatively neglected areas, such as the conservation and restoration of wetlands and coastal ecosystems.

Evidence from the US and elsewhere shows that such expenditures have extremely high rates of return when measured in economic terms (for example, the benefit-cost ratio of the US Clean Air Act is estimated to be 25:1 by 2015 and 31:1 by 2020) (USEPA 2011). Increased environmental expenditure in China would have similar high rates of return by increasing natural and human capital in the economy. By this account, a relatively modest incremental increase in environment-related expenditures would go a long way towards securing the 6.3% of GNI gain in social welfare shown above in **Table 3.3**.

[13] This is a rough estimate; due to a lack of more publicly available information on China's national accounts, it may be an under-estimate of China's expenditures.

## d. Adapting to a changing climate by increasing resilience to risk

A further benefit that green development would bring to the quality of China's growth is increasing resiliency to climate risks.[14] China's climate is already changing, and changes will accelerate. Even taking into account current scientific uncertainty about the extent and nature of future climate change impacts, preparedness for a more variable, unpredictable, and extreme future climate will be a prerequisite for sustained economic growth. Adopting planning and investment approaches to better address risks and uncertainties are a reason for China to fully incorporate climate change in its economic management.

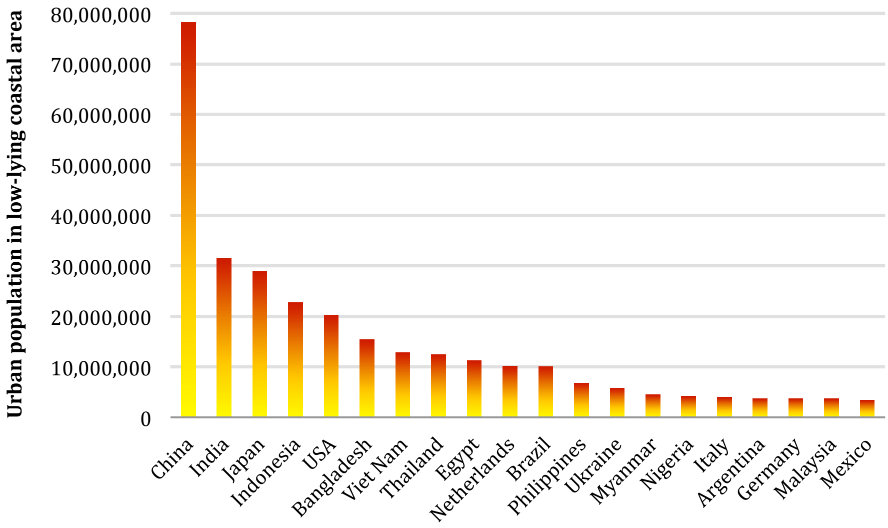
Among the observed effects of climate change are: average annual surface temperatures increased by 1.1°C over the last half of the 20th century for the country as a whole, and much faster in the north and northeastern provinces. The number of rainy days has decreased for most regions, and more precipitation has come from shorter, more intense storms (Di P.M. et al, 2007; Zhai P.M. et al, 2005). The area of cropland exposed to drought has also increased for many regions. In the years to come, despite more rainfall projected for China as a whole, many regions may actually suffer from more droughts (Woetzel et al, 2009). Agriculture will be particularly hard hit, because precipitation will come during the winters and less during the crucial spring and summer months. The area of cropland affected by flooding each year has increased significantly for parts of the Yangtze River basin. Although the projections are highly uncertain, flooding may continue to increase for this region in the coming decades (Ding Y.H. et al, 2007; Ren G.Y. et al 2007).

The agricultural sector is likely to have the greatest early climate change impacts. Annual crop losses due to drought in the Northern China plain and Northeast provinces are projected to rise (Chen et al and Nelson et al, forthcoming). While warming will probably hurt rain-fed agriculture in parts of the country where there is more indigent poverty, other areas may actually benefit from night-time warming, longer growing seasons, and increased water available to irrigation systems (Wang J.X. et al 2008 and 2010). Coping with the significant variability of future impacts will require geographic shifts in production and more flexible and robust water management.

Urban populations and industry will also be more exposed to extreme weather events. Much of the population lives in areas where sea level rise, storm surges, flooding and tropical cyclones are a concern (**Figure 3.5**). The concentration and value of productive capital and valuable infrastructure increases in these areas, and so do potential damages. This is particularly worrisome for long-term capital assets, such as power grids, water supply and wastewater treatment systems, and road and rail networks.

[14] Given the country's importance as a carbon emitter, green (low-carbon) development will reduce emissions, reduce the magnitude of climate change, and reduce the need to China to adapt.

**FIGURE 3.5 Vulnerability to sea-level rise and storm surges by country, ca2000**




*Note:* ***"low-lying coastal area"*** *defined as "the contiguous area along the coast that is less than 10 meters above sea level" (McGranahan et al 2007).*
*Source:* World Bank, World Development Indicators; McGranahan et al 2007.

Institutions, planning processes, and policies that effectively manage future risk through green development will increase the resilience of China's economy. In turn, China will be able to mitigate, and recover quickly from damage due to adverse weather, and ready to seize new opportunities for growth should these arise. For example, long-term glacier melt on the Himalayan plateau will generate both enormous challenges and opportunities for water conservation and storage technologies. Opportunities, for both domestic and international gain, abound in other sectors as well, such as agriculture, building design, and infrastructure design.

# Chapter Four Factors Favoring and Impeding Green Development in China

In pursuing green development, China enjoys a number of unique advantages that other countries do not have. At the same time, it also faces unique challenges. The largest of these challenges is not a lack of financing, but rather a lack of incentive structures to promote green development. If it can overcome these challenges in the next two decades, then it could position itself as a world leader in green development.

**China's advantages:**

1. Government ability to mobilize action on high-priority issues
2. The advantage of being a relative late-comer
3. Large domestic market to scale up green sectors
4. Abundant capital (including human capital) to invest in green sectors
5. Natural endowment of resources for clean energy
6. Potential to still avoid lock-in effects of higher levels of urbanization
7. A destination for global investments and R&D in green technologies

**China's challenges:**

1. Distorted prices of resource commodities
2. Over-reliance on administrative measures for reducing carbon emissions
3. Weak incentives for environmental protection
4. Lack of a competitive market environment for green sectors
5. Sector coordination failures
6. Weak monitoring and enforcement of environmental standards, especially at the local level

## a. Factors favoring green development in China

*First, government ability to mobilize action on high-priority issues.* China's top leaders have already reached a high level of consensus on the importance of green development. As President Hu Jintao remarked in a speech at the November 2011 APEC summit, China is committed to "vigorously developing the green economy." This commitment is also evidenced by the *Work Program to Control Greenhouse Gas Emissions during the 12th Five Year Plan*, in which the State Council makes clear that "addressing climate change will accelerate economic restructuring and the reform of economic development, driving forward the opportunities of the next industrial revolution."

Beyond expressions of commitment, the government has demonstrated numerous times that it can take decisive action on issues of high political and economic priority. Reforms undertaken over the past three decades have fundamentally redefined the functioning of the Chinese state in allowing the market to play a greater role. Green development is consistent with further market reforms that promote efficiency, while increasingly correcting for market externalities that can only be addressed with a proactive government.

*Second, the advantage of being a relative late-comer.* Because developed countries industrialized following a high-carbon model, their economies have to a great extent been locked into a high-carbon path. On the other hand, China and other developing countries can meet additional demand by building new green productive capacity and infrastructure without eliminating equal amounts of existing physical capital. China's present level of economic development is only one-eighth to one-tenth the level of developed countries, measured in terms of per capita energy use, car ownership, and other indicators (**Table 4.1**). Because China is still in a stage of rapid development, the incremental costs of green development will be relatively low. China can avoid the higher costs of transitioning to low-carbon technologies compared to countries with less rapid growth and less rapid turn-over of capital stock.

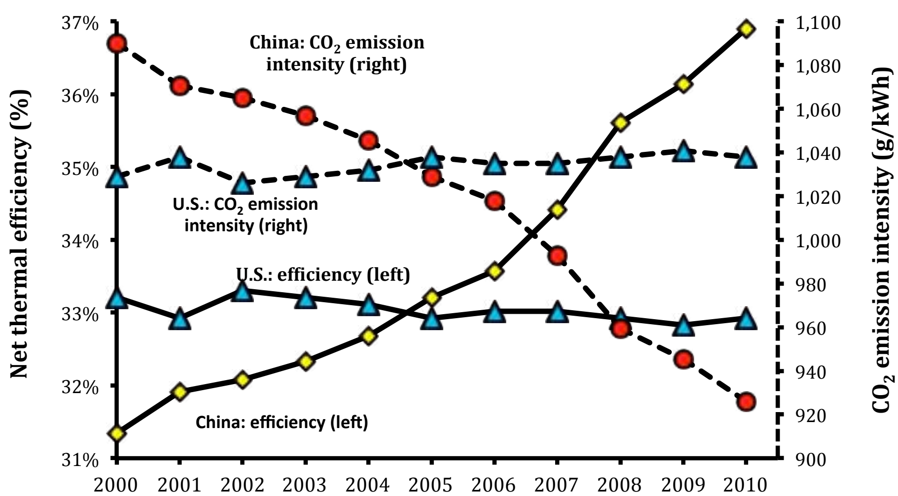
**TABLE 4.1 Comparison on selected indicators for China and developed countries**

| | China | U.S. | Japan | OECD |
|---|---|---|---|---|
| Per capita GDP ( US$, 2010) | 4,393 | 47,184 | 43,137 | 34,673 |
| Per capita gasoline consumption (2008) | 1.60 | 7.50 | 3.88 | 4.50 |
| # of automobiles per thousand population (2008) | 27 | 451 | 319 | 391 |
| Per capita transport gasoline consumption (kg oil, 2008) | 0.05 | 1.15 | 0.33 | 0.48 |
| Urbanization Rate (%, 2009) | 49.95/* | 82.3 | 66.8 | 77.0 |

*Note: (*) China's latest urban census data is for 2010.*
*Source:* World Development Indicators, 2010.

Nevertheless, capitalizing on this advantage and leap-frogging certain technological stages into the most efficient and greenest options will require early strengthening of incentives. This is clearly shown in how rapidly China has overtaken the United States in the efficiency of its coal-fired power plants (**Figure 4.1**). In the past 10 years, due to large-scale installations of larger and more efficient supercritical and ultra-supercritical power plants, the overall efficiency of China's coal-fired plants has made a qualitative leap, and overtook the U.S. in 2005.

**FIGURE 4.1 Efficiency and $CO_2$ emissions of coal-fired plants in China and United States**




*Source:* Yuan Xu et al (2011) .

*Third, large domestic market to scale up green sectors.* China has a vast domestic market that provides excellent conditions for the formation of industrial green sector supply chains, giving companies in China an advantage over competitors in other countries in seizing "first-mover advantages". The rapid expansion of both wind power and solar photo-voltaics (**Box 4.1**), for instance, has shown that China is capable of achieving economies of scale with the support of its large and growing domestic market. Large market size will drive down production costs through learning by doing as well as by lowering unit costs. Scale combined with high investment levels and the ability to implement decisions quickly suggests that opportunities can be exploited ahead of competitors.

