The Environment and Sustainable "Green" Development in China
– local and global implications

Gabriel Somesfalean

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Why Green Development?

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 – 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.

The process of "going green" can itself be a source of growth.

The present development in China

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.

An economic miracle – an unfinished miracle.

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.

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.

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 May 2011, Germany announced that it would strive to be the first industrialized country to achieve a complete shift to clean energy. Japan is pushing for an additional 30% in energy efficiency gains.

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.

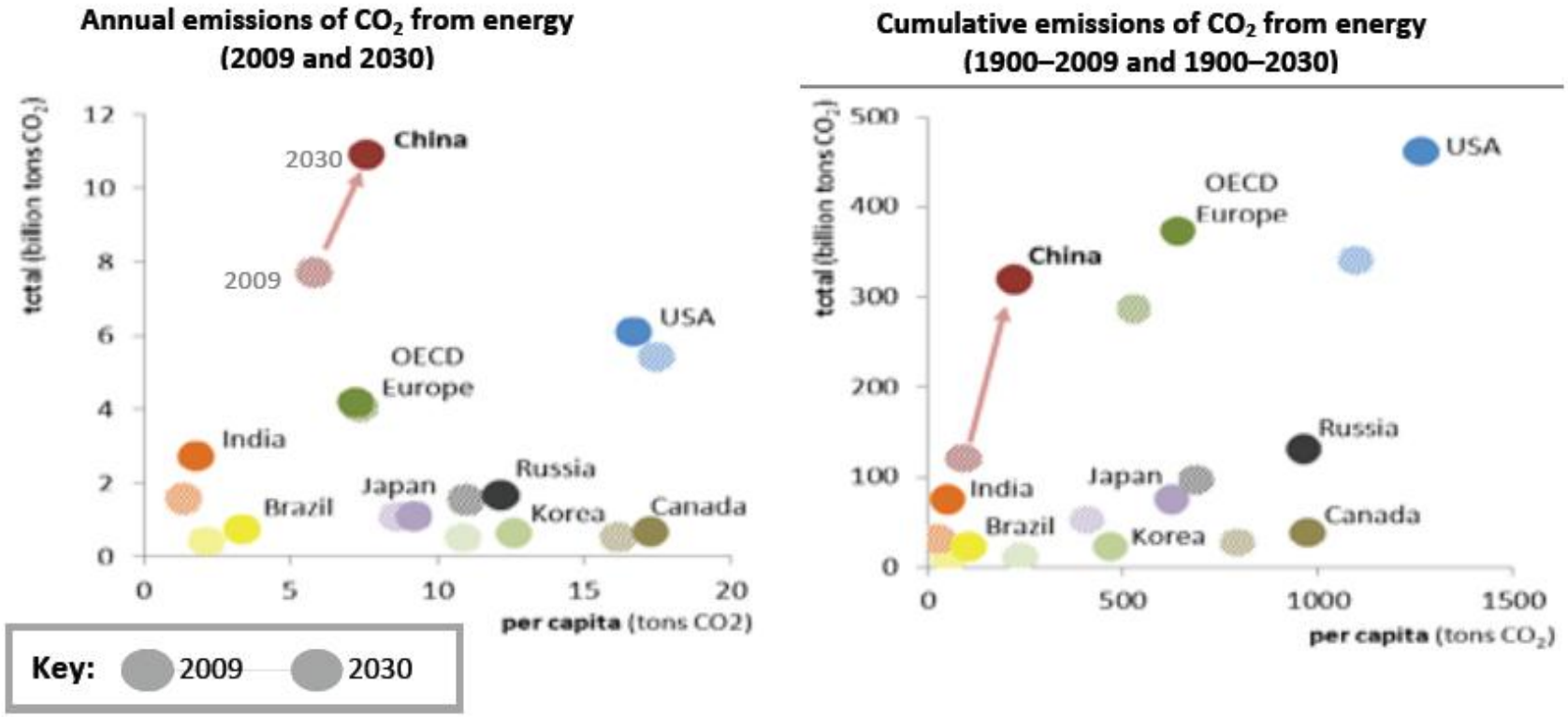
The global climate crisis

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 simply not enough "carbon space" to satisfy the emission needs of all countries if they continue to grow in the traditional mode of development.

FIGURE 1.1 Emissions of CO_2 from energy, annually and cumulatively



During the period 2006–2010, Chinese reduced the energy intensity of its economy by 20%, through strict energy conservation and emission reduction measures, even as it maintained overall economic growth of over 10% per year.

Green development is being driven by harsh economic realities, changing global priorities, and growing technological possibilities.

Traditional analysis shows that the benefits of climate change mitigation are global, while the costs local – but local environmental co-benefits.

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".

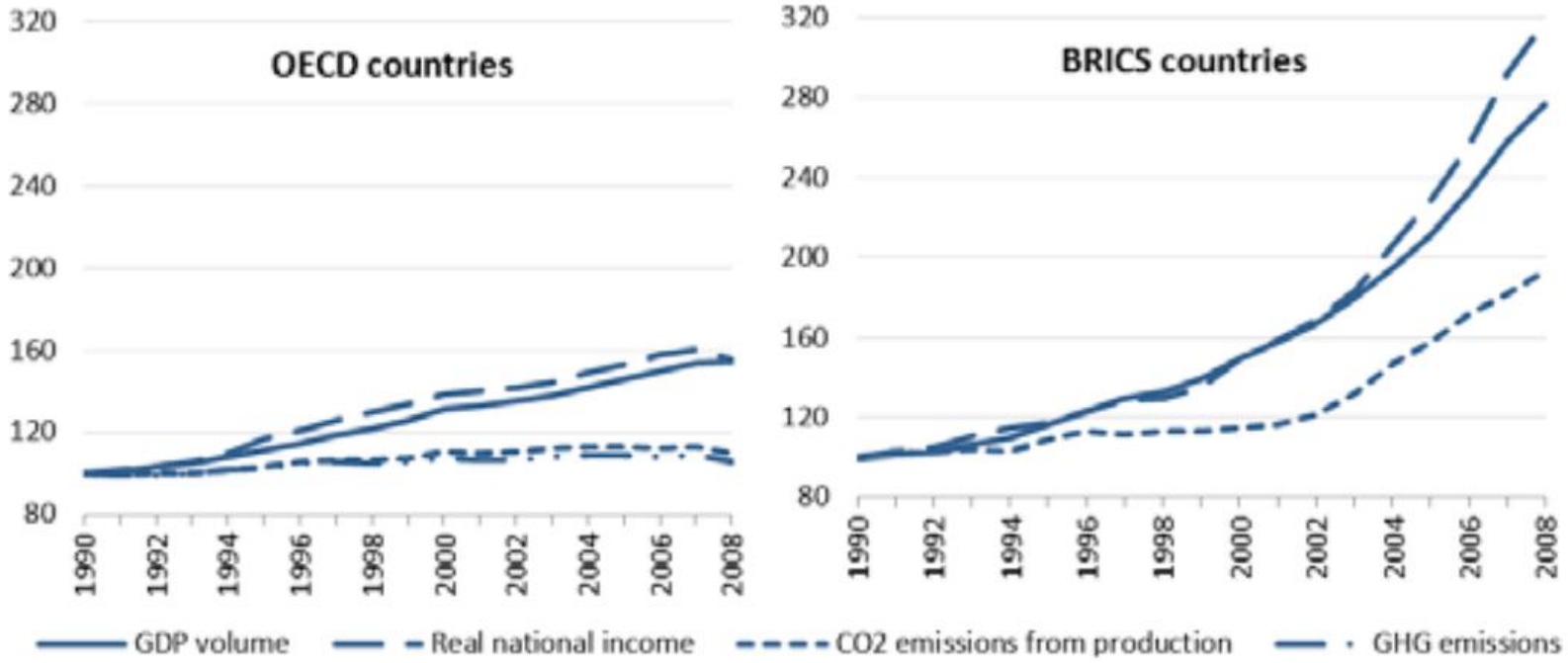
Transitioning to green development is critical to China's economic competitiveness in the future world economy.

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.

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.

The transition will span manufacturing and services, construction and transport, city development and management, and energy production and consumption.

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



Source: OECD 2011b.

China's vision for its future development

- "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.

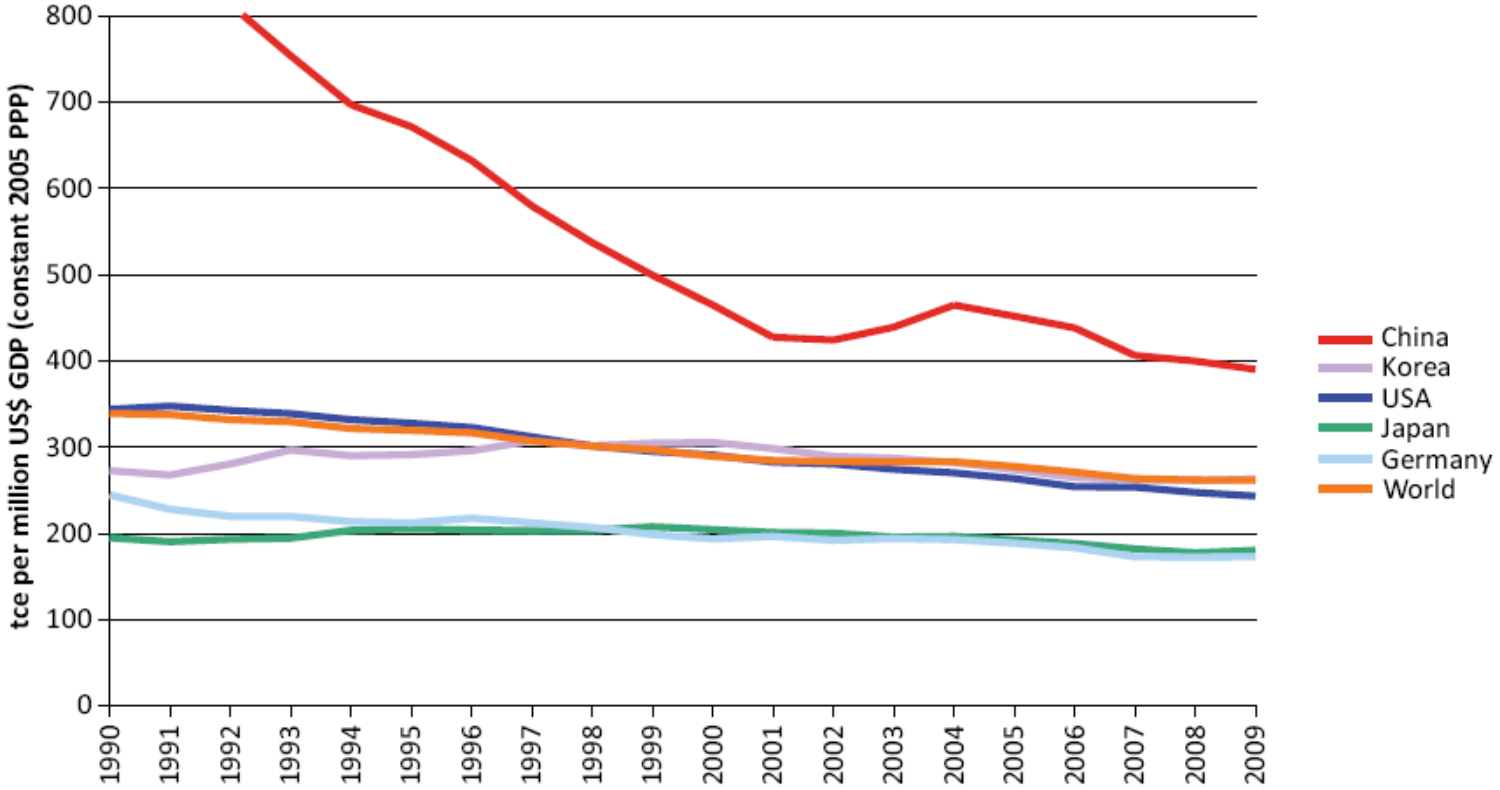
- China's cities will have low-carbon and smart transportation systems and buildings. They will be livable by international standards.
- The quality of air, water, and natural ecosystems will have improved dramatically. The recovery of the natural environment will significantly improve both public health 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.

