Goldman Sachs

Sustainable Growth in China: Spotlight on Energy

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Rapid growth has created an enormous demand for energy

The rapid pace of economic growth in China has raised concerns about the country's large consumption of energy and the environmental impact. The transition from an agricultural- to an industrial-based economy has meant that growth is extremely energy-intensive. At the same time, industrialization raised working wages, helping spur the growth of the Chinese middle class as the population continued to urbanize; these demographic changes have created an additional boost in energy demand. Consequently, energy use increased by more than 150% during the past ten years and China became the world's largest consumer of energy by 2010, surpassing the United States. The country's energy demand is expected to continue on an upward trajectory.

Coal remains the dominant source of energy

This rise in energy demand has primarily been met by "dirty" sources, particularly coal, which accounted for roughly 70% of the country's energy use in 2011. China is both the world's largest producer and consumer of coal. In order to diversify the country's fuel mix, the Chinese government has announced plans to encourage the development of alternative sources, such as nuclear and hydroelectric. China aims to fulfill 15% of its energy needs with non-fossil fuels by 2020, up from 8.3% in 2010. As a result, renewable energy is a major area of investment. This steady stream of investments, along with the supportive policy environment, has helped China become the global leader in clean energy capacity in 2011. However, despite the focus on alternative energy sources, they remain overshadowed by capacity from thermal (i.e., carbon-based) sources.

Increasing government focus on sustainable growth leads to opportunities for key strategic industries

The 12th Five-Year Plan (FYP), which covers the years 2011 to 2015, emphasizes achieving growth in an environmentally sustainable manner. It includes targets to improve energy efficiency, as well as ambitious goals to increase renewable energy capacity. However, these national targets rely on implementation by provincial officials who tend to prioritize economic growth over environmental targets. The 12th FYP also outlines strategic emerging industries, including clean energy technology and alternative energy, which are expected to benefit from the favorable government policy.

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Rapid economic growth has raised environmental concerns

Driven by industrialization, China has had remarkable economic growth.

Beginning in the late 1970s, China embarked on a series of economic reforms to encourage growth, including efforts to promote investment in industrial production and to liberalize foreign trade. These initiatives have helped the country average double-digit real GDP growth over the past several decades, propelling China to become a major force in the global economy. In the past decade, China accounted for roughly 30% of the increase in worldwide GDP. In 2010, it surpassed Japan as the second largest economy. China, despite recent deceleration, continues to be the world's fastest-growing large economy.[1]

The rapid growth has led to environmental damage like air pollution and water shortages.

The robust pace of industrial growth has created an enormous demand for resources. For example, energy use increased by more than 150% during the last ten years. During this period, a policy and public focus on economic growth outweighed concerns about environmental and conservation issues. This has begun to change in recent years: overuse and heavy contamination of the water supply have led to scarcity concerns, while air pollution has become a serious health issue, particularly in major Chinese cities.

China will need to address these sustainability issues as it strives to maintain long-term economic growth.

These are critical issues China will need to address as it strives to maintain long-term economic growth. In this paper, we focus on the role of energy in China's growth story. We intend to discuss other important areas, including water and the impact of pollution, in subsequent reports.

[1] The Goldman Sachs economics team has highlighted the Chinese growth story in their BRICs (Brazil, Russia, India, and China) work. For example, see the first piece on this topic, 'Dreaming with the BRICs: The Path to 2050', *Global Economics paper No. 99,* October 1, 2003.