**BOX 4.1 China's solar photo-voltaic (PV) industry**

China is already the lowest-cost producer of solar panels in the world. This is due in no small part to the country's large domestic market, which has allowed the solar industry to rapidly specialize and establish an efficient division of labor. From equipment manufacturing to the production of accessories and auxiliary parts, the indigenization of the industry has been especially fast. As part of the supply chain for solar PV, by 2011 China already had 20–30 companies producing crystal silicon, more than 60 companies producing silicon panels, more than 60 companies making solar-powered batteries, and more than 330 companies producing components for solar technologies. There are 14 Chinese companies already listed on foreign stock exchanges, and 15 companies listed on domestic stock exchanges. The industry's annual production value has exceeded US$45 billion, imports and exports have topped US$22 billion, and it has employed around 300,000 people.

*Source:* Li J.F. et al 2011.

*Fourth, abundant capital (including human capital) to invest in green sectors.* China has traditionally enjoyed high rates of savings and investment (**Table 4.2**); it attracts more direct foreign investment than any other country; it has built up an impressive research and development infrastructure; and it will have more than 200 million college graduates within the next 20 years. Clearly, China possesses an abundant amount of capital for green development that can be put to work, often with government support, to develop sunrise industries. The country is able to quickly acquire, adapt, and master new technologies. Combined with the previous advantage of its large market, China's ability to attract foreign companies and investors seeking to commercialize their own technologies brings additional know-how and spill-over effects.

**TABLE 4.2 Investment, savings, and consumption rates for various countries**

| Country | Saving Rate (%) | | Investment Rate (%) | | Consumption Rate (%) | |
|---|---|---|---|---|---|---|
| | 1970 | 2008 | 1960 | 2008 | 1960 | 2008 |
| Average of developed countries | 27 | 20 | 26 | 22 | 75 | 79 |
| Average of Russia and Eastern European countries | 26 | 25 | 31 | 27 | 70 | 69 |
| Average of South American countries | 22 | 24 | 23 | 24 | 76 | 74 |
| Average of Asian and African countries | 23 | 34 | 19 | 29 | 61 | 47 |
| China | 27 | 54 | 36 | 44 | 61 | 47 |

*Source:* World Development Indicators 2010.

*Fifth, natural endowment of resources for clean energy.* China's natural endowments, such as wind, solar, biogas, and shale gas energy sources, favor new energy sources (**Table 4.3**). The country's theoretic solar energy reserves are equivalent to 1,700 billion tons of standard coal per year, and two-thirds of the country receives more than 2,200 hours of annual sunshine. Compared with other countries at the same latitude, China's solar energy resource is at par with that of the United States, and much larger than that of Europe or Japan. China's wind resources are also very high—almost two times its power generation capacity 2005 (NDRC 2007). In addition, China's current dependence on and large endowment of coal also provides an opportunity—in the form of strong demand for cleaner coal, and the continuing dynamism of investment in the coal sector—for lower emissions coal technologies (Shi, 2008).

**TABLE 4.3 Total exploitable renewable energy resources in China**

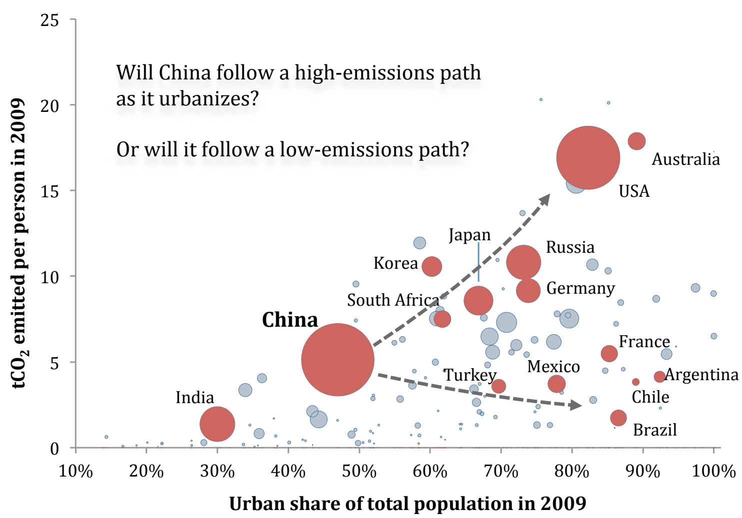
| | Potential Capacity Based on Resources (TW) |
|---|---|
| Wind power | 173.4 |
| Small-scale hydropower | 133.3 |
| Biomass | 25.4 |
| Solar PV | 22.7 |
| **Total** | 354.7 |

*Source:* Gao H. & Fan J.C. (2010), 48. Note: Small-scale hydropower includes retrofits.

*Sixth, potential to avoid the lock-in effects of higher levels of urbanization.* Although China's current level of urbanization is low (47.5 percent) compared to high-income countries, this will change. During the 12th Five-Year Plan period (2011–2015), the country is expected to invest US$ 300 billion in basic infrastructure. According to UN estimates, by 2030, about 65 percent of China's people will live in cities (UN Population Division 2009.

The policy and investment choices made today and over the next two decades will have long-lasting implications for efficiency, life-style, environmental impacts, and carbon emissions. For example, if cities lack adequate public transit facilities, commuters have no alternative but to resort to private vehicles. As vehicle density increases, so does congestion, which, in turn, sharply increases pollution, including emissions of $CO_2$. Similarly, commercial and residential building design will largely lock-in energy needs for the life of the building, even if future price and other policy incentives change dramatically. An electric generation plant has a lifetime of 30–40 years; its carbon footprint is fixed at the time it is built. *Only if China adopts green development policies sooner rather than later will it capture "lock-in" benefits of efficient buildings, cities, transport systems, and industries* that use low-carbon, environmentally-friendly technologies and standards (**Figures 4.2** and **4.3**).

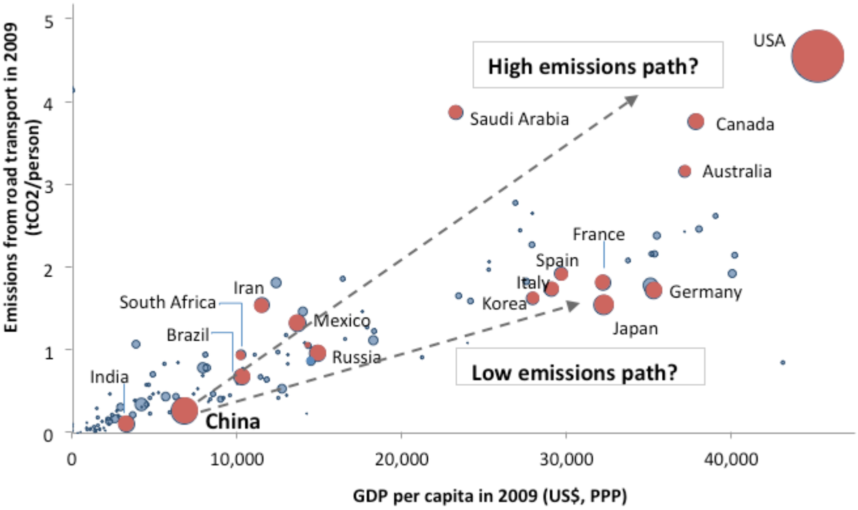
**FIGURE 4.2 What emissions growth path should China's cities take?**




*Source:* World Bank, based on IEA 2011, UN Population Division 2009.
*Note:* Bubble size corresponds with total annual $CO_2$ emissions.

Conversely, high-carbon investments today will render it exceptionally difficult and expensive to achieve future emissions targets. If negative lock-in effects occur, China will have to either retire assets early, well before the end of their service lives, or purchase emissions reductions elsewhere in the market. The incremental cost of going low-carbon now, such as by designing lower energy intensive urban and transport structures, is much less than the future cost to retrofit high carbon cities to a lower carbon track. High-carbon power plants may not even be amenable to retro-fitting. The prudent strategy is to introduce forward-looking low-carbon incentives now that lay the foundation for even stronger low carbon policies in the future. The sheer speed and scale of China's urbanization and infrastructure construction lends urgency to this issue, as does the rapid expansion of the private automobile fleet.

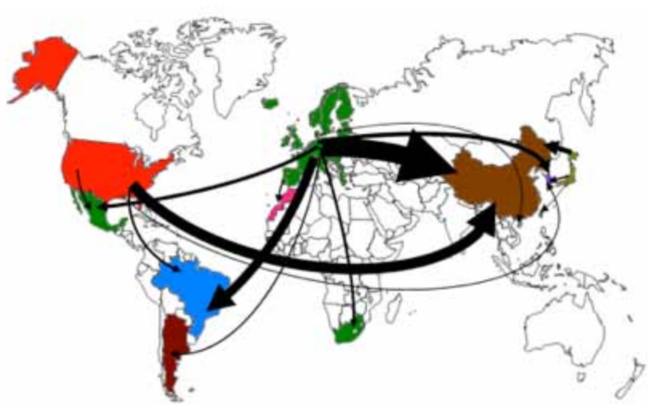
**FIGURE 4.3 Which way will China's transport sector efficiency evolve?**




*Source:* World Bank, based on IEA World Energy Statistics and Balances, World Bank World Development Indicators.
*Note:* Bubble size corresponds with total annual $CO_2$ emissions from road transport.

*Seventh, a destination for global investments and R&D*. All of the above advantages, coupled with China's manufacturing capabilities, make China an excellent location for investments in many global green technologies (**Figure 4.4**). Regardless of whether future technologies are invented in China, they will likely be commercialized in China. Global corporations find the competitiveness of China's economy attractive. The case of coal technologies is illustrative. Since over 70% of China's energy consumption is coal, there is a broad market space in China for technologies to clean up coal production and use. China can attract the world's best green technologies. This will not only promote China's own green transformation, but will also accelerate the development of technical options available elsewhere.

**FIGURE 4.4 Direction of Wind Power Technology Transfers, 1988–2008**



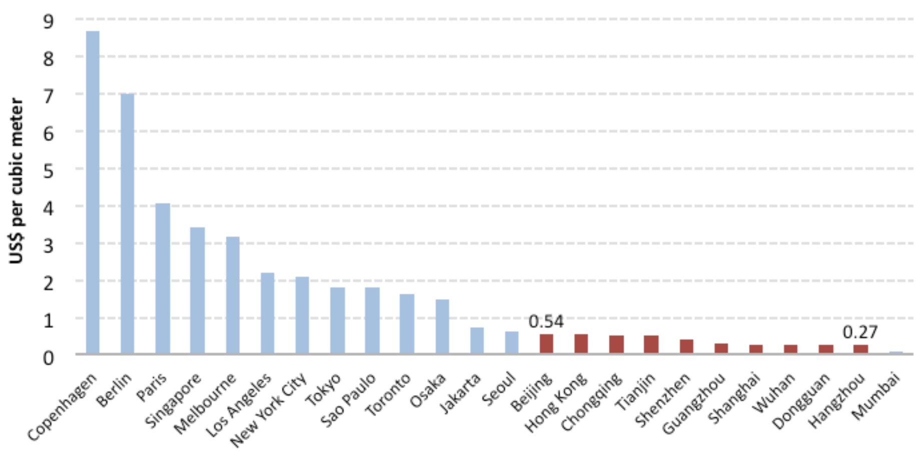
*Note: this figure illustrates the transfer of technologies from Annex I countries under the UNFCCC to non-Annex I countries, as measured by duplicate patent filings for wind power technologies in non-Annex I countries.*
*Source:* OECD 2010.