In the past, a clean environment has too often been considered an unaffordable luxury.

Green development is primarily market-driven. High polluting, high emitting and resource-intensive products will become less competitive as their external costs are internalized.

Source 1: Green transformation of traditional sectors.

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



Source: IEA 2011.

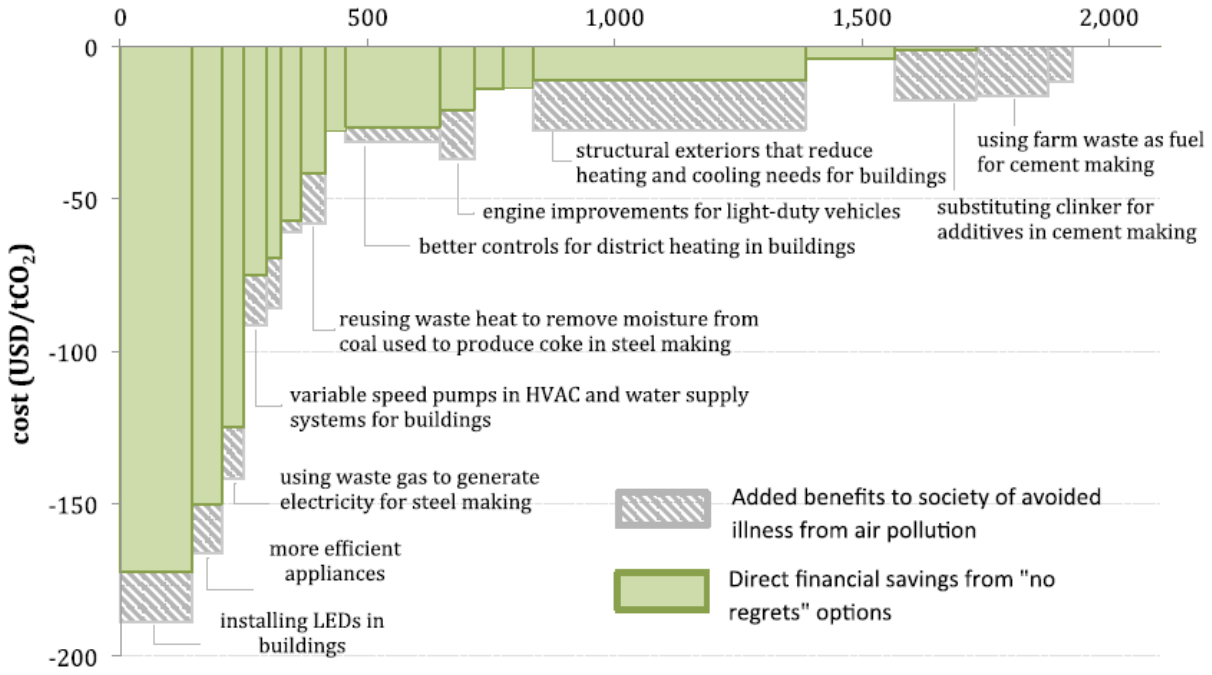
According to estimates by McKinsey & Company, installing LEDs for lighting in buildings could generate US$25 billion in financial savings per year by 2030 compared to business as usual (measured in 2009 US$). Improving passive heating and cooling in buildings through design modifications could provide another US$6 billion.

The direct benefits of these "no-regrets" options are to reduce the amount of fossil fuels burned per unit of economic activity.

"Co-benefits" that add further value to the economy:
(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
(c) reducing import dependence.

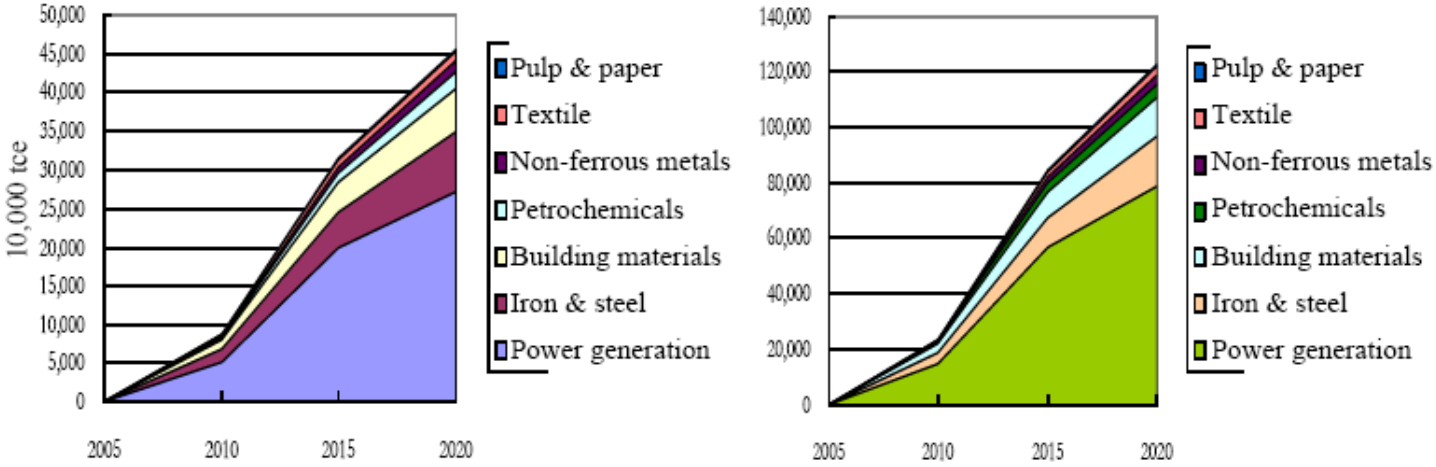
Cost-effective energy efficiency and renewable energy investments offer triple-win ("win-win-win") outcomes by trimming production costs, mitigating emissions of greenhouse gases, and improving public health risks.

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.

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

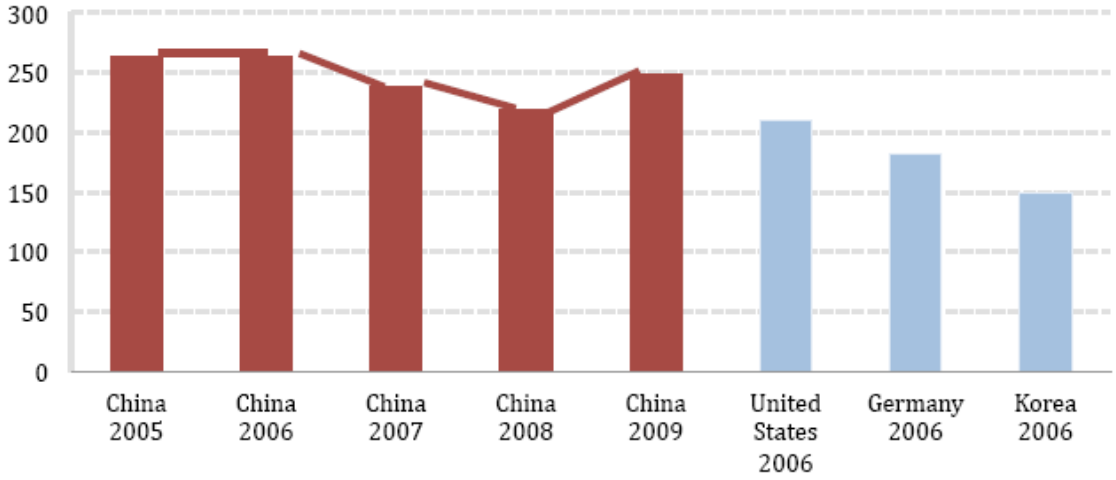


Source: Feng F. et al (forthcoming).

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.

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

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 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.