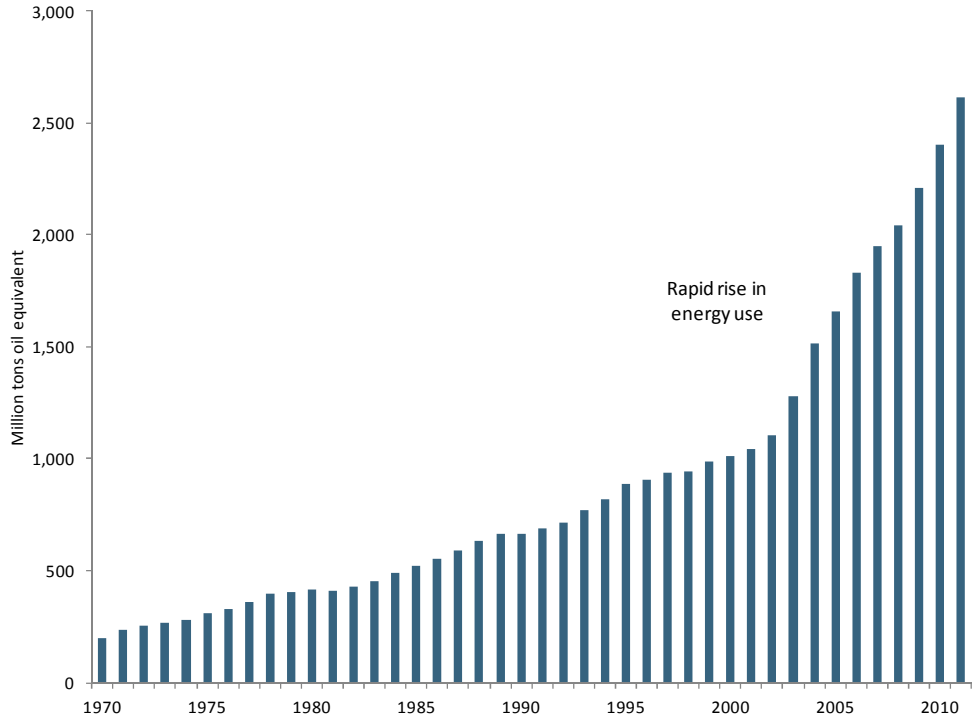
Energy: a critical part of China's development

Industrialization and the rising middle class have spurred an enormous demand for energy.

The industrialization of the economy in China, in combination with the rise of the middle class, has led to a rapid growth in energy consumption. As the share of industrial activity in the Chinese economy increased, the need for energy grew as well. At the same time, as industrialization raised wages, the Chinese middle class rapidly expanded, increasing from 10% of the population in 2000 to 40% in 2010. The rising prosperity of the increasingly urban population has created an additional boost in energy consumption.

As a result, Chinese energy demand rose dramatically, in particular over the past decade (see Exhibit 1). Between 2001 and 2011, China's share of global energy use nearly doubled, rising from 11% to 21%. It surpassed the United States to become the world's largest energy consumer in 2010.

Exhibit 1: Energy is a critical part of China's development
Energy consumption has increased dramatically, in particular over the past decade



Source: BP Statistical Review of World Energy 2012.

Much of the energy needs in China are met with "dirty" sources, in particular coal.

Currently, much of the country's energy needs are fulfilled through "dirty" sources (i.e., emissions-intensive sources), in particular coal. As the Chinese government endeavors to diversify the country's fuel mix, the development of alternative energy, such as nuclear and renewables, will be encouraged. However, these alternative sources are small parts of the consumption mix today and it will take time to build up the necessary capacity to meet China's vast energy demand. As a result, the abundance of domestic coal reserves means that coal will likely remain the dominant energy source for years to come.

The growing Chinese demand for energy

China is the world's largest consumer of energy.

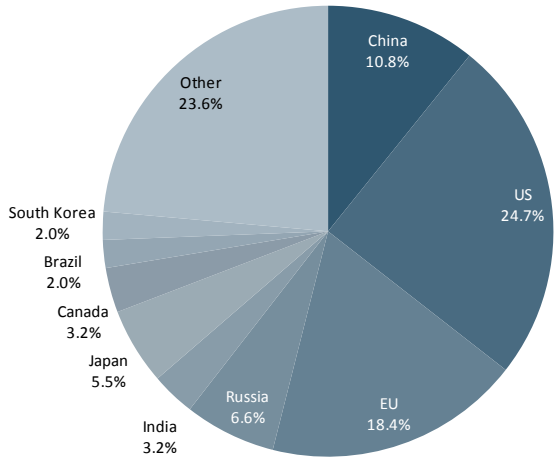
China is the world's largest consumer of energy, accounting for approximately 21% of global energy use (see Exhibit 3). In 2011, China's energy use reached 2,613 million tons of oil equivalent (Mtoe), surpassing that of the long-time leader, the United States, by 15% (see Exhibit 4). The energy use of the European Union in aggregate that year was just 65% of China's consumption. This breakdown looked significantly different a decade ago: in 2000, energy use in China was less than half the consumption in the United States and 40% lower than the levels in the EU (see Exhibit 2).