## b. Factors impeding green development

In spite of the above advantages that favor seizing green growth opportunities, China also has to overcome a range of obstacles, as described here.

*First, distorted prices of resource commodities*. Due to market distortions and rigidities, the major factor markets of land, labor and capital have encouraged capital-, land-, energy-, and pollution-intensive development. As a consequence, damages to the environment and public health associated with the use of resource-intensive production technologies have not been included in production costs of companies; nor does the supply and demand of these resources on the market reflect their true scarcity. This is partly due to inefficient pricing mechanisms, such as for water and land, and partly due to institutional weaknesses, such as the strong presence of monopolistic SOEs. For example, water tariffs in China are extremely low by developed country standards in China (**Figure 4.5**). For China to focus investments and innovation in green industries and technologies, it must pursue deep-reaching policy and institutional reforms and establish markets in which prices reflect scarcity as well as social and environmental costs.

**FIGURE 4.5 Household water and wastewater tariffs in China's 10 largest cities compared to other major cities, 2008**




*Source:* Global Water Intelligence (2008).

According to research by Huang Yiping and others, under-valuing China's labor, capital, land, energy, and environment is tantamount to offering subsidies to resource-intensive industries (Huang Y.P. 2010; Huang & Tao 2010). For example, in 2009, subsidies embodied in artificially low energy prices were equal to about 0.7 percent of GDP. According to Li Hong (2011), based on 2007 data, eliminating fossil fuel subsidies reduce China's carbon emissions by 6.21 billion tons $CO_2$. Similarly, Zheng Xinye (2011) predicts that if electricity prices are not raised, then by 2020, China's urban residents will use 10 times the electricity they do today; and if water prices are not increased, then by 2020, the average urban household would use a multiple of current consumption. These research results suggest that raising electricity and water prices for urban residents may be an effective policy tool. In Beijing, for example, it is estimated that raising electricity prices by just RMB 0.02 per kWh will slow the average annual increase in household electricity consumption from 35.6 percent to 23.9 percent. It is also estimated that slightly raising the water tariff in Beijing from RMB 3.70 per cubic meter to RMB 4.00, would reduce the average annual increase in water use from 14.7 percent to 5 percent. The use of tiered pricing could prevent undue burden on low-income households.

The distortion of factor prices in China is a serious problem, but not one that is unique to China. It is a global problem (**Box 4.2**). If perverse subsidies for fossil fuels are eliminated, this will dramatically improve the competitiveness of solar power, wind power, and other forms of clean energy. Going further and including the social costs of pollution and illness associated with the burning of fossil fuels would raise the price of fossil fuels even more.

**BOX 4.2 International fossil fuel subsidies**

The International Energy Agency (IEA) estimates that in 2008, fossil fuel subsidies reached US$557 billion. According to the IEA's analysis, if subsidies can be gradually lowered by 2020, then global primary energy demand will decrease 5.8 percent and $CO_2$ emissions from energy will be reduced by 6.9 percent, compared to a situation in which subsidies are unchanged. At the 2009 summit of the G20 in Pittsburgh, the G20 leaders reached consensus on the need to gradually reduce subsidies while providing support to low-income groups. The G20 resolved, "inefficient fossil fuel subsidies encourage wasteful consumption, reducing our safety, obstructing investment in clean energies, and negatively influencing measures to mitigate the dangers of climate change".

*Source:* cited in Feng F. 2011.

*Second, over-reliance on command-and-control measures for reducing carbon emissions.* By relying too much on inflexible administrative measures, resources for reducing carbon emissions have not been optimally allocated and compliance has been uneven. This is exemplified by the current provincial allocation of targets to reduce the energy intensity of economic output. First, the targets are not allocated according to means or resources. During the 11th Five-Year Plan (2006–2010), energy intensity targets for individual provinces were pegged to the national target of 20 percent. Although this method seems to make sense, it has placed an overly heavy burden on the less-developed provinces. Because these provinces are currently experiencing a period of heavy industrialization, they faced an extra heavy burden in meeting their targets. Second, although targets for reducing energy or carbon intensity are the result of a negotiated political process, they are rigid (neither flexible nor tradable). This has increased the costs of compliance and made it more difficult for individual provinces to save energy and reduce emissions, leading to such phenomena as cutting off power (i.e., resorting to "energy poverty") in order to meet targets that are even lower than what could otherwise be achieved.

*Third, weak incentives for environmental protection.* Clear environmental regulations enforced by government are crucial for improving the quality of the environment. However, at present, China's environmental regulations remain relatively weak and there has been inconsistent enforcement.

The problems associated with a lack of incentives for environmental protection are evident in both pollution monitoring and compliance, and in natural resource management. Of course, there are some successes as well, often market-based. In agriculture, the lack of longer-term property rights in land and water has created a disincentive to farmers to invest in longer-term sustainability. Instead of increasing soil organic matter in their fields, for example, it is more economical to increase output in the short run by using more fertilizers and pesticides. The same is true for China's grasslands, many of which have been over-grazed or encroached upon by expanding settlements and are in decline.[15] It was also true for China's forests, which, up until the late 1990s, experienced heavy cutting and were shrinking. This changed, though, largely due to the introduction of eco-compensation programs and reforms in forest ownership. Between 2000 and 2009, the central government invested RMB 365 billion (US$55 billion) on afforestation programs, providing cash payments and other incentives for farmers to engage in

[15] China's Ministry of Agriculture (2007) estimates that 90 percent of the country's grasslands are degraded, and that about one-third are seriously degraded.

such activities as restoring marginal lands in fragile watersheds, planting shelterbelts to protect against sandstorms, and protecting natural forests. Reforms introduced in 2009 that extended the contract period for household forest rights to 70 years and allowed households to mortgage their rights strengthened the incentive for rural people to invest in sustaining forests.

Similar to land, China's water resources management system lacks incentives to promote efficiency at the scale required. As mentioned above, the first obstacle to efficient water use is low tariffs. In addition, the lagging water rights system reform and the inefficient utilization of market mechanisms result in the low efficiency of water resource use. Some of the examples are: the profligacy of water for irrigation and the inefficient allocation of water between different crops and regions result in the lowest productivity of water for agriculture, which accounts for 65 percent of total water use but only 45 percent of which is actually used for crops. Only 40 percent of industrial water is recycled in China, while the ratio in developed countries is 75 to 85 percent.

China's existing fiscal policies have discouraged investment by local governments in environmental protection. Since many local governments lack fiscal resources, they have found it difficult to support long-term public investments in projects that promote environmental sustainability. Many have turned to an excessive reliance on rents from land in peri-urban areas that have been converted from farmland and leased for development. As localities have tried to attract outside investment and develop new industries to make up budgetary shortfalls, there has been a large influx into these areas of projects that have damaged the environment and depleted natural resources.

Finally, the lack of incentives for environmental protection is tied to the inadequacy of the predominantly command-and-control pollution control regulations, and to the small scale of market-based pilots undertaken to date. For example, China has already attempted to establish local $SO_2$ permit trading schemes, modeled after the system in the United States. These programs have largely failed, however, because of over-involvement by the government in trading that has weakened the role of the market, led to the unfair allocation of permits, introduced problems in the design of trading mechanisms, and interfered with monitoring of emissions.

*Fourth, lack of a competitive market environment for green industries.* There are really two levels to China's transition to green development: the first is "greening" its current economic base, and the second is a more fundamental shift towards emerging industries. In terms of the more fundamental shift, some Chinese green industries have experienced rapid growth in recent years, as exemplified by the rise of its clean energy industries. Yet, despite this, its emerging industries lack a fair and open competitive market environment in which to grow.

At present, there is still not a level playing field for investment in emerging industries. In the case of the wind turbine and solar PV industries, for example, private companies are mainly concentrated in equipment manufacturing, while state-owned enterprises (SOEs) continue to monopolize the electricity generation market (SERC 2011). State-owned enterprises also dominant the development of shale gas, which will continue to be non-competitive so long as the legal rights to shale gas resources are not clearly defined (**Box 4.3**).

The Chinese government expects that SOEs will continue to play a leading role in strategic emerging industries, which may lead to disappointment given that SOEs have historically been unable to take on the role of green innovators. Not only do they lack the same incentives to innovate, they have also been placed in an awkward position by the government which expects them to meet short-term GDP growth targets while also engaging in the innovation of high-risk, cutting-edge technologies. As SOE managers are usually unwilling to take on the risk of failure; they are much more willing to purchase new technologies than invest in R&D on their own.

There is also a problem of regulation. Presently, wind power development projects smaller than 50 megawatts must be approved by local governments; and projects larger than 50 megawatts must be approved by the National Development and Reform Commission (NDRC). Egged on by local governments, a "clean energy rush" is now underway that has quickly led to over-capacity in the small undertakings. This campaign-style investment has long been a problem in China, and one that has been hard to correct.

**BOX 4.3 A lack of competition has held up China's shale gas exploration**

China possesses abundant shale gas reserves with an estimated 25–35 trillion cubic meters of recoverable resources, comparable to the 38 trillion cubic meters of conventional natural gas on hand.[16] The country's richest shale gas reserves tend to overlap with areas in which state-owned oil companies have registered conventional oil and gas fields. Under current policies, these reserves can only be explored by existing state-owned oil companies. Yet, these companies are mainly interested in conventional oil and gas resources and have made very limited investments in exploring shale gas resources. Some resources are claimed by companies but not explored. In other cases, companies are interested in developing the resources but lack access rights. The result of this situation has been to hold up technological innovation in the sector.

Extracting shale gas involves surveying, drilling, fracking, micro-seismic monitoring, environmental monitoring, water treatment, and other advanced technologies. Exploiting shale gas resources requires sustained, successive investments over the span of many years. For that reason, it is particularly suited for exploration via coordinated investment by a diverse number of investors. For a single company to develop a site from start to finish often puts great strain on the investor and leads to low-levels of efficiency and a lack of technological innovation.

*Source:* Zhang Y.W. 2010.

*Fifth, sector coordination failures.* Coordination failures between government and the private sector, as well as between different levels of government, have stalled key green development projects. The complexity of coordinating different areas of public policy and investment is apparent with green industries, since they tend to span multiple sectors and often require some form of government support due their infancy and infrastructure focus. Typically, since each agencies working in one sector only consider what is in their own interest and within their own purview, different agencies may actually hold each other back. The same is true between the central government and local government. For example, in the area of clean energy, investment in a single project may involve the National Development and Reform Commission (NDRC), the National Energy Administration, the Ministry of Environmental Protection, and various other local agencies. Generating electricity and connecting to the grid will involve the State Electricity Regulatory Commission and the state-owned power companies. Pricing subsidies are equally complicated and cumbersome to navigate. In the case of SOEs, top management will be evaluated by a number of different agencies.