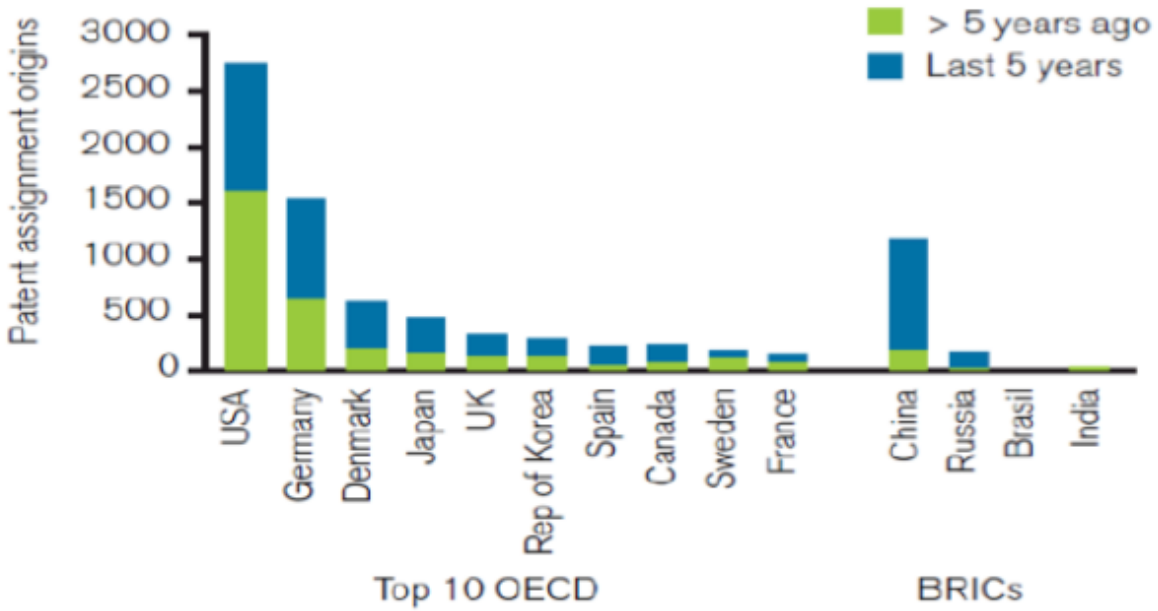
China is now the world leader in renewable energy investment, surpassing all other countries. The wind power industry alone could account for over US$25 billion per year in investment, assuming 20 gigawatts installed per year.

Relentless cost reductions and technological progress in renewable energy technologies in China have exceeded expectations, mostly due to massive scaling-up of the industry.

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).

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.

FIGURE 2.6 Patent Assignee Origins for Wind Power Technologies



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

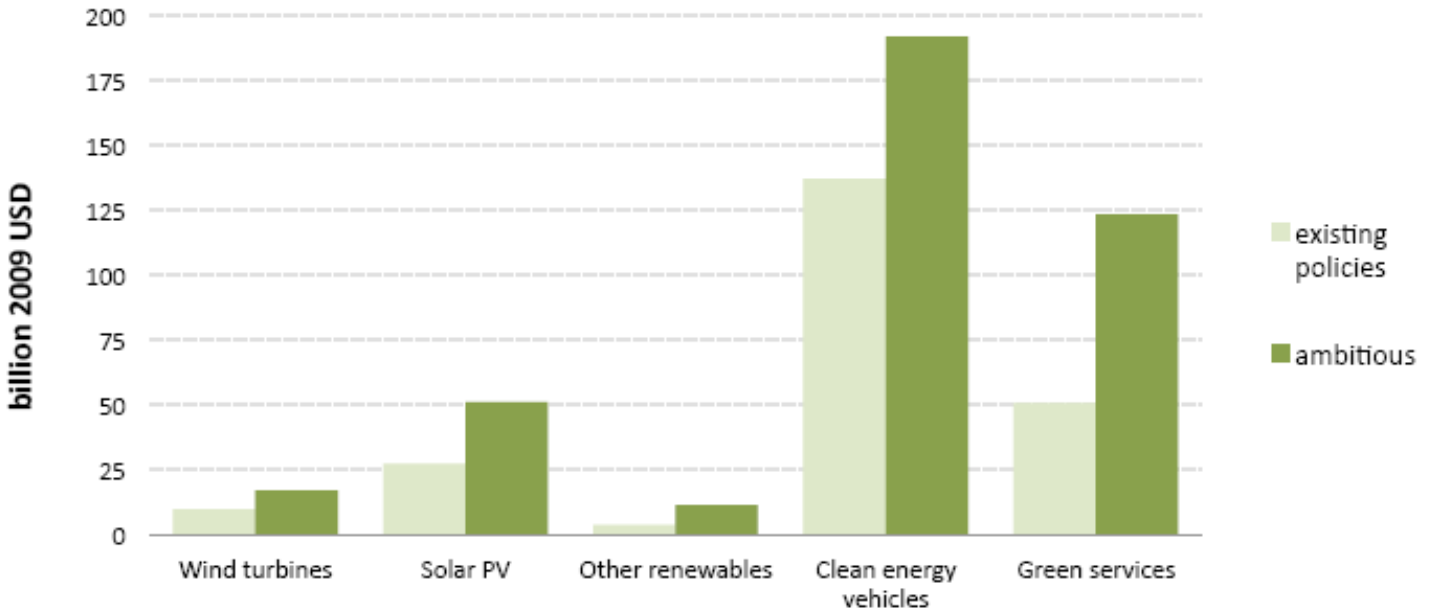
The growth of China's nascent environmental protection industry, in particular, demonstrates the important role that the state will play in promoting the growth of green sectors.

Example: Flue gas desulfurization (FGD) industry. Under the 11th Five Year Plan, the central government mandated that SO2 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 SOx scrubbers on coal-fired power plants have increased at an average rate of 34%.

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).

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 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.

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.

But "green" also implies some higher costs, industrial restrictions, and layoffs as well as government actions lead to changes in prices and production patterns.

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.

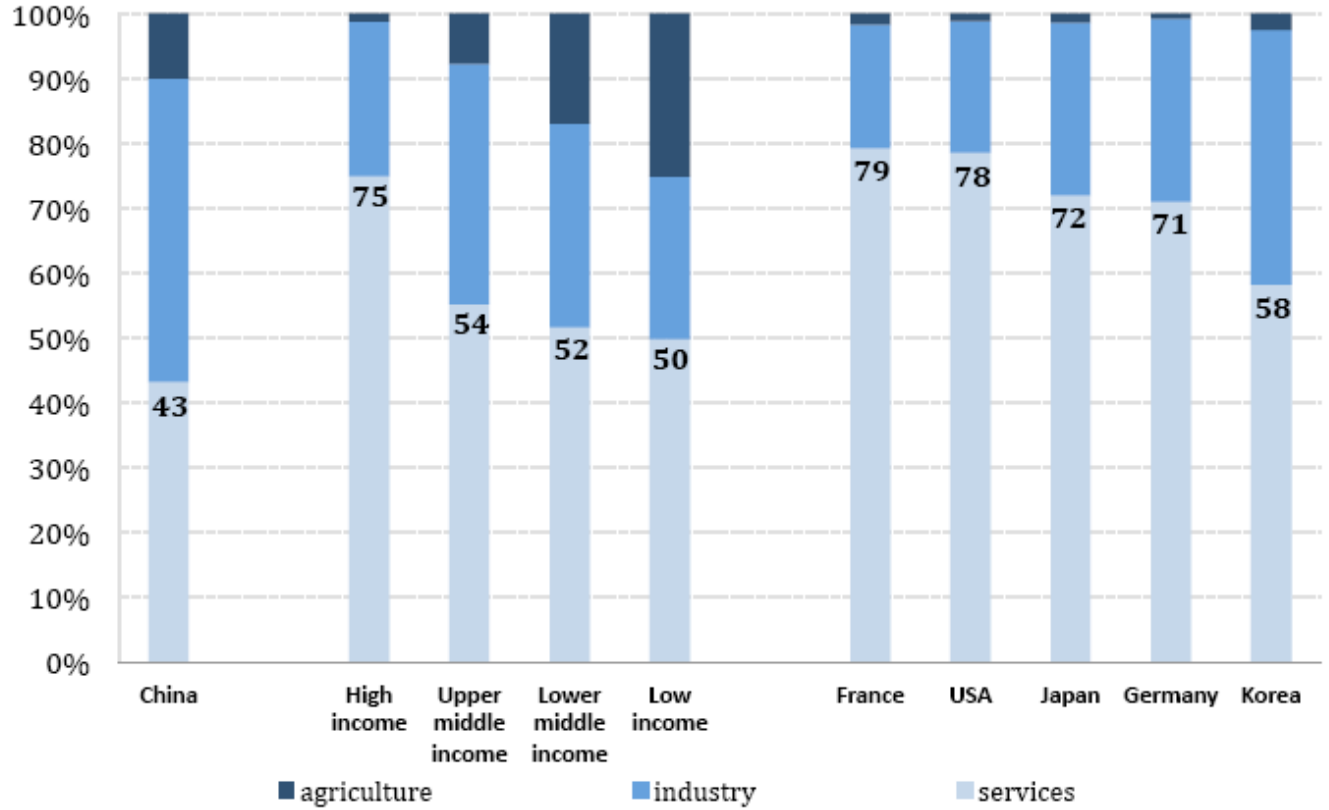
Source 3: Expansion of the service sector.

Examples of such services are ecosystem services, carbon asset management services, carbon trading, and contract energy management.

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.

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).

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.

There are several reasons why the share of services in China's economy is low:

- 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.
- 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.

- 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.

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 some estimates, the energy intensity of output (value added) by secondary industries in 2009 was eight times higher than agriculture.

Every percentage point increase in the share of services in GDP is associated with a decline in energy consumption of 1.4 percentage points.

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.

Reasons why the interior provinces should avoid the conventional (and environmentally degrading) growth path of the east:

- the ecological environment of the interior provinces is relatively fragile compared to the east, and the costs of "clean-up later" would be prohibitive.
- 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.
- 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.
- with rapid expansion of cities onto increasingly scarce land, the national government has imposed stricter controls on the use of land for industry.

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.

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.

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.