China's energy use today also readily surpasses that of other emerging economies (see Exhibit 4). In 2011, energy consumption in China was nearly ten times that of Brazil and close to five times the levels in India.

An additional way of viewing China's vast demand for energy is to contrast its consumption against a similar-sized economy. For example, in 2010, the GDPs of China and Japan were roughly equivalent but Chinese energy consumption exceeded Japan's use by about five times. There are several factors explaining the enormous gap in energy use between the two countries, including the differences in growth rates and economic structures. We address these later in this section.

Exhibit 2: US was the largest user of energy in 2000…
Breakdown of global energy consumption in 2000

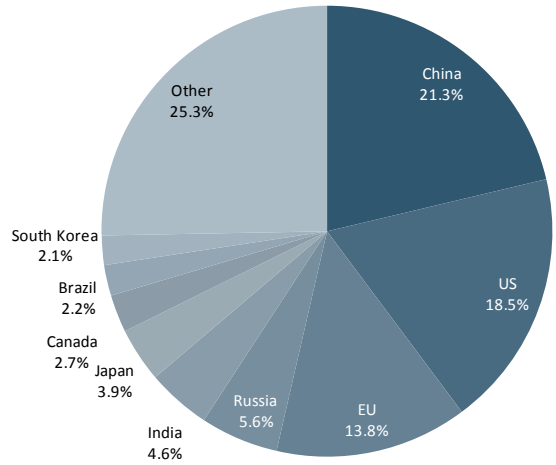
Total use in 2000: 9,355.6 million tons of oil equivalent



Source: BP Statistical Review of World Energy 2012.

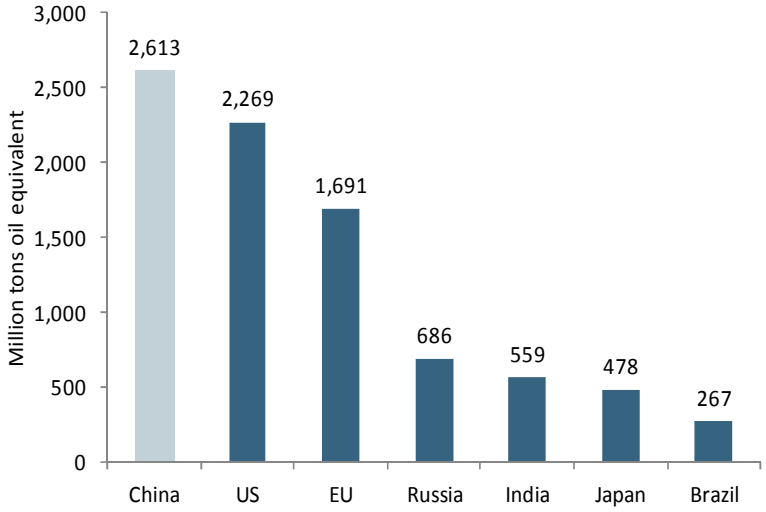
Exhibit 3: …China is now the global leader in energy use
Breakdown of global energy consumption in 2011

Total use in 2011: 12,274.6 million tons of oil equivalent



Source: BP Statistical Review of World Energy 2012.