For these reasons, the development of clean energy has been held back. For wind power, according to the State Electricity Regulatory Commission (SERC), coordination problems exist in several areas. First, there is difficulty in connecting wind power to the grid. In drawing up plans to develop wind power, local governments tend to consider only the availability of resources in one particular area in deciding the scale and timing of grid construction. Less thought is given to the long-term development of the wind power market. Second, the development of power generation capacity and the electrical grid is not well coordinated. For example, China had proposed to construct seven large wind-power generating bases (with a capacity of 10 GW), but did not lay down plans for how that electricity would be transmitted and distributed. Third, the development of wind power is not well integrated with the development of

[16] China has yet to make a systematic exploration and assessment of its shale gas resources, and there are large discrepancies between various estimates. PetroChina, for example, has calculated that there are 21–45 trillion cubic meters of recoverable resources, while the US Energy Information Administration puts this number at around 36 trillion cubic meters (Zhang Yongwei 2011).

other types of power. The potential benefits of inter-provincial trading and power-switching are very high, although coordination has proven difficult.

*Sixth, weak monitoring and enforcement of standards, especially at the local level.* Government monitoring and enforcement of standards remains weak. For example, China issued green building design standards, but these are not strictly enforced, even though buildings account for about 30 percent of the country's energy demand. There are lax standards for air conditioners and large-scale chillers. In the case of wind farms, Standards are lax or lacking for low-voltage ride-through, and for operating frequency (inactive vs. active power). Since market externalities exist by definition in weak or distorted markets, the public market regulatory role based on standards is essential. Weak institutions will hinder progress into green growth unless adequate institutional strengthening is undertaken. There is no substitute for strong monitoring and enforcement, even when market-based instruments are used to reduce market externalities.

In summary, these above six barriers will have to be overcome through appropriate policy and institutional reforms that together provide clear incentives for changes in technologies, investments, and behaviors. That there is a long list of barriers should not be surprising; if it were otherwise, green development would already have been a reality in China. In the absence of reforms, financing for green investments will not be forthcoming, as the cost may continue to be seen as too high and the investment too risky.

## c. Addressing concerns on green development

While ample opportunities exist to increase the environment and natural resource efficiency of the Chinese economy, there will be trade-offs, winners and losers. Policymakers need to recognize that relative price changes arising from changes in taxes, subsidies, regulations, and standards generate losers as well as winners. This section notes various types of impacts across the economy, industries, regions and socio-economic groups. Section 5 will provide more details on the numerous policy options that government has available to dampen negative impacts on different groups.

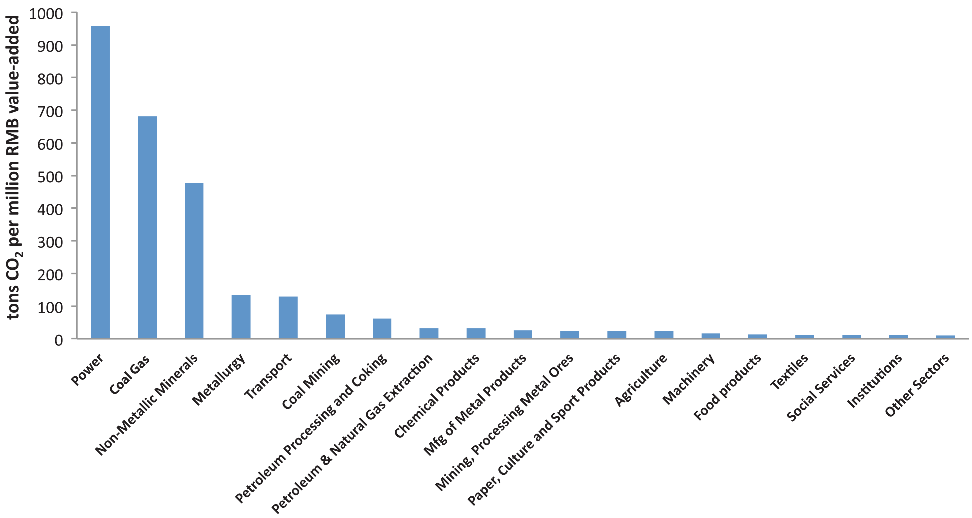
*First, economy-wide trade-offs.* Concerns are often raised that the economic, social and even political cost of green development is unacceptably high. A proper response to that concern is that while pursuing green development will require greater public investment in certain areas, such as environmental protection and basic infrastructure, the core of green development is really to introduce market-based incentives that raise the efficiency and sustainability of China's economy while also improving social well-being. By no means does China need to undergo "shock therapy" in order to transition to green development.

It is unlikely that green development will divert public expenditures from important public services. As China introduces new market incentives such as auctioning permits for carbon trading, strengthens a property tax, and/or raises prices of under-valued resources, green development may actually increase tax revenues and bolster the capacity of the government to provide funding for social services. Moreover, improving the quality of the environment will significantly reduce the need for spending on healthcare related to the burden of environment-related diseases.

In terms of political costs, it is important to remember that the political economy of policy reform is complex and difficult in all countries, including China. Every subsidy creates its own lobby, whether the subsidy takes the form of preferential access to land and credit, or access to cheap energy and resources. State-owned enterprises have political power and lobbying capacity, and energy-intensive export industries will also lobby for subsidies to maintain their competitiveness. Government will need to balance the wider social benefits of reforms with the losses of those adversely affected. Safety net policies for those likely to be negatively affected may include income support, and access to alternative employment, retraining opportunities, and relocation assistance. Such policies will go a long way in mobilizing the political and workplace-based support for the changes that are needed (ILO 2011).

*Second, impacts on different industries*. High emission industries include power generation, coal gas, metallurgy, non-metallic mineral products, shipping, coal mining, oil refining. Three industrial sub-sectors are the most energy intensive ones, and will be most directly affected by stringent carbon emissions policies (**Figure 4.6**). More generally, raising the costs of energy, water, natural resources, and/or of pollution, will more directly impact those industries that incur relatively more of those costs. Some firms may even be eliminated, while others will survive and upgrade their production processes, supply chains, and management techniques by investing in greater efficiency.

**FIGURE 4.6 Direct $CO_2$ emission intensities of different Chinese industries (2007)**




*Source:* DRC, based on the 2007 input-output table in NBS 2008a.

*Third, impacts on different regions*. As less-affluent provinces tend to invest more in heavy manufacturing and other lower value-added industries, they may be relatively more affected by green development policies. A number of China's poorer interior provinces are undergoing a period of heavy industrialization. If policies are administratively allocated and relatively rigid, as has been the case in China in recent years, this will place a heavy burden on these provinces. Conversely, relaxing price controls on energy so that the environmental costs of extracting fossil fuels may be passed onto the more affluent regions that consume more of these fuels, and introducing flexible trading mechanisms for emissions and energy intensity targets, may soften the negative impacts on the interior provinces.

As discussed in Section 3, the less-developed regions of China will benefit in the long-term by avoiding the costs of being locked into a high-carbon pathway. Once green development policies are put in place, they will also be able to better capitalize on previously undervalued resources, such as water, forests, grasslands, and renewable energy. Since these regions should no longer follow the precedent set by the more-affluent provinces in growing first and cleaning up later, they will find new opportunities provided by green development.

*Fourth, impacts on different social-economic groups*. Since energy use is so pervasive in production and in the household, reforms in energy and carbon pricing will have impacts on a broad range of consumer prices, and the net effect may be regressive for some households. In general, energy price increases will generally be progressive rather than regressive, since high income households use proportionately more energy than poorer ones (Cao J., 2011). (However, some argue that poorer households are more emissions intensive because of their heavy dependence on coal (Golley et al, 2008).) In response, fiscal transfers to households, financed by revenues from eco-taxes, resource fees, or emissions reductions auctions, could be transferred to consumers to offset price increases without affecting incentives to use energy more efficiently. Even more importantly, carbon revenues might be best considered in a revenue-neutral fashion, in which the selection of revenue sources to be replaced would also have a distributional element. The specific distributional impact of a carbon emissions trading scheme (ETS) can also be adjusted by freely allocating permits in the initial stage (Zhang & Wu, 2011).

Other aspects of green growth reforms, such as strengthening of rural property rights and reduced air and water pollution levels, are typically progressive because the poor have traditionally suffered the most. Investments in improved ecosystem health, biodiversity, and watershed management will be sustainable with local people's engagement and employment through ecological protection, restoration and related payments for ecological services.

# Chapter Five The Road Towards Green Development

Whether China can capture strategic green opportunities over the next two decades will depend on whether it can create implement reforms sufficient to remove the obstacles in its way. Wide-ranging policies are needed to provide the necessary long-term incentives to the private sector and to strengthen the public sector's regulation of lingering environmental problems. Policies for green development should focus on six main goals.

| Key policy packages to achieve green development: |
|---|
| 1. Provide strong market stimuli for transitioning to green development |
| 2. Foster green sources of growth |
| 3. Improve environmental quality |
| 4. Minimize the negative impacts of green development |
| 5. Manage risks associated with climate change impacts |
| 6. Strengthen local institutions |

## Goal 1: Provide strong market stimuli for transitioning to green development

The basic driver of green development is market stimuli. The most pressing market reforms will kick-start the transformation of traditional sectors, start reducing environmental externalities, and mainstream long-term sustainability goals. The highest priority interventions are described here.

*First, reforming pricing mechanisms for coal, electricity, gas and water and other resource commodities to provide the basic market conditions for green development.* This is the most urgent reform so that prices reflect not only the market scarcity, but also as much as possible the external hazards on environment and health in the process of mining, producing and utilizing these resource commodities. At the same time, this reform requires removing and eliminating direct and indirect subsidies for the traditional energy and resource commodities, and charging the state-owned enterprises full market price for their resource inputs (such as minerals, oil, natural gas, shale gas, and coalbed methane).

*Second, continue to impose $CO_2$ emission reduction targets, and accelerate the establishment of market-based mechanisms to reduce emissions.* The Chinese government has announced ambitious plans to reduce emissions of carbon dioxide and environmental protection, and the emission reduction and environmental protection objectives set for the local government are binding. For example, in 2020 the carbon dioxide emissions per unit of GDP is targeted to be 40%–45% lower than in 2005. However, these policy objectives over-rely on administrative measures, and emission reduction and environmental resources are not optimized. The measures do not promote technological innovation to the extent possible. According to DRC (2011), the following short-term steps should be considered. First, convert the current target for reducing the carbon intensity per unit of GDP into a total emissions reduction target, so as to create the conditions for introducing more flexible market mechanisms. Second, the emissions cap could then be distributed in accordance with advanced industrial emission standards, regional GDP per capita and other criteria, and a carbon budget account shall be established for each area. The carbon budgets set by the different provinces can be balanced to ensure the achievement of nationwide targets. Third, establish flexible and diverse mechanisms to achieve emission reduction targets, including emissions trading, a carbon tax on fuels, emission technology standards, regional cooperation mechanisms for emission reduction, administrative control measures. Among them, emissions trading might initially cover about 1000 high emitters, or about 1/3 of the country's total emissions.[17] The emissions of most other enterprises could be addressed via other emission reduction policy instruments. Fourth, establish new assessment methods for emission reductions, by province. Provinces should be able to reduce their actual carbon emissions, or achieve their reduction targets via cross-regional or national trading.