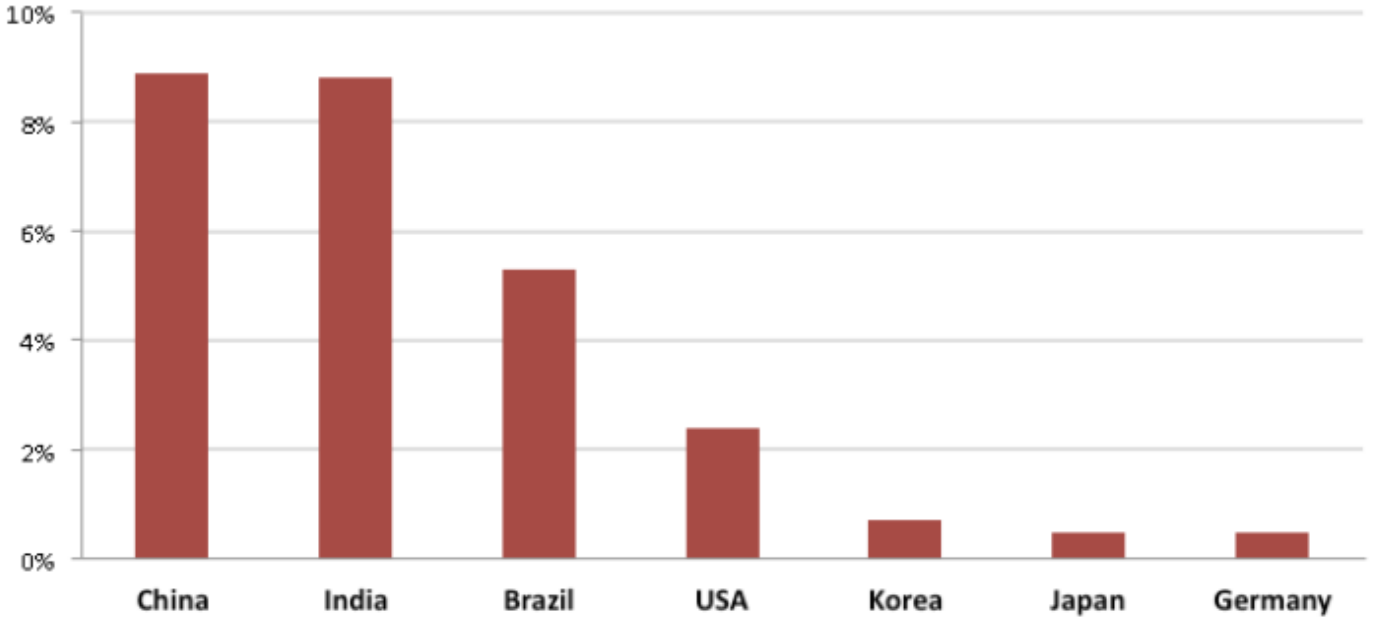
Farmers in some poor parts of China have already transitioned from selling timber to marketing ecosystem services to earn a living.

"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. 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.

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. The experience of Japan shows that stringent environmental policies do not interfere with economic growth. In fact, they may even catalyze growth.

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.

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.

TABLE 3.1 A Greener China

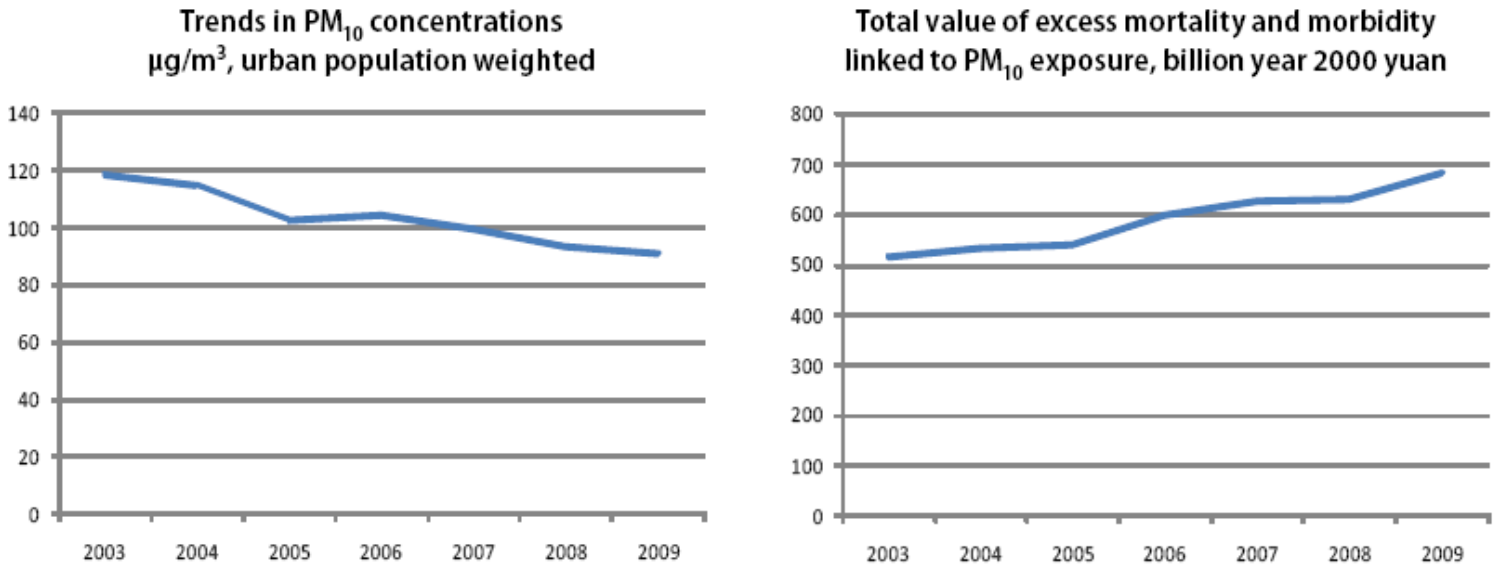
Environmental depletion and degradation, all number are % of GNI	2009 value	"Greener" value, reachable by 2030	Net improvement
Energy depletion	2.9	1.9	1.0
Mineral depletion	0.2	0.2	0.0
PM_{10} health damage	2.8	0.1	2.7
Air pollution material damage	0.5	0.1	0.4
Water pollution health damage	0.5	0.1	0.4
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.

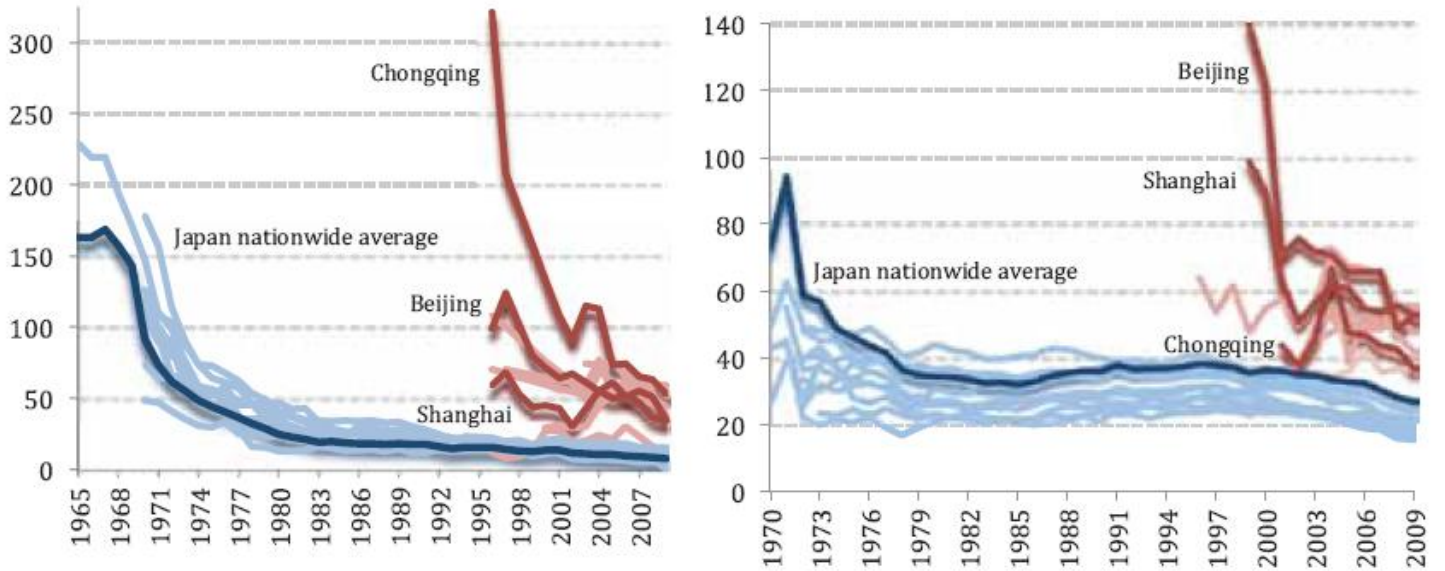
China currently faces one of the world's highest current and projected burdens of environmental disease linked to urban air quality. Trends in urban air pollution are improving, but the impact on health is still extremely large, nearly 3 percent of GNI in 2009.