Exhibit 4: Energy use in China exceeds that of the US
Energy consumption levels of selected nations (2011 data)

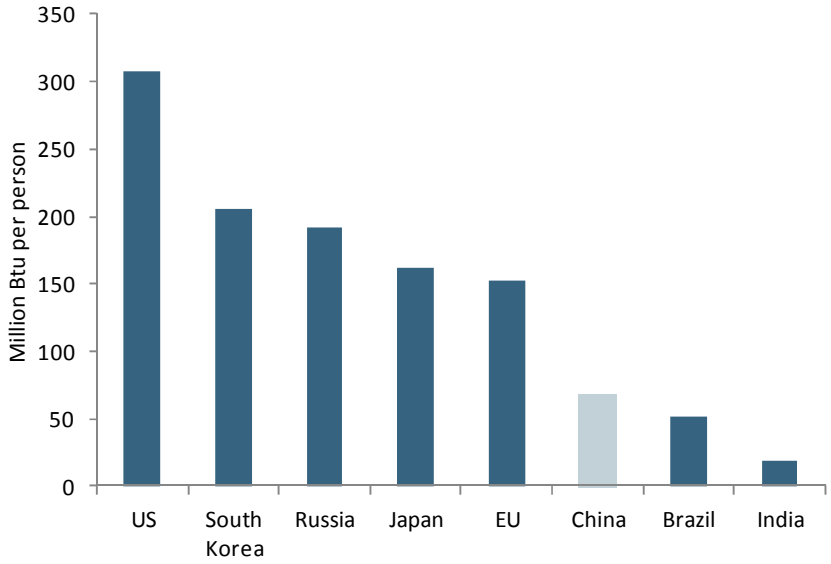


Source: BP Statistical Review of World Energy 2012.

Per-capita energy consumption in China is relatively low compared to developed economies, but is rising rapidly.

Given its vast population, China's consumption level on a per-capita basis is quite low. In 2009, the Chinese energy consumption per capita was just 20% of the per-capita use in the United States and about 40% of the per-capita consumption in Japan. See Exhibit 5. Over the past decade, however, the per-capita use in China has risen sharply; between 2000 and 2009, energy consumption per person grew by over 130%. As is discussed in the next section, China's energy use is relatively inefficient, especially when viewed in the context of economic output.

Exhibit 5: Per capita energy consumption in China is relatively low
Per capita energy consumption levels of selected nations (2009 data)



Source: US Department of Energy, Energy Information Administration (EIA).

The robust energy demand in China has been primarily driven by two factors: the industrialization of the economy and the rise of the Chinese middle class.

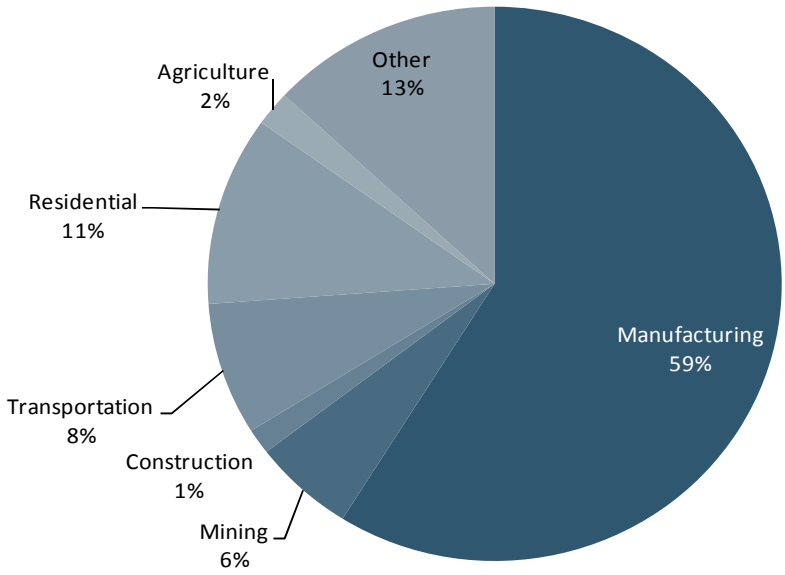
Key drivers of energy demand

The industrial sector is both the primary engine of growth and the largest consumer of energy.