The above approach puts a price on carbon using diversified instruments including a cap and trade market mechanism. Analysis shows that it will be possible for China to significantly limit its emissions without reducing social welfare (see Annex for details). Any carbon revenue collections could be done in a revenue-neutral way. For example, recycling the revenue from emissions auctions by offsetting labor taxes normally paid by employers is one way of achieving job creation goals via green growth. In this way, governments tax "bads" such as $CO_2$ emissions rather than "goods" such as labor. Such a strategy has proven successful in Germany, where revenues from a tax on fossil fuels and electricity was channeled to workers' pension funds, thereby lowering the overall cost of labor and contributing to a increase net employment (cited in ILO 2011).

*Third, strengthening other environment-related markets, and introducing market-based environmental incentives*. Property rights for water, land and forests should be strengthened, and market mechanisms for water, ecosystems and land should be increasingly introduced. These resource issues are complex, politically as well as socially, but urgent. Poorer regions, for example, might bring new areas of land under cultivation and sell these quotas of farmland to the more developed regions to increase the efficiency of land use. For water scarce regions, conservation and quality improvements can be market-driven. For degraded ecosystems, expanded payments for ecological services (PES) in poor and ecologically important rural areas (for example, upriver watersheds or downriver flood plains) are needed. PES programs have the potential to provide supplementary source of financing for local governments and create alternative job opportunities. For all of the above measure, reforms in property rights and land markets are fundamental to improving farmer and business incentives to protect the local environment.

## Goal 2: Foster green sources of growth

Going beyond the provision of market stimuli for transitioning to green development is the need to more actively promote emerging green technologies and services. The national goal as articulated in the current Five-Year Plan is to turn China's green industries into a world-class example of innovation and competition. Further steps to be taken involve both focusing the role of the state, and opening up competition in the private sector. Priority actions include:

*Removing barriers to private capital and stimulating private investment*. There is great potential in urban infrastructure and services (such as water treatment, waste disposal, contaminated site clean-up), but various barriers exist for private capital entry, including information barriers. Once financial access restrictions are released, and new sources of capital are created, such as through international climate policies, investment would grow.

*Reforming state enterprises to eliminate monopolies that limit new entrants to better promote innovation without excess state market presence* (see the Innovation paper of this China 2030 study).

*Increasing governmental investment in critical infrastructure for green development*. Two examples are in charging stations required by the emerging electric car market and improved electrical grids designed to absorb large amounts of fluctuating power generated by solar PV and wind generators. Related to expanding government investment are addressing institutional and governance issues (see goal 6, below).

[17] These industries include power generation, iron & steel, non-ferrous metals, chemicals, petroleum, and building materials.

*Offering targeted support for R&D, especially in strategic industries, either through competitive grants to private research or through public RD&D in sectors where public goods dominate.* Complementary policies to "grow bigger fish by adding more water" may also be applied, such as through limited tax relief, enterprise bonds, and preferential financing to infant green industries. It should be ensured that subsidies are phased out as each sector matures and the need for public support diminishes. To complement support for green sectors, the government should also draw up a schedule to cancel export tax rebates and perhaps set export quotas for the most polluting and most resource-intensive products.

*Encouraging green consumer habits and increasing demand on green products.* For example, governments can engage in public advocacy of green consumption; establishment of labels and standards for green products and services so that they are easily recognizable by consumers; and efforts to mobilize NGOs, media and other organizations to promote green consumption (**Box 5.1**).

**BOX 5.1 Energy efficiency and consumer behavior**

Prices are typically very poor for signaling the carbon content of consumer products, even if a country has adopted carbon pricing, since it is likely a very small share of a product's price. As a result, guiding consumers to choose low-carbon goods and services through other means than pricing will be a key factor in determining the country's future emissions profile.

In the US, households use one-third of total energy and it is estimated that existing energy efficiency measures could save 30% of household energy use, reducing overall energy use by 10% (World Bank 2010). While these measures would be money-saving as well as energy-saving, many profitable energy efficiency measures are never undertaken. Compact fluorescent lighting (CFL) provides one example: while the up-front cost of CFL bulbs is higher than for incandescent bulbs, the life-cycle cost is lower. In practice, the uptake of CFL bulbs by consumers continues to be low in many countries.

While this low uptake may be due to credit constraints, behavioral economics also offers a range of explanations for this household behavior, falling under the general heading of 'cognitive biases' (Diamond and Vartiainen 2008):

- Status quo bias—the tendency to 'continue doing what you are doing' instead of taking more profitable actions
- Anchoring—giving undue weight to one piece of information over other available information
- Heuristic decision-making—(for example) using 'rules of thumb' to evaluate investments instead of accurate accounting of expected costs and benefits

Given these and similar divergences from what economists would consider rational behavior, traditional economic incentives such as taxes and subsidies may have weak impacts on consumer behavior. A broader policy mix for energy efficiency could therefore include information programs (which can help to reduce anchoring effects and status quo bias) and quotas and technical standards (which can overcome the limitations of heuristic decision-making). Similarly, promoting social norms in favor of saving energy and avoiding waste can help to change consumer behavior at relatively low cost.

*Source:* World Development Report, World Bank 2010.

## Goal 3: Improve regulation of environmental quality and the management of natural resources

Although market incentives are fundamental to achieving green development, there are important areas where regulations and other government actions are an important complement. The first is to strengthen regulation generally, i.e., improving the monitoring and enforcement of existing regulations. In addition, there are other priority steps to be taken that will enhance the basic market incentives established above.

*Strengthen standards*. Standards are a key regulatory area where improvements will shape behavior and create market incentives for green technologies. A key example is the automobile industry where standards can be set for fuel consumption. Another is the appliance and lighting industry where new standards for energy efficiency can have a direct and widespread impact. A third is the potential for national standards related to climate-robust green buildings, urban design, and transportation to prevent cities from "locking in" their carbon footprints, especially given the scale of urban construction. Compliance with standards can be increased through tougher inspections and buttressed by market-based incentives (such as insurance policies that require flood proofing or compliance with energy efficiency standards). And a fourth is to establish labels and standards for green products, services, and technologies so they are easily recognizable and understood by consumers.

*Government procurement*. Government can signal its seriousness about environmental goals by changing the way it conducts its own business. The most important and pervasive approach would be to introduce green standards for the roughly RMB 1 trillion (US$150 billion) in government procurement each year, which can open up a huge market for green products and usher in a robust period of private sector growth.

*Information disclosure*. Health damages from air pollution in China's cities have increased as the urban population is growing faster than air quality is improving. Investing in the monitoring of the most damaging pollutant, $PM_{2.5}$, and then regulating it, is the first step to curbing this trend. Public disclosure of air quality data is critical for both awareness and effective action. In rural areas, an expanded network of water quality monitoring stations is needed to identify and reduce non-point sources of pollution from agriculture, the next major challenge to improving China's water quality.

*Waste minimization and recycling in cities*. Recycling guidelines and targets can reduce the need for new urban landfills or incinerators. By some estimates, China may need an additional 1,400 municipal landfills over the next 20 years, creating sitting challenges and competition for scarce land resources. It can significantly reduce waste generation and landfill through waste separation and recycling. Germany and the Netherlands, for example, send only 1 percent of their waste to landfills and recycle 60 percent. Reducing waste will be especially critical as the size and population of Chinese cities continue to grow and as land becomes scarcer.

*Immediate measures to protect natural resources and biodiversity*. The natural resource-oriented market mechanisms mentioned above will take time to implement, and many of China's ecosystem problems are urgent and irreversible. Therefore, complementary measures are required to invest in ecosystem management programs, protected areas, and watershed conservation. (In some cases, maintaining healthy ecosystems, such as wetlands and coastal mangroves, can be the most cost-effective way to manage weather-related risks, such as storm surges and flooding.) In parallel, investments in water use efficiency and water quality monitoring stations would complement market-based initiatives concerning water rights, just as investments in agricultural R&D and extension services would complement reforms concerning agricultural land property rights.

## Goal 4: Minimizing the negative impacts on vulnerable groups

Overall, green development will bring enormous benefits for China; however, as with previous reforms, such as those leading up to China's accession to the World Trade Organization, some sectors, regions, and groups will inevitably bear higher costs than others. The introduction of reforms, whether fiscal and financial incentives or non-market policy instruments (such as new standards and regulations) will inevitably alter relative prices and change the profitability of different sectors. Pollution-intensive sectors will see profitability reduced while green sectors will see profitability enhanced. Resources will need to shift over time from one to the other, and this may pose adjustment challenges. Similarly, jobs in pollution-intensive industries will decline, while those in clean industries will increase. Through a mix of properly designed policies, the adverse impacts of green development may be minimized.

*First, for regions most impacted by policies to reduce emissions, compensation for carbon pricing (whether through taxation or tradable permits) could be made through fiscal transfers.* If done in a fiscally neutral manner, other taxes that may be more regressive could be replaced by carbon revenues. In addition, where price increases in water, electricity, oil, gas and other markets specifically affect low-income groups, progressive "social" tariffs could be introduced.

*Second, if carbon trading is introduced, the initial allocation of permits, both by sector and across regions, can be done in an equitable manner with the specific cost of the low carbon transition in mind.* Less developed areas may have relatively fewer opportunities for emissions reductions, and may therefore receive more favorable emissions allocations so as to not negatively impact their economies. High-emission enterprises that may be most affected (especially industries still subject to price controls or that cannot pass on the cost of carbon emissions to consumers) could receive free allocations at the beginning, moving to a partial and then full auction over time.

*Third, for displaced workers, job retraining as well as labor market policies that permit workers to move jobs and locations at relatively low cost will be needed.* Managing this transition, and ensuring that the pace of change is well within the capacity of the economy absorb, will require careful policy planning and pro-active implementation of social safeguards.

## Goal 5: Reduce risks associated with climate impacts

In parallel to reducing the social and economic costs of green development, China's future strategy should also reduce environmental risks associated with the impacts of climate change. China's climate will not only become warmer, it will become more variable, with both greater extremes and increasing frequency of extreme weather events. Policies to better understand and manage risk—and recover from damages—are pro-growth by nature, since they reduce uncertainty and diversity risk. New planning tools can help ensure that long-lived infrastructure assets can withstand future climate change impacts, and new financial tools, such as insurance for disaster recovery, can help transfer disperse weather-related risks. The recommended steps include:

*Improve information on weather-related risks.* Already, China has invested considerably in its network of weather monitoring stations, and it has set up emergency alert systems in coastal areas. The country can continue to improve its understanding of past, present, and future impacts of climate change by increasing the quantity, quality, and accessibility of weather data. It should also continue to invest more in public institutions to research, analyze, and disseminate this information.