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)**



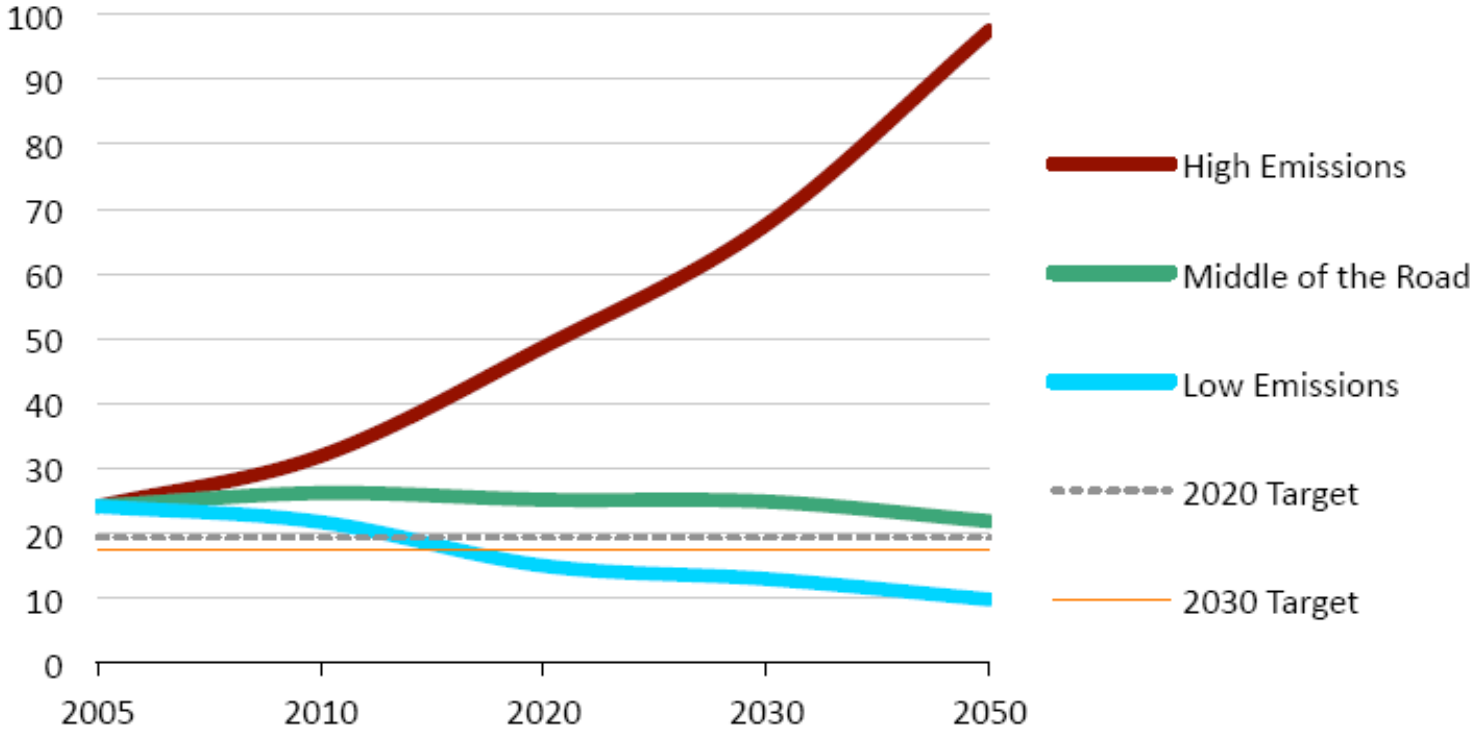
Notes: Includes ten largest cities in Japan by population in 1970; 10 largest cities in mainland China by downtown population in 2009 (excluding Dongguan city, Guangdong).
Sources: NIES database, Japan Ministry of Environment (1989), Kawasaki Air Pollution Monitoring Center; NBS, China Environmental 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+.

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".

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.

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



Source: MEP and CAE 2011.

Land degradation presents a similar problem of scarcity. Heavy use of agrochemicals, combined with pollution from cities and industry has degraded soil quality. Heavy metal contamination of farmland is a serious issue raising concerns that these pollutants can make their way into the food chain.

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.

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.

Environmental co-benefits of green development

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**

- 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.

The benefits of investing in environmental protection

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.

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.

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.

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.

China's climate is already changing, and changes will accelerate.

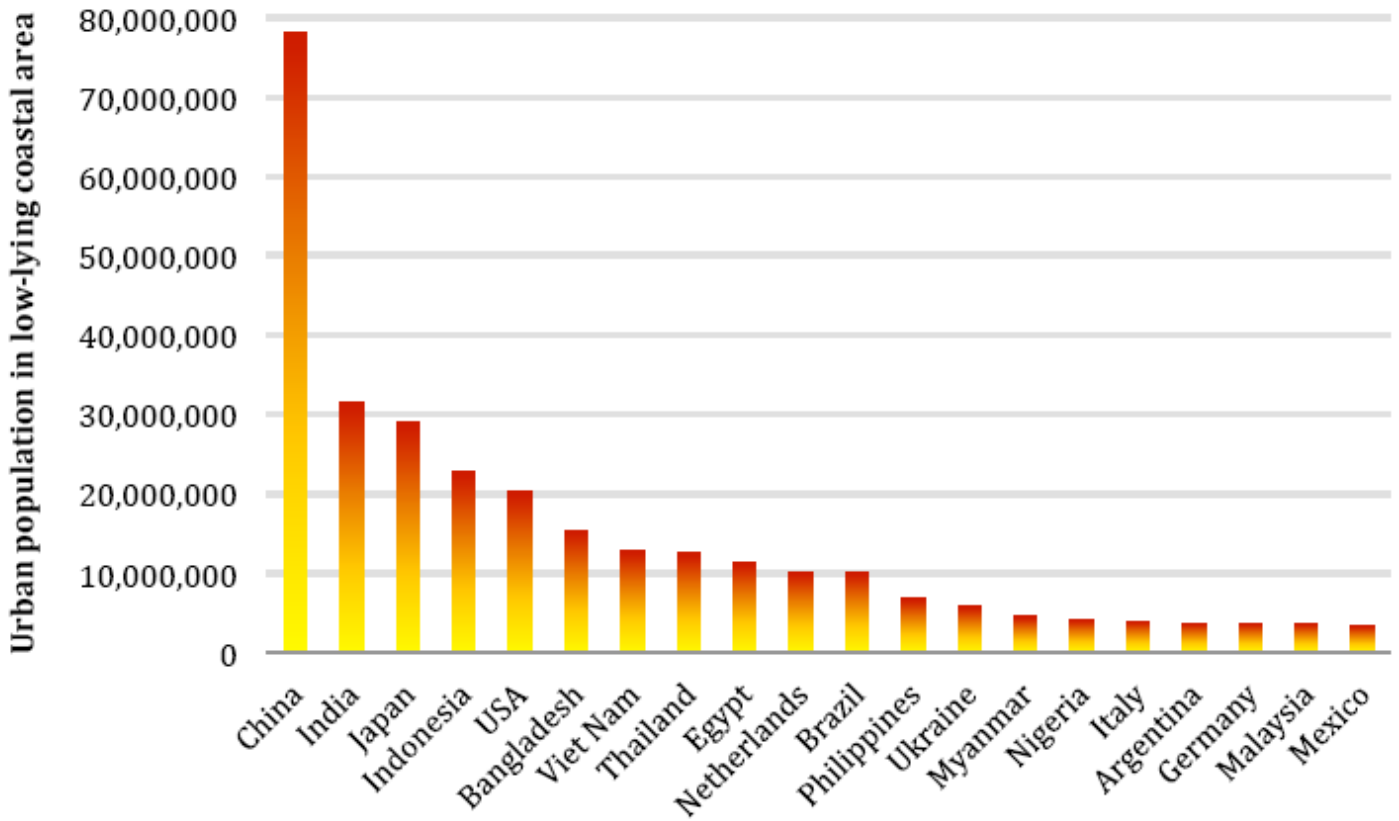
Among the observed effects of climate change are: average annual surface temperatures increased by 1.1˚C over the last half of the 20th century for the country as a whole, and much faster in the north and northeastern provinces.

The number of rainy days has decreased for most regions, and more precipitation has come from shorter, more intense storms. The area of cropland exposed to drought has also increased for many regions. 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.

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. The concentration and value of productive capital and valuable infrastructure increases in these areas, and so do potential damages.

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.

Factors Favoring and Impeding Green Development in China

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

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.

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 Comparison on selected indicators for China and developed countries

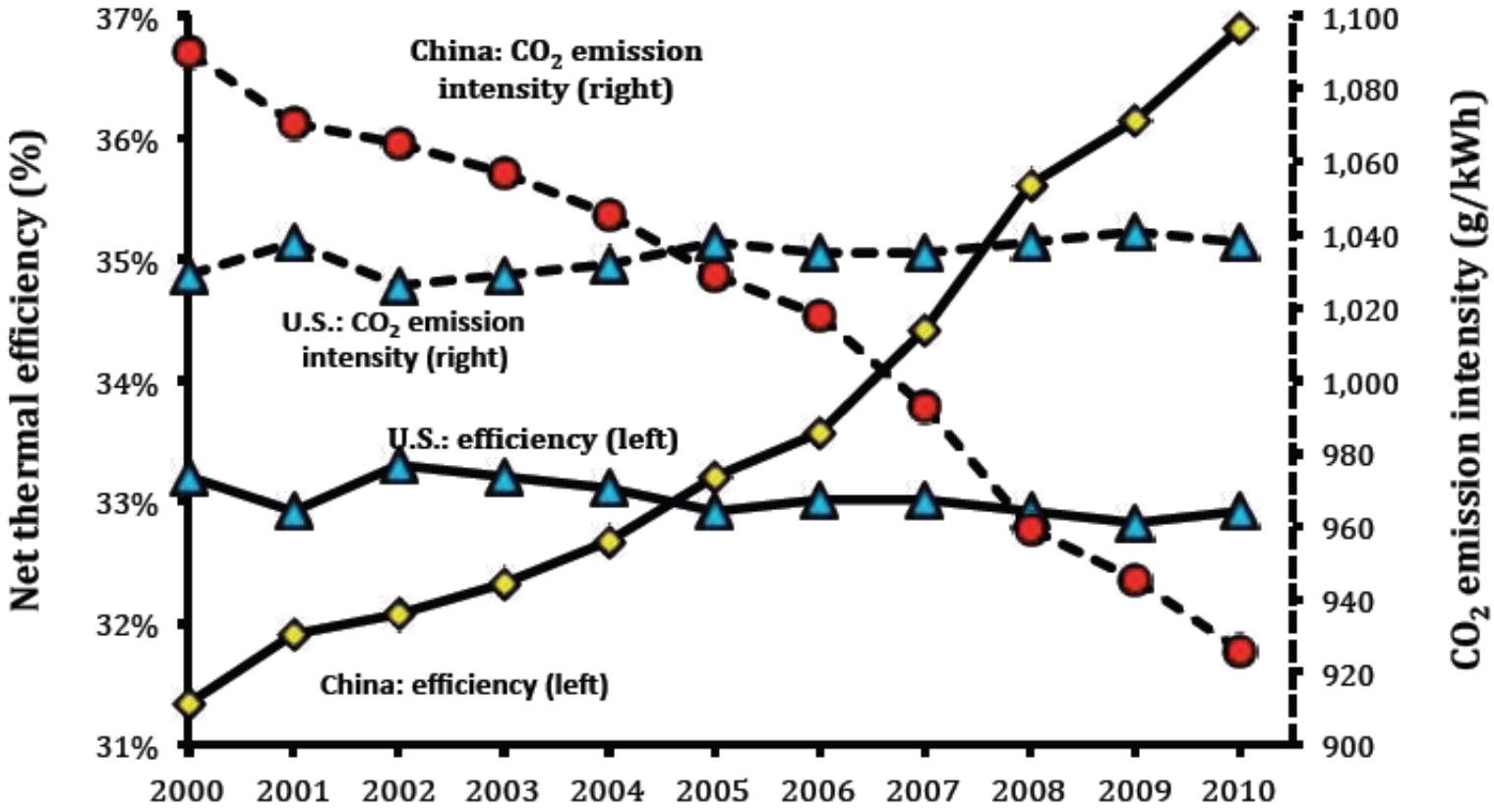
	China	U.S.	Japan	OECD
Per capita GDP (US$, 2010)	4,393	47,184	43,137	34,673
Per capita gasoline consumption (2008)	1.60	7.50	3.88	4.50
# of automobiles per thousand population (2008)	27	451	319	391
Per capita transport gasoline consumption (kg oil, 2008)	0.05	1.15	0.33	0.48
Urbanization Rate (%, 2009)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

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

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.