1. Industrialization has created an enormous need for energy

The industrial sector is a major driver of economic growth. Close to half of the country's GDP comes from industrial activity. At the same time, the industrial sector (which includes activities such as manufacturing and mining) is the country's main consumer of energy, responsible for close to 70% of total use in 2009 (see Exhibit 6).

Exhibit 6: China's energy consumption by sector
Industrial sector drives both economic growth and energy consumption



Source: China Statistical Yearbook 2011.

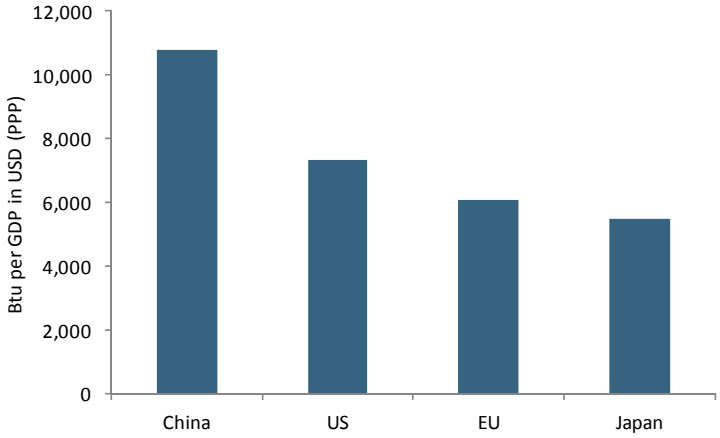
Economic growth in China is extremely energy-intensive.

The large role of the industrial sector means economic growth in China is extremely energy-intensive

Energy intensity[2] is measured by the quantity of energy needed to generate each unit of GDP. In China, the dominant role of the industrial sector means economic growth is extremely energy-intensive: vast amounts of energy are required to power industrial activity. As a result, it is not surprising that China's energy intensity exceeds that of most developed nations (see Exhibit 7). This is largely the result of differences in business mix—GDP composition in developed economies such as the United States and Japan is dominated by the less energy-intensive services sector.

[2] Energy intensity is defined as the energy used to generate each unit of GDP, expressed in purchasing power parity (PPP) terms. For consistent comparisons across economies, the GDP in each country is converted to dollar equivalency.

Exhibit 7: China's economy is extremely energy-intensive
The large share of industrial activity in the Chinese economy leads to a high level of energy intensity



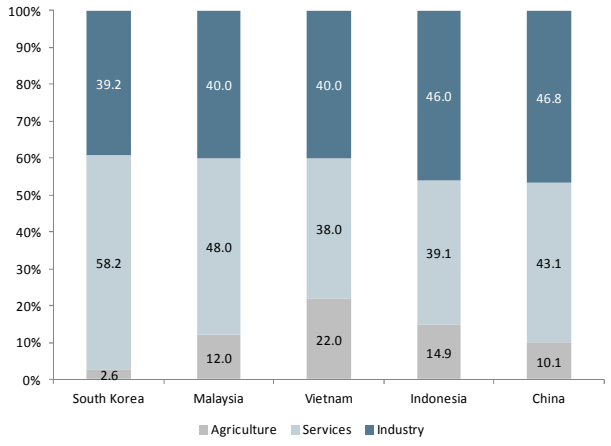
Source: US Department of Energy, Energy Information Administration (EIA).

Economic activity in China also tends to be energy inefficient.

To gauge the relative *energy efficiency* of the Chinese economy, it can be compared against countries with similar GDP composition (identified as economies with comparable shares of industrial activity, illustrated in Exhibit 8). Despite the similarities in business mix, it is notable that China has a higher energy intensity level than the comparable economies (see Exhibit 9). In other words, China's economy is often energy inefficient; it requires more energy to generate each dollar of GDP.

Recognizing the inefficiency of the economy's use, improving energy efficiency has been outlined as one of top environmental targets in the country's Five-Year Plans (FYP). The 11th FYP, which covered the years 2006 to 2010, included a target to reduce energy intensity per unit of GDP by 20%. Over the five-year period, a reduction of 19.1% was achieved. The current plan calls for an additional 16% reduction in energy intensity by 2015.