*Update and develop new climate-robust technical standards for valuable infrastructure and physical assets.* For example, China should ensure that transmission lines and distribution systems for power grids in coastal areas are designed so that these assets can resist to increases in sustained peak wind speeds. Storm water drainage systems in cities should be designed to handle changes in peak daily and weekly rainfall at least 30 to 40 years ahead. And ports should be assessed for exposure to at least 50–100 cm of sea level rise.

*Strengthen the enforcement of technical standards and building codes.* Not only do building codes and other standards need to be climate-robust, they should also be uniformly enforced. Compliance with standards can be increased through tougher inspections and the introduction of more market-based incentives (e.g. insurance policies that require flood proofing or compliance with energy efficiency standards).

*Enhance disaster response systems.* Emergency preparedness plans and coordinated procedures for government agencies to respond to disasters are critical, especially if the intensity and destructiveness of extreme weather events increases.

*Offer insurance and other financial instruments to transfer risk and assist with recovery.* This includes such instruments such as disaster and calamity funds, contingent lines of credits, insurance, micro-insurance, re-insurance, and risk pooling. Insurance schemes can be designed in a way that they encourage beneficiaries to avoid occupation of high-risk areas, comply with building standards, and implement flood- and storm-proofing.

*Invest in agricultural R&D and extension services to help make the agricultural sector more resilient to the impacts of climate change.* Well-funded research institutions can help develop new seeds and management techniques that require fewer agrochemical inputs and are better suited changing climate patterns. More effective extension services can help to diffuse these technologies and practices. In this effort, cooperation between the public and private sector will be critical.

*Mainstream risk management into development planning.* China has issued laws for protecting cities against floods, the outbreak of disease, and other hazards; however, the current approach to risk management is highly fragmented, especially at the local level. Planning for weather-related risks should be better integrated into infrastructure and land use plans. Risk management audits should be incorporated into performance evaluations for local officials.

## Goal 6: Strengthen local institutions

Smart urban planning, water supply management, pollution control, and disaster risk reduction planning all require coordinated action at the lowest levels of government. To achieve this, measures are needed to strengthen local-level governance and institutions, and to provide clear incentives in the direction of green growth. New, sustainable sources of fiscal revenue and standards for evaluating the performance of local government agents are needed to provide the right incentives for provinces, cities, counties, and townships to pursue green growth strategies.

*First, encourage different regions to explore different models.* In the past, some of China's most successful reforms, such as the household responsibility system, originated as local experiments that were later scaled up. The same could be said for green development. As the green development is still in its infancy, some places will play a pioneering role. For example, in Baoding and Rizhao, bold efforts are underway to deploy clean technologies, improve energy efficiency, and reduce GHG emissions. The success of a few regions, will play a very good demonstration effect, and were soon imitated elsewhere. Yet, local institutional innovation is often suppressed because local officials are still under immense pressure to grow their economies and protect jobs, and there is often a lack of incentive for officials from different localities or bureaucracies to cooperate in solving trans-jurisdictional environmental problems. The current competition between municipalities across China is healthy, and can benefit from following some basic principles for low carbon urban development (**Box 5.2**).

**BOX 5.2 Low-carbon urban development in China**

Cities account for about 70% of energy related carbon emissions worldwide. This is expected to increase to 76% by 2030, with most of the increase coming from rapidly urbanizing countries such as China and India. Chinese cities already have relatively high levels of per capita GHG emissions. With hundreds of millions of people expected to migrate to the cities in China over the next 20 years, implementing policies to reign in carbon emissions in urban areas will be a central feature of China's emissions reduction strategy. Taking into consideration the characteristics of Chinese cities, the following elements are essential building blocks for successful low-carbon urban development:

- *Increasing energy efficiency and clean energy sources:* Cities should make a consistent and dedicated effort to reduce carbon emissions by sustaining demand-side energy efficiency measures—particularly in industry, power, heating and buildings. In addition, clean sources of energy supply can be developed within cities, with rooftop solar PV and solar water heating installations.
- *Reducing transport sector emissions:* to minimize emissions from the transportation sector, reduced motorization will be required. Decisive action should be taken to both adopt new technologies and provide high-quality public and non-motorized transport.
- *Managing cities' physical growth:* Cities need to intervene in the shape and direction of their physical growth. Cities with higher densities emit less GHG. Cities not only need to grow denser but also *smarter*, fostering compact communities, multiple use buildings, and public transport networks.
- *Support of low-carbon lifestyles:* With rising income and higher individual purchasing power and consumption demands, a low-carbon lifestyle will be a key determinant factor of future energy demand in Chinese cities. Some tools have been developed internationally to engage citizens in understanding their household carbon footprint and taking action to reduce it. Similar partnerships at the city and neighborhood level in China could contribute to less carbon intensive households.
- *Replacing energy-intensive manufacturing with low-energy intensive economic activities*: changes in the urban economic base, such as through expanded services, will reduce emissions. However, such strategies need to be considered carefully. For today's industrial centers, simply relocating higher emission industries outside a city boundary to reduce the carbon footprint of that city would make little (if any) difference on the national scale. But rapidly growing small and medium-cities may have the opportunity to leap-frog and bypass the polluting, high-carbon growth paths taken by the earlier generation of Chinese cities.

*Source:* Based on Low Carbon Cities in China, the World Bank, December 2011.

*Second, improve coordination vertically, between the central state and provinces, and horizontally, between different agencies and across jurisdictional boundaries.* Urban, transport, and environmental problems are not confined to the jurisdictional boundaries of local governments. The design aspects, costs and benefits of land use planning, transport networks, and water resources management are not confined to one jurisdiction. Also, competition between local governments to attract business investment and create jobs can discourage coordinated planning on issues such as protecting against floods or preventing urban sprawl. Incentives are needed to encourage smart urban planning and risk management by local and regional governments. Trans-jurisdictional bodies, such as river basin commissions and regional planning boards, should be given more authority. Membership should be expanded to include representatives from multiple line agencies, local governments, and major users of natural resources.

*Third, provide greater environmental protection incentives for local governments.* Adjusting the tax structure by establishing stable local revenue sources (such as a property tax, not land sales) is fundamental to more efficient land use. A property tax would also encourage localities to improve the quality of the environment so as to raise property values and thereby increase local tax revenues. The introduction of explicit performance indicators for local governments that support green growth is also key. Higher-level governments could reform the performance and promotion system to reward lower-level officials with new and specific emphasis on measuring the quality of growth and the sustainability in the use of natural assets. Indicators of "greenness" and quality of growth should carry the same weight as GDP in performance reviews. To make these indicators work, local targets for ecosystem health will be needed, and jurisdictional authority of various agencies responsible for meeting these targets need to be clearly defined by law in anticipation of possible bureaucratic gridlock.

# Annex: Sequencing Actions and Confirming Results

The policy areas described in this paper will have a profound effect on the pattern of China's development. The demands on government to correct years of market failures and price distortions are enormous. This annex makes some cross-sectoral observations about how to sequence these recommendations, measure results, and confirm that the long-term targets for green development are being achieved. It was prepared by and represents the views of the World Bank team.

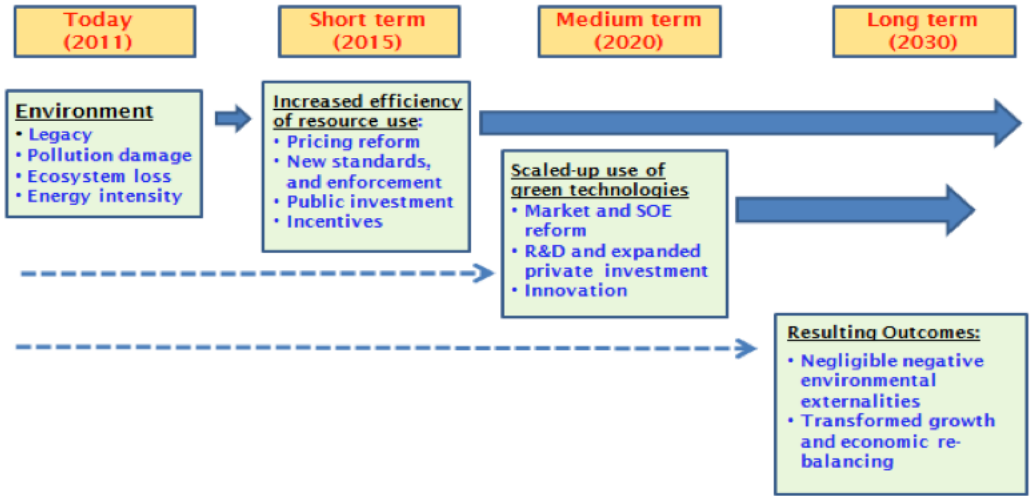
## a. Sequencing of green development actions

The concrete actions needed to achieve greener growth in China fall under the broad headings: (i) creating market incentives which alter current behavior and foster technological innovation, (ii) using regulation, backed by enforcement, to complement these market incentives, (iii) financing public investments in domains where public goods, such as better weather monitoring, will not be provided by the private sector, and (iv) reforming and strengthening the local institutions which play a key role in resource allocation and managing environmental quality. While steps in all four of these areas can be taken now, the gains from green growth will follow a natural sequence (**Figure A.1**):

- Short-term gains will be due to improved economy-wide efficiencies, to be achieved through efficient pricing (land, water, carbon, and pollution), regulatory reform, and public investment in critical green infrastructure. Early steps should also be taken to tighten standards in areas that will pave the way for technical developments and behavioral change, such as more efficient buildings, transport vehicles, and household appliances.
- Medium term gains will accrue from innovation and changing behaviors, which will come in response to government reforms to SOEs; targeted R&D in support of new technologies, goods, and services; infrastructure and information support to green domestic and export markets; and scaled up public education for all ages to help induce consumer and household behavior changes. The growth impacts of new technologies—in output, employment and exports—should be measurable and significant by 2020.
- By 2030, important targets in lower emissions growth, clean energy, air pollution, waste management, and efficient land markets can be met. In addition, risks associated with resource scarcity, climate change, and irreversible biodiversity losses can be managed. However, sustained government intervention will be required in all of these areas, at both the national and local levels, for the simple reason that most environmental gains require government intervention to help internalize environmental externalities, and government monitoring of compliance with standards.

Finally, while the twenty-year time frame up to 2030 is sufficient time for some early and important successes—such as in renewable energy, air pollution, and waste management—other challenges will certainly remain, such as ecosystem conservation, water pollution, carbon emissions reduction, and adapting to climate change.

FIGURE A.1 Indicative sequencing of green development reforms




## b. Measuring progress towards green development

Part of defining, pursuing, and achieving green growth is measuring progress. This point has been recognized both in OECD work on green growth (OECD 2011b) and the World Bank's new program to develop a green growth "knowledge platform" to guide its activities in developing countries. For example, the OECD has identified four clusters of appropriate indicators for monitoring progress towards green growth:[18]

- **Environmental and resource productivity,** to capture the need for efficient use of natural capital and to capture aspects of production which are rarely quantified in economic models and accounting frameworks.
- **Economic and environmental assets,** to reflect the fact that a declining asset base presents risks to growth and because sustained growth requires the asset base to be maintained.
- **Environmental quality of life,** capturing the direct impacts of the environment on people's lives, through e.g. access to water or the damaging effects of air pollution.
- **Economic opportunities and policy responses,** which can be used to help discern the effectiveness of policy in delivering green growth and where the effects are most marked.