Leap-frogging certain technological stages into the most efficient and greenest options will require early strengthening of incentives.

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



Source: Yuan Xu et al (2011) .

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 "firstmover advantages". The rapid expansion of both wind power and solar photo-voltaics.

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.

China's solar photo-voltaic (PV) industry

China is already the lowest-cost producer of solar panels in the world. 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.

Abundant capital (including human capital) to invest in green sectors.

China has traditionally enjoyed high rates of savings and investment; 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.

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.

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.

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.

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.

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.

Potential to avoid the lock-in effects of higher levels of urbanization.

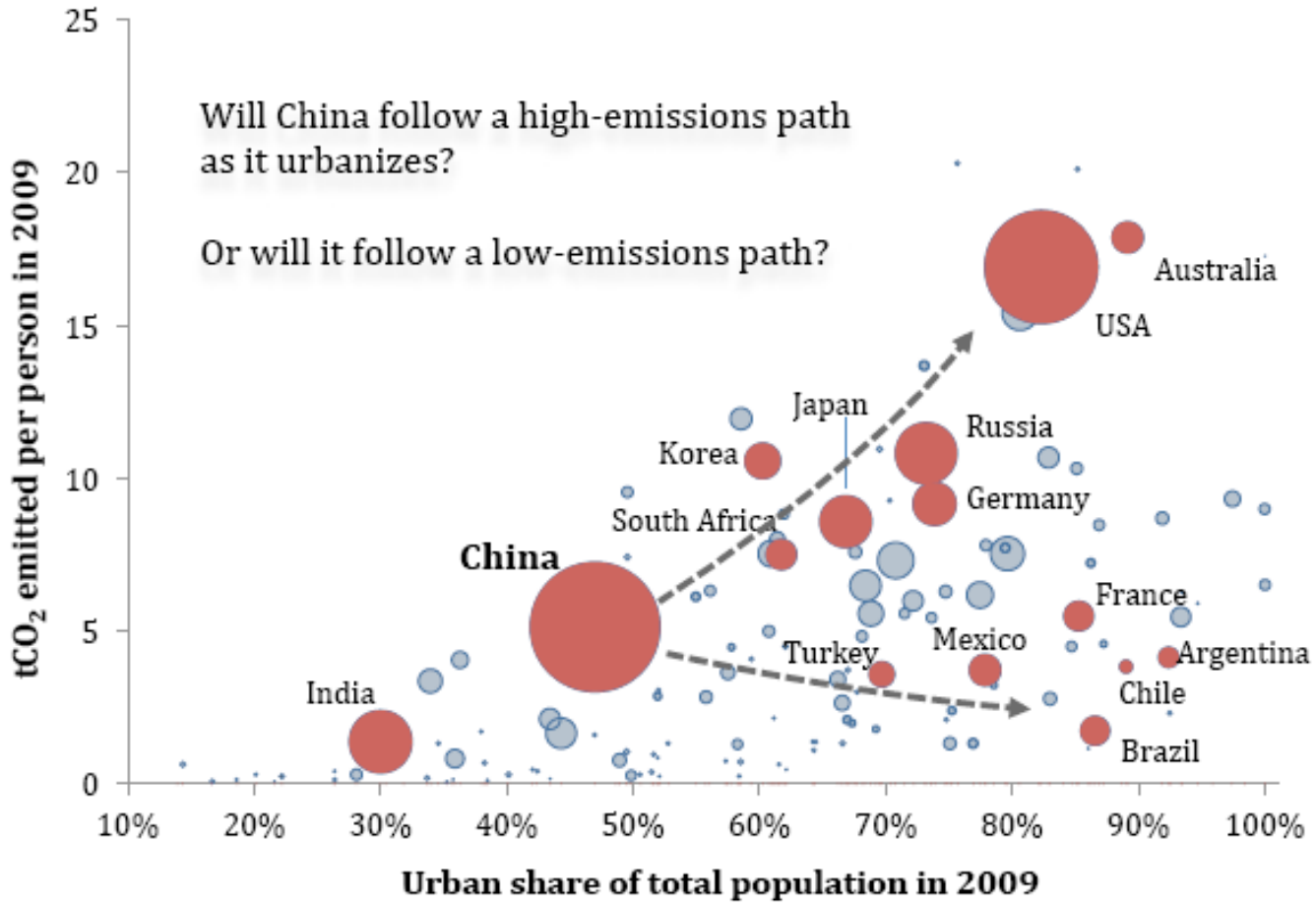
Although China's current level of urbanization is low (47.5 percent) compared to high-income countries, this will change. During the 12th Five-Year Plan period (2011–2015), the country is expected to invest US$ 300 billion in basic infrastructure. According to UN estimates, by 2030, about 65 percent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

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 CO2.

Similarly, commercial and residential building design will largely lock-in energy needs for the life of the building. An electric generation plant has a lifetime of 30–40 years; its carbon footprint is fixed at the time it is built.

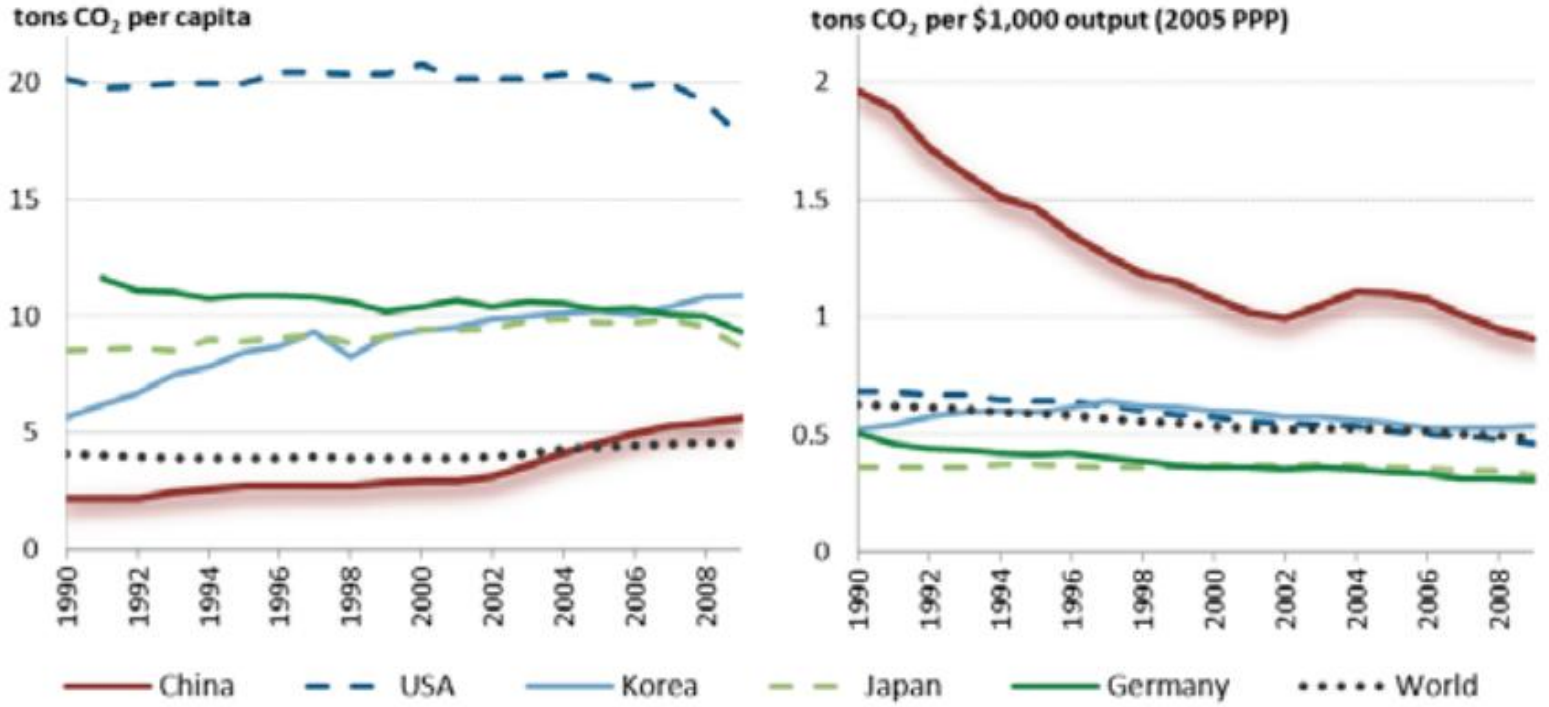
Only if China adopts green development policies sooner rather than later will it capture "lock-in" benefits of efficient buildings, cities, transport systems, and industries that use low-carbon, environmentally friendly technologies and standards.

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.