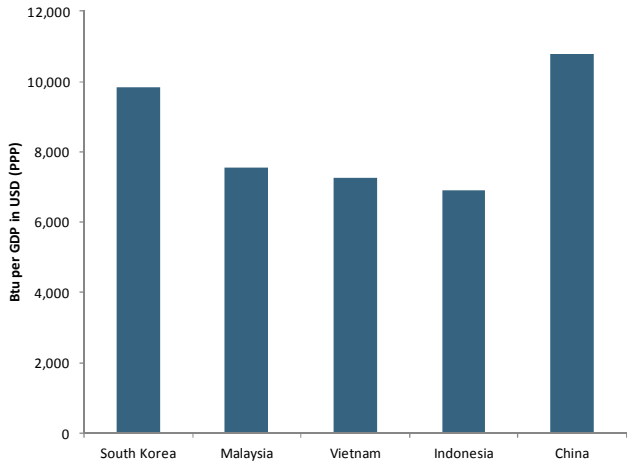
Exhibit 8: Comparing countries with similar economic structure …
GDP composition of selected countries



Note: Industry includes mining, manufacturing, energy production and construction.

Source: Central Intelligence Agency The World Factbook.

Exhibit 9: …illustrates that economic activity in China tends to be energy inefficient
Energy intensity levels of selected countries



Source: US Department of Energy, Energy Information Administration (EIA).

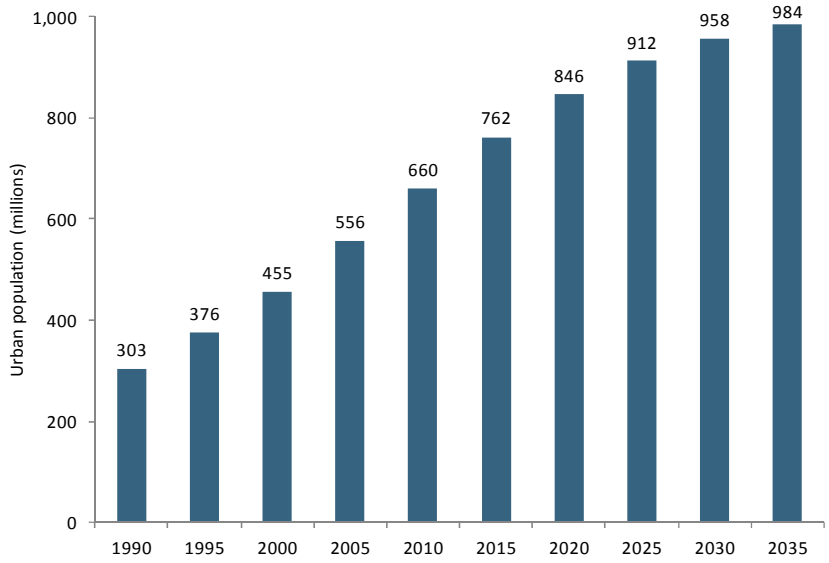
2. Industrialization has fueled the growth of the middle class, leading to additional energy demand

As the shift to an industrial economy drove economic growth, it also significantly raised working wages in China, fueling the rapidly expanding middle class. Average wages of urban workers rose nearly 250% from 9,333 Yuan (approximately $1,127) in 2000 to 36,539 Yuan (approximately $5,349) in 2009. Meanwhile, the middle class (defined as those with annual income between $6,000 and $30,000, PPP-adjusted) expanded from 10% of the total population in 2000 to roughly 40% of the population in 2010.

Rising incomes in China have led to higher consumption of energy. Urbanization is further driving energy demand through increased electricity use.

A correlate of increased income is a rise in energy use. Chinese government statistics indicate the average annual energy consumption for households has been increasing rapidly. In fact, the average household consumption more than doubled between 2000 and 2008. A large part of the additional energy demand has been a result of the migration to cities. As people move from simple rural settings to urban dwellings with electricity access, their energy consumption increases dramatically. According to findings from a United Nations Development Programme (UNDP) China report,[3] per-capita energy use in urban regions in China is 2.1X that in rural regions. This is an increasingly important factor, particularly as the proportion of the urban versus rural Chinese population reached a milestone at the end of 2011 with the number of residents in cities surpassing the number in rural areas. There are now nearly 700 million people living in Chinese cities. Projections from the UN indicate that by 2035, the urban population will total close to 1 billion people (see Exhibit 10).