Not all of the desired OECD indicators are measurable today, and many countries and agencies are working to establish an optimal set of green development indicators. Although this topic remains a work in progress, the two most important areas for defining indicators are the ***quantity*** of growth and the ***quality*** of growth.

For the ***quantity*** of growth, in addition to measuring economic output (GDP or GNI), it is also important to measure changes in people's wellbeing.[19] Two indicators used by the World Bank are the *Adjusted Net National Income (aNNI):* a truer measure of income than GDP or GNI, and the *Adjusted Net Savings (ANS).*[20]

[18] *Towards Green Growth—Monitoring Progress*, OECD, May 2011.

[19] The UN's work on a system of environmental and economic accounts (SEEA), building on the SNA, is one such initiative to measure the change in social welfare as a measure of progress toward green growth. The World Bank's work on comprehensive wealth accounting (World Bank 2006 and 2011) is a complementary initiative.

[20] ***aNNI*** accounts for the both the depreciation of produced capital and the depletion of natural resources such as forests, minerals, and fossil fuels. The growth rate of real aNNI is proportional to the change in social

For the ***quality*** of growth, indicators are needed at the sector or even sub-sector level. At this level, one challenge is to keep the list of indicators to a manageable size. A highly selective but informative set of indicators for the quality of growth includes:

- *Energy productivity:* increasing GDP per unit of energy used is greener because it is a sign of increasing energy efficiency
- *Share of fossil fuels:* decreasing the shares of fossil fuel in total energy used increases greenness, as does increasing the share of alternative and nuclear energy
- *$CO_2$ emissions intensities of total energy and of GDP*
- *$CO_2$ emissions per capita*

One of the important functions provided by green growth indicator systems is the ability to benchmark performance against international good practice examples. These benchmarked indicators are shown in **Table A.1** and **Figure A.2**, with these results:

- In terms of **quantity** of growth, the adjusted income and saving indicators show China's outstanding growth achievements. Over the period 2000–2009, the average growth rate of real aNNI per capita in China was roughly 10 times that in the OECD; and net wealth creation in 2009 as a share of GNI was 7 times higher in China than in the OECD.
- The **quality** of growth indicators shows, however, where progress is needed. China's energy productivity is half that of OECD countries; its fossil fuel share of energy is 10% higher than OECD countries; its share of renewable and nuclear energy production is only one quarter that of OECD countries, and its $CO_2$ intensity of GDP is over twice that of OECD countries. (On a per capita basis, however, OECD countries emit 80% more $CO_2$ per capita as China.)

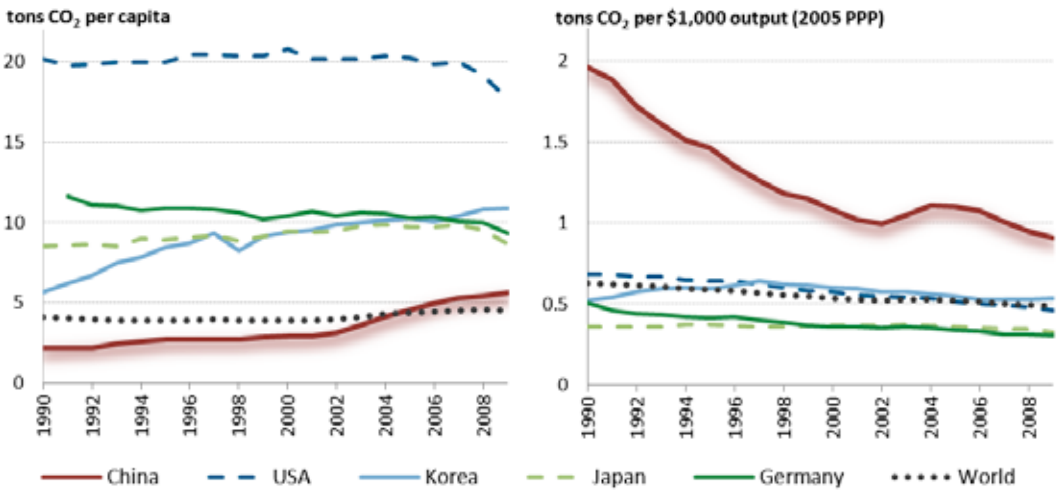
**TABLE A.1 Comparison of specific indicators, China vs High Income OECD**

| Indicator | China | OECD | Year | Measure |
|---|---|---|---|---|
| aNNI % growth rate | 5.5 | 0.6 | 2009 | Growth of real per capita PPP $, 2000-2009 |
| ANS % of GNI | 37.7 | 5.5 | 2009 | Share of GNI |
| Energy productivity | 3.77 | 6.73 | 2009 | Constant 2005 PPP $ GDP per kg oil equiv. |
| Share of fossil fuels | 92.6 | 82.9 | 2009 | % of total primary energy use |
| Alternative and nuclear energy production | 3.53 | 13.88 | 2008 | % of total energy use |
| $CO_2$ intensity of energy | 3.44 | 2.54 | 2009 | t $CO_2$ per t oil equivalent |
| $CO_2$ intensity of GDP | 0.91 | 0.38 | 2009 | kg $CO_2$ per 2005 PPP $ GDP |
| $CO_2$ emissions per capita | 5.67 | 10.36 | 2009 | t $CO_2$ per capita |

*Source:* World Bank, based on World Bank database, BP 2011, and US EIA database.

welfare, and so the sign of this growth rate indicates whether the economy is on a sustainable path. A higher aNNI means that a country is using its natural resources more efficiently. ***ANS*** is a measure of net wealth creation that measures the depreciation of fixed capital, the depletion of natural capital, investments in human capital, and health damages from pollution. Positive savings represent an improvement in social welfare, while negative savings indicate a decline, implying that an economy is on an unsustainable path.

**FIGURE A.2** $CO_2$ emissions per capita and per unit of GDP, 1990–2009




*Source:* World Bank, based on World Bank World Development Indicators, BP 2011, IEA World Energy Statistics and Balances, and US EIA International Energy Statistics.

As China transforms its economy towards high income status, both benchmarks and targets will be useful in measuring progress towards greening growth. For example, specific targets could be set for China's green growth, such as the share of renewable energy, the declining share of coal in total energy use, the declining level of average urban air pollution; and the increasing value of water productivity. Chinese targets, based on international benchmarks, could include:

- an OECD benchmark of energy productivity that nearly doubles between 2010 and 2030;
- the EU target of reaching a 20% share in renewable energy by 2020, and 30% by 2030;
- the Japanese air quality level of 25 μg/$m^3$ in annual average PM10 concentrations;
- a water productivity target of reaching best practice in OECD countries; and
- $CO_2$ emissions intensity falling by 60–65% between 2010 and 2030.

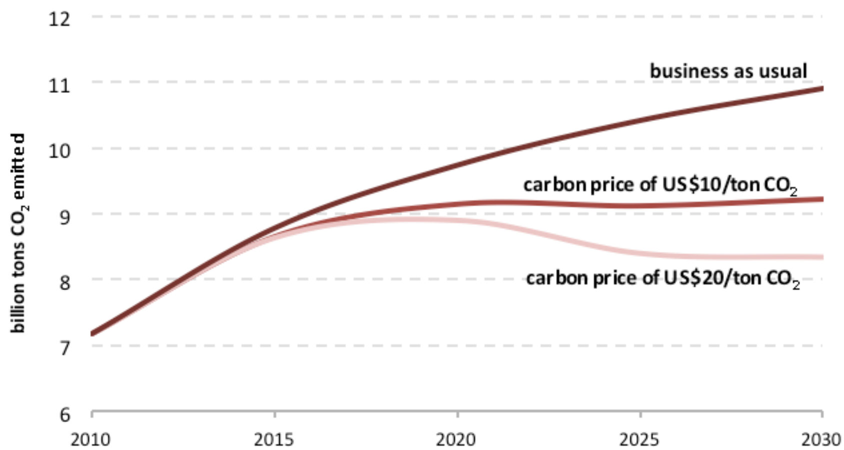
As is the case in OECD countries, green growth indicators and future targets are a work in progress in China, but an important step to be taken in implementing a green growth strategy.

## c. The potential impact of a carbon price

Carbon pricing, whether achieved via trading or taxation, would impact such variables as the cost of emissions reduction and structural shifts in the economy. By applying the base model used in Supporting Report 5 of this China 2030 study, the World Bank team simulated the introduction of a carbon price in China, starting in 2015 and phased in over eight years.

**Figure A.3** shows the path of $CO_2$ emissions in gigatons for three scenarios. The "business as usual (BAU)" scenario features continued strong growth in $CO_2$ emission to 2030, from 7.2 gigatons (5.4 tons per capita) in 2010 to 10.9 gigatons (7.6 tons per capita) in 2030. The key moderating influence on emissions in this scenario is the decline in GDP growth rates in 2025–2030. In contrast, the scenario in which a $10/ton $CO_2$ price is gradually phased in over eight years beginning in 2023 produces substantial reductions and flattens the upward growth in China's emissions, resulting in total emissions of 9.2 gigatons of $CO_2$ (6.4 tons per capita) in 2030. And the $20/ton $CO_2$ price scenario produces an even greater effect, so that China's absolute emissions peak and then drop down to 8.4 gigatons (5.8 tons per capita) in 2030—a total level about 17% higher than in 2010.

**FIGURE A.3** China's annual $CO_2$ emissions under three scenarios, 2010–2030




Carbon revenues in China could be significant in macroeconomic terms. The $10/ton scenario would yield fiscal revenues of 1.4% of GDP by 2030, and the $20/ton scenario would go up to 2.7% of GDP. If the carbon revenues were rebated to households, this would amount from $329 to 634 per household per year by 2030, depending on the price and assuming a household size of 3. While government has considerable discretion on how such a lump sum could be distributed, a flat lump sum per capita would be progressive by definition, helping to offset any regressive tendencies of the carbon price itself. Further notes on lessons learned from other countries on selecting and implementing climate policy instruments are given in **Box A.1**.

Although the simulated carbon price rates used in this analysis are too low to significantly affect the structure of the Chinese economy in 2030, there is a clear impact on the amount of coal the country would consume (**Figure A.4**). In the $10 price scenario, China uses 492 million tons less coal compared to business as usual in 2030 (a difference of 15%). Under the $20 price scenario, coal use drops by 770 million tons compared to business as usual (a difference of 23%). *Both* scenarios result in a peak in China's coal use before 2020. This decline is driven largely by a shift in the relative prices of different fuels for electricity generation. The market share of coal-fired electricity in the power sector (in terms of the portion of coal-fired power in total real output by the sector) drops 6% and 11% by 2030 in the U$10 and US$20 carbon price scenarios respectively. This drop is made up for by mainly by an increase in output volume for hydropower.