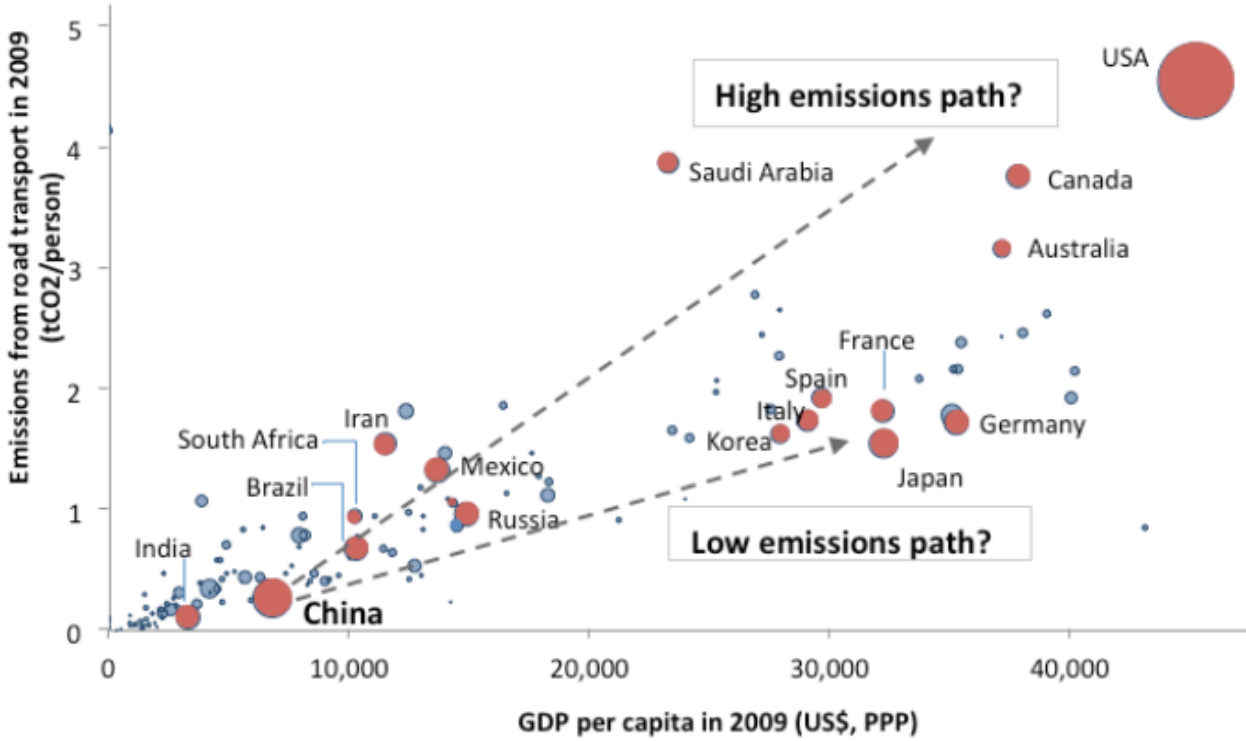
FIGURE A.2 **CO_2 emissions per capita and per unit of GDP, 1990–2009**



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

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.

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



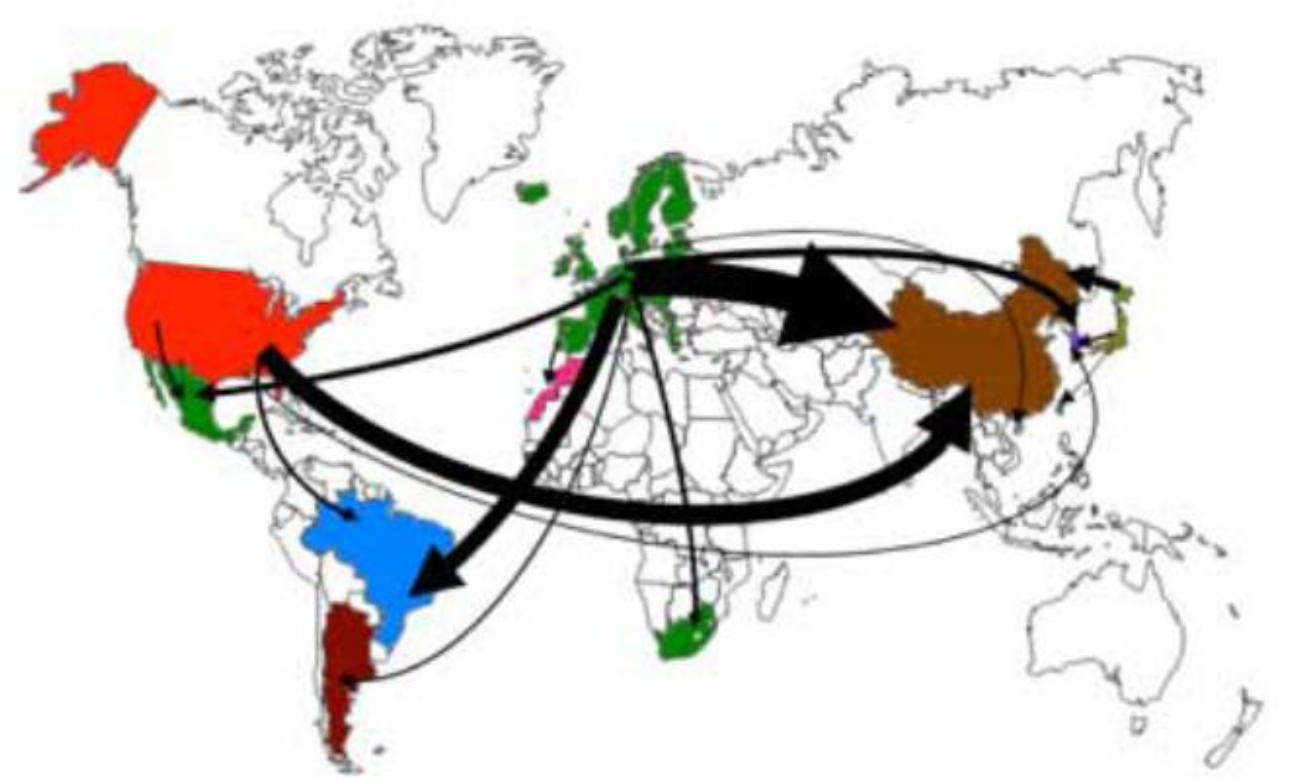
Source: World Bank, based on IEA World Energy Statistics and Balances, World Bank World Development Indicators.
Note: Bubble size corresponds with total annual CO_2 emissions from road transport.

A destination for global investments and R&D.

These advantages, coupled with China's manufacturing capabilities, make China an excellent location for investments in many global green technologies. 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



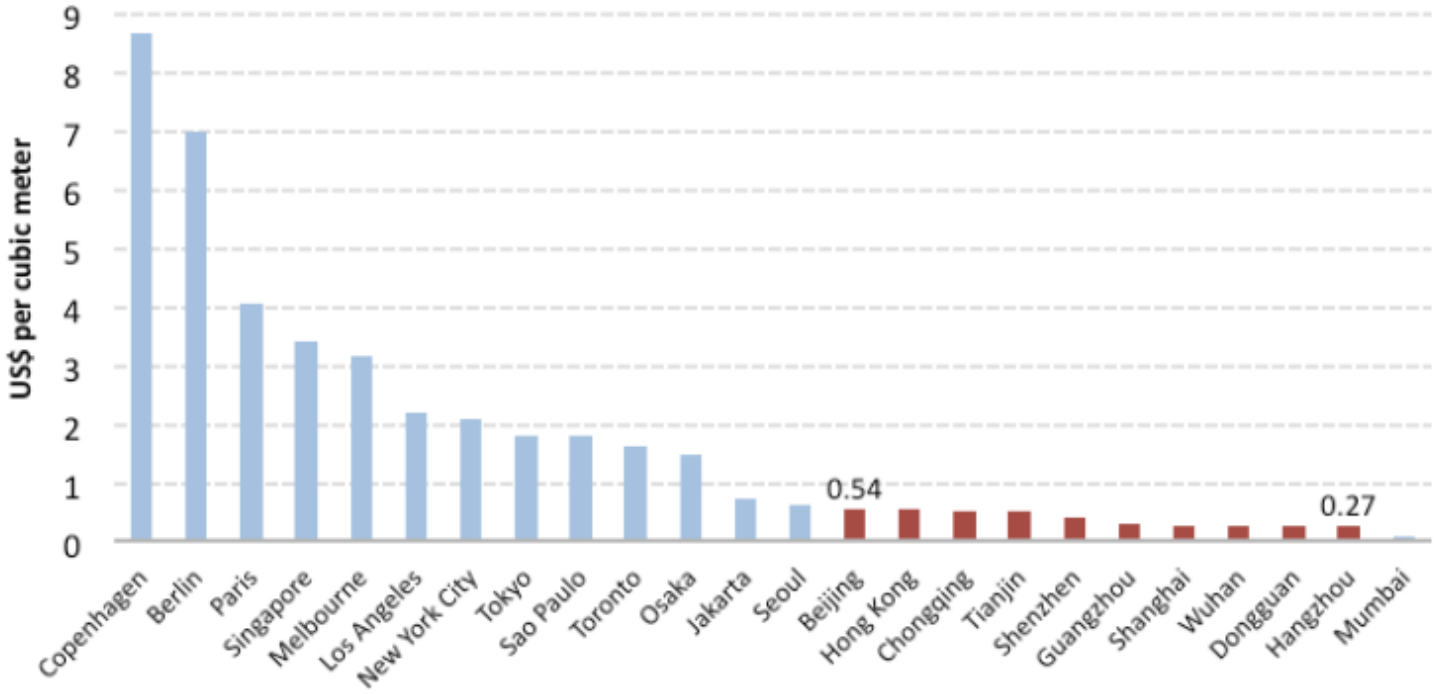
Note: this figure illustrates the transfer of technologies from Annex I countries under the UNFCCC to non-Annex I countries, as measured by duplicate patent filings for wind power technologies in non-Annex I countries.
Source: OECD 2010.

Factors impeding green development

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.

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).

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.

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.

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.

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.

Similar to land, China's water resources management system lacks incentives to promote efficiency at the scale required. Low 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.

Fourth, lack of a competitive market environment for green industries. 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. 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.

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. 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.

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.

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, 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 other types of power.