Exhibit 10: The urban population in China is growing rapidly
Close to 700 million people live in cities today



Source: UN World Urbanization Prospects.

The changing consumption patterns of the growing middle class also have an impact on energy demand in China. For example, with the rise in wages, many consumers moved away from bicycles to cars; the number of registered vehicles in China has nearly tripled in the last ten years. This shift in turn increases the demand for fuel.

[3] "China and a Sustainable Future: Towards a Low Carbon Economy and Society," China Human Development Report 2009/2010, UNDP China, April 2010.

Immense infrastructure construction is needed to accommodate the growing urban population.

In addition to household consumption, immense infrastructure construction is necessary to accommodate the migration to cities. A report from the McKinsey Global Institute[4] estimates that by 2025, China could build 50,000 new high-rise buildings and 170 new mass transportation systems to prepare for the burgeoning urban population. The continued growth of the Chinese middle class, along with the migration to cities, spells additional resource demand in the future.

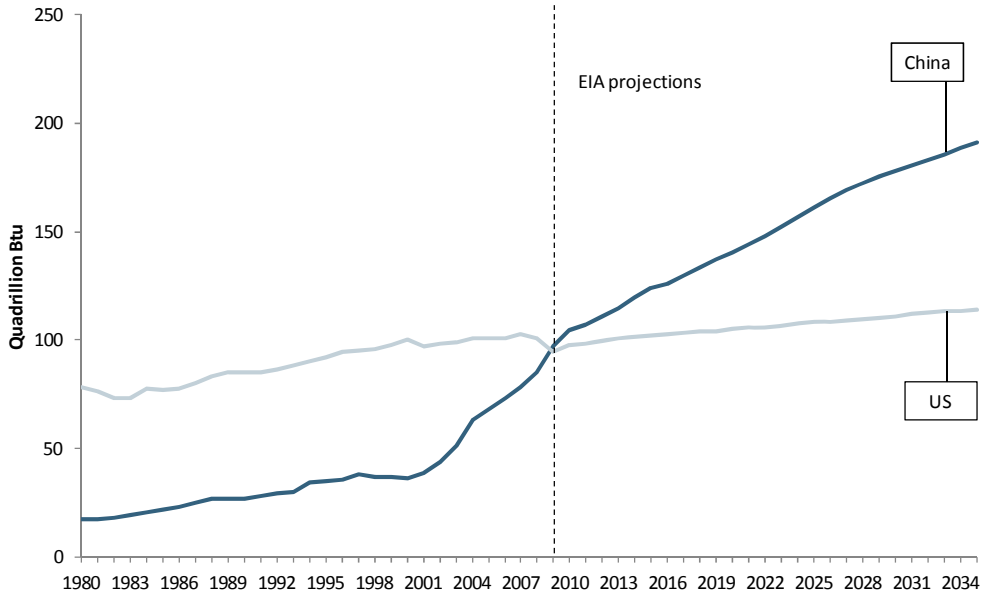
Robust energy demand is here to stay

Energy consumption in China is expected to continue on an upward trajectory.

We believe China will remain a significant user of energy, even at a slower pace of economic growth. Driven by the burgeoning middle class, energy consumption is set to remain robust. There is still significant room for growth in residential energy demand; per-capita energy use in China remains far below the levels in developed countries. For example, World Bank statistics indicate that while per-capita electricity use in China more than doubled over the past decade, it remains just one-fifth of the per-capita use in the United States and less than half the consumption per person in the EU. Given the continued expansion of the middle class, we expect demand for residential electricity and energy overall to continue to increase.

The US Energy Information Administration (EIA), which provides energy consumption and emissions forecasts, projects that by 2035, China will account for nearly 25% of global