These results actually under-estimate the benefits of the simulated carbon price, since they do not include the co-benefits from reducing fossil fuel use related to reduced impacts on human health and crops. One important study (Aunan et al 2007) shows that the cost to households of imposing a carbon tax of RMB 290 per ton of $CO_2$ (US$ 43 in 2007 dollars) generates the same amount of economic co-benefits associated with reduced air pollution, improved health, and increased crop production. According to this analysis, the co-benefits in China associated with reducing carbon emissions and recycling carbon tax revenues are substantial.

**BOX A.1 Lessons from international experience on climate policy instruments**

The World Development Report 2010 on climate change outlines the issues concerning instrument choice for reducing carbon emissions. Permit systems give certainty on emission reductions, but uncertainly about price. Taxes are the opposite—they give certainly on price, but uncertainly about emission reductions. Since price volatility is an issue more with permits than taxes, investment in R&D for new technologies (especially without government support) may be depressed with permits. Revenue generation is possible under both regimes, though the administrative efficiency of the instruments differs considerably. Taxes on $CO_2$ can be integrated with fuel excise systems, requiring little additional monitoring effort. Permit systems require new regulatory institutions as well as monitoring and enforcement systems to ensure compliance.

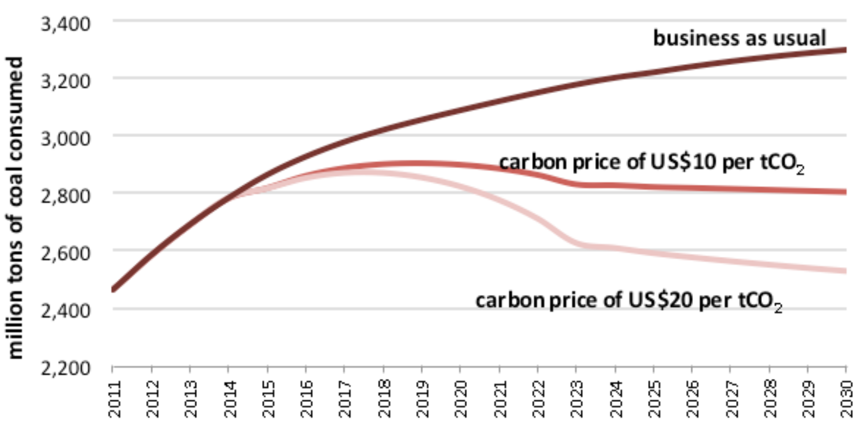
The International Energy Agency recently reviewed existing and proposed carbon trading schemes in Alberta, Australia, the EU, New Zealand, Switzerland, Tokyo and the United States (both national and state-level schemes). Some of the key conclusions are:

- *Targets*. Ambitious long-run targets are needed if firms are to invest in lowering their carbon footprints.
- *Allocation*. Countries tend to allocate permits free of charge or to rebate costs to sectors heavily affected by taxes, since it eases the transition to a lower-carbon investment. It does, however, lead to some windfall profits and also delays adjustments by firms. The European ETS is phasing out the free allocation of permits.
- *Startup*. Trading schemes have tended to over-allocate in the initial phase, leading to a price collapse. Banking permits can overcome this, but this only carries forward the surplus permits into the next phase. Other options include establishing a price floor with cancellation of any unsold permits; or using a fixed price in the initial phase, which would aid in the collection of emissions and cost data to better guide subsequent phases.
- *Support to carbon-intensive sectors*. Concerns about potential competitive impacts on carbon-intensive sectors will lead to lobbying for financial support to these sectors. Any support should be time-limited, and communicated as such, in order to reduce fiscal costs and provide incentives for firms to invest in less-polluting technologies.

In practice, many jurisdictions have opted for hybrid schemes, using tradable permits for the big emitting sectors and taxes for smaller sectors characterized by many actors, such as transport. Environmental taxes and levies are used in all OECD countries, raising revenues totaling 2.0–2.5 percent of GDP.

*Source:* World Bank 2010; Hood 2010, OECD 2006.

**FIGURE A.4 Coal consumption trends for China under three scenarios, 2011–2030**



## d. Sectoral considerations

Fully pursued, green development will pervade all sectors of the economy, ranging from industry and energy to the management of cities, water resources, agriculture, forestry, and biodiversity resources. Background papers prepared for this report include sector-specific studies of the issues involved in achieving green development targets by 2030.[21]

Each sector-specific paper follows a similar structure, which is to, first, indicate a vision for China 2030 consistent with its status as a high income country, and second, conduct an analysis of the issues surrounding the implementation of that vision. While each sector is very different in its challenges and targets, the recommended actions fall into the various policy packages introduced in Section 5, above. The chart at the end of this chapter summarizes the key findings of these seven sectoral background papers.

[21] The seven sectoral background papers covered: (i) Energy, (ii) Urbanization; (iii) Water Resources; (iv) Pollution and Waste; (v) Agriculture; (vi) Natural Resource Management; and (vii) Adapting to a Changing Climate. They are available on-line.

**TABLE A.2 Sector-specific recommendations for achieving green growth in China**

| Today's challenges | Short term targets and policies | Medium term targets and policies | Long term goals (by 2030) |
|---|---|---|---|
| **Energy** | **Seek cost-effective, market-based solutions using existing technologies** | **Scale up and accelerate innovation** | **Develop a sustainable, efficient, and competitive energy sector** |
| | Reduce energy sector subsidies and introduce market pricing | Scale up renewable energy in a competitive market | A greener energy mix in which renewable energy meets 30% of primary energy demand |
| | Invest in improving performance and reducing cost of existing renewable energy technologies | Cap fossil fuel consumption and deploy CCS on a large scale | Carbon emissions peak and decline |
| | Amend energy legislation and create a more effective regulatory body | Implement carbon cap and trade | Chinese energy companies are world-class businesses, operating in an open, competitive market |
| | Continue to focus on reducing energy intensity and improving efficiency | | A sound, fully functioning public regulator separate from the government focused on making policy |
| | | | China is the global leader in clean energy technologies and innovation |
| **Water** | **Use directives and market-based approaches to control water use by main sectors** | **Deepen resource governance reforms; ensure clean water supplies and sanitation** | **Achieve efficient, balanced, and sustainable use of water resources** |
| | Introduce consumption-based water allocation rights and fees for agriculture and industry | Expand water allocation right and fee programs to other major basins and industrial sectors | All major water users are covered by consumption-based allocation system |
| | Launch national rural sanitation program | Ensure safe drinking water from the tap for large cities and improved sanitation for all rural people | Safe drinking water for all urban residents |
| | Expand membership in a major river basin commission to include a wider range of water users | 60% of China's surface waters meet standards for Grades I-III | 70% of China's surface waters meet standards for Grades I-III |
| | Double efficiency of water use and achieve 50% reuse rate in industry by 2015 | Expand river basin commission membership for all major rivers; new financial mechanisms such as flood insurance | Water use efficiency reaches current high-income country average |
| | Expand payment for ecosystem services | Water use efficiency doubles again | |
| **Cities** | **Pilot new regulations, policies, and financing mechanisms to alter current growth patterns.** | **Scale up coordinated policies for land use planning, urban finance, and urban governance** | **Create efficient, liveable, and sustainable cities** |
| | Pilot new performance indicators for local officials | Roll out green growth performance indicators for local officials across the country | Urban in-fill and higher density without spatial expansion |
| | Introduce new financing mechanisms to support green growth and steer cities away from land sales | Expand fiscal support tools | Livability achieved through connectivity, strategic development corridors, and efficient transport options |

| | | | |
|---|---|---|---|
| | Pilot a flexible land conversion quota and reallocation mechanism | Create functioning urban and peri-urban land markets in several municipalities | National integration of markets of goods, capital, and labor |
| | Change regulations and standards leading to inefficient land use | Coordinate all new development and mass transit plans with urban land use zoning regulations | Low carbon status through overall resource use efficiency, bench-marked internationally |
| | Roll out market-based mechanisms to encourage efficient resource use | | |
| **Ecosystems** | **Identify and implement immediate actions needed to restore ecosystem health** | **Bring all major ecosystems under sound management and significantly reduce the costs of ecosystem degradation** | **Halt biodiversity loss and the degradation of ecosystems** |
| | Introduce targets for all natural resource management (NRM) sectors based on measures of ecosystem health | Ecosystem health targets for NRM fully incorporated and given equal weight as production targets | Integrated ecosystem landscape-scale planning with full cost and valuation data |
| | New incentives introduced for restoration of degraded ecosystems and ecosystem services, providing rural employment | All KBAs are well managed components of the national protected area (PA) system | Perverse environmental subsidies are eliminated |
| | Key biodiversity areas (KBAs) are designated and actions taken to begin management of these areas | Agrochemical and fertilizer use is halved | Biodiversity loss is halted |
| | Agricultural production targets reoriented and remediation measures taken to restore agricultural system health | Remediation actions started for farmland that is most contaminated with heavy metals | Land degradation is halted |
| | Inspection capacity is doubled and penalties are increased for illegal import or sale of native or imported wild products | Invasive species costs and illegal product trade are both halved | Health of major ecosystems is restored |
| | Urgent actions needed to protect forest health are identified and implemented in remaining natural forests | | Efficient and effective national-level PA system is in place |
| **Agriculture** | **Remove market distortions** | **Create a competitive agricultural market focused on high-value products** | **Develop modern, commercial smallholder agriculture** |
| | Reforms in support rural land rental markets | Land consolidation through improved rental markets and supporting institutions | Fully functioning land markets |
| | Limit growth of agricultural subsidies (even if WTO compliant) | Expand extension services to better manage climate change risks | Measurable share of low-carbon agriculture |
| | Reform extension services to | Scale up pilot schemes for input saving technologies | Complete coverage of low-water technologies in water-scarce areas |
| | Reform producer cooperatives | Strengthen producer cooperatives in supply chain for high-value agricultural products | |

| | | | |
|---|---|---|---|
| **Air Pollution and Waste** | **Invest in systems to control the most damaging forms of pollution and waste** | **Bring pollution to within safe limits for people and ecosystems** | **Complete coverage and attainment of pollution targets** |
| | Agree on standards for PM2.5 | Achieve Class I targets for PM2.5 in major cities | Achieve Class I targets for PM2.5 for all cities |
| | Phase out inefficient waste disposal methods, pilot new methods | Pilot air quality management plans in major cities | Complete implementation of air quality management plans |
| | Pilot incentives for efficient waste utilization | All new landfills meet international standards; incineration of municipal waste reaches 10% | High-tech monitoring of waste stream and utilization |
| | | Scale up waste utilization initiatives | |
| **Adapting to climate change** | **Improved information and understanding of climate risks** | **Mainstream climate risks into development policies** | **Develop an economy that is resilient to climate change impacts and uncertainties** |
| | Invest in weather information and warning systems | Update and enforce building codes | Fully functioning risk management and recovery mechanisms |
| | Make information on hazards accessible | Introduce financing frameworks for catastrophic risks | |
| | Identify cost-effective adaptation measures | Expand social services and support networks in vulnerable rural areas | |

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