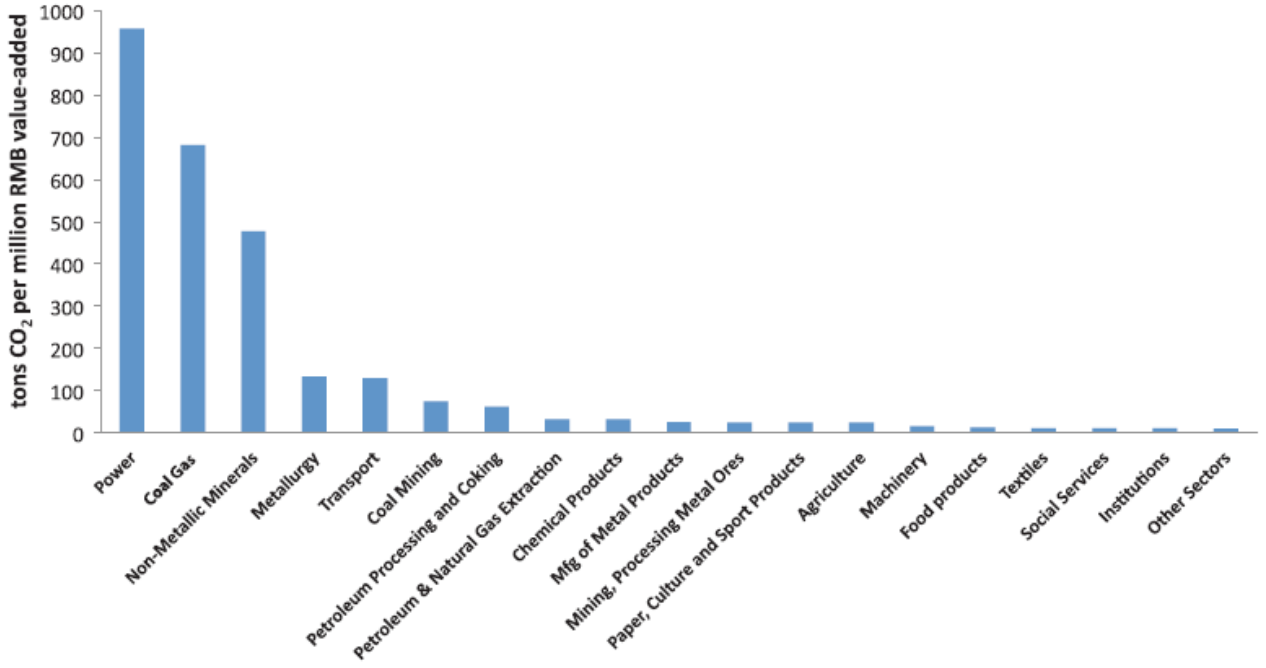
Sixth, weak monitoring and enforcement of standards, especially at the local level.

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.

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.

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.

FIGURE A.1 **Indicative sequencing of green development reforms**

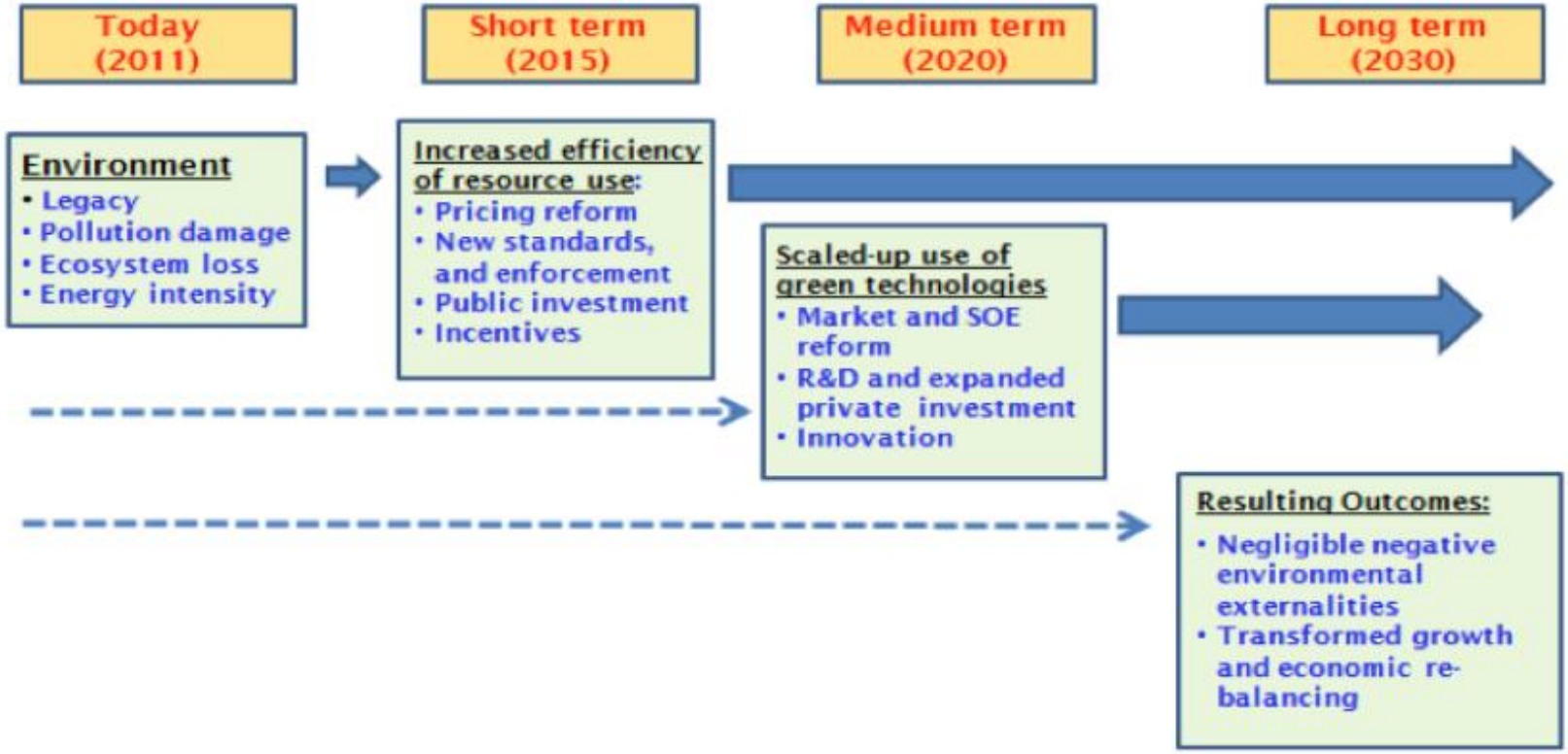
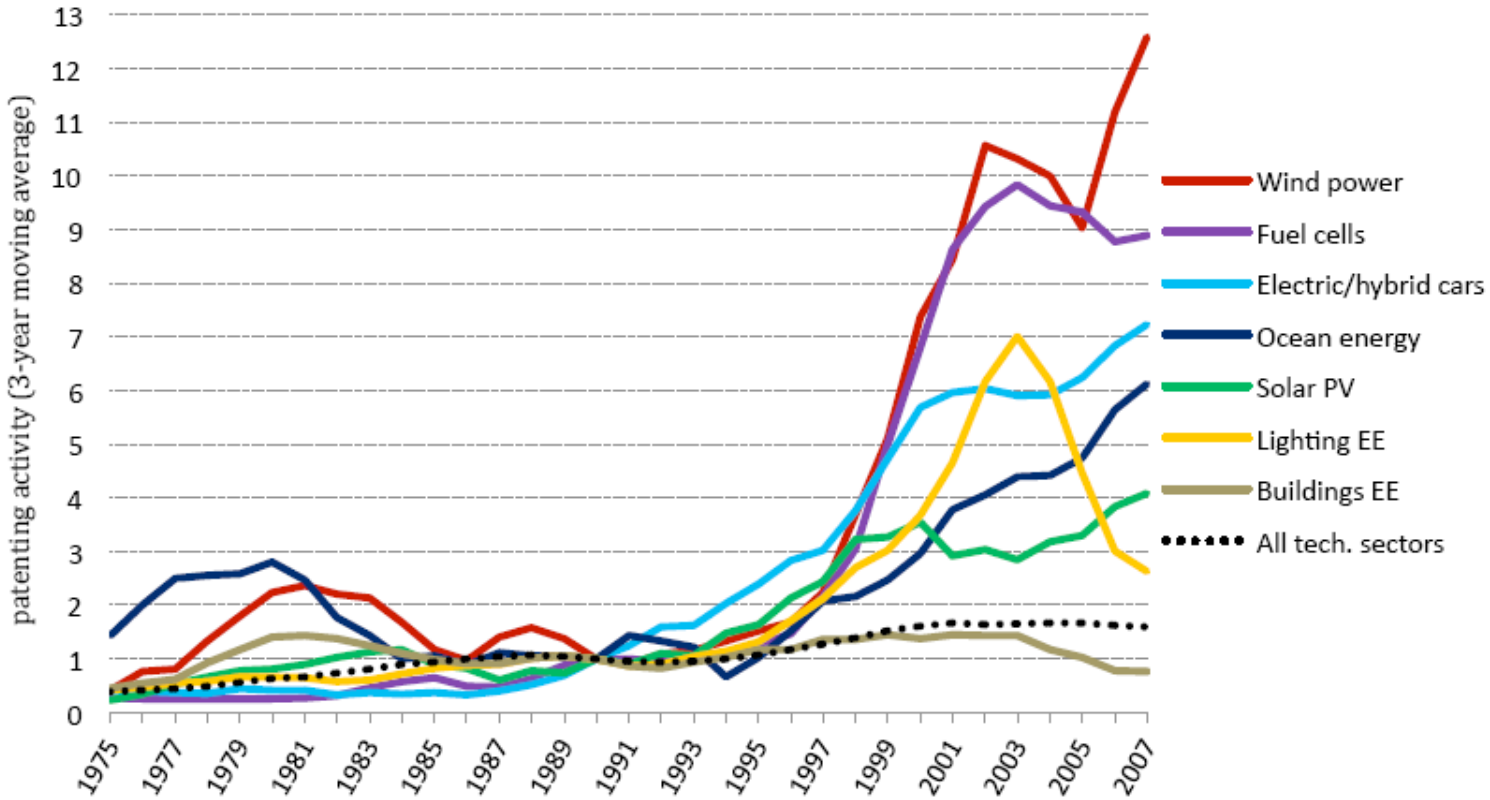


FIGURE 2.1 **Index of innovation in climate change mitigation technologies (1990 = 1)**



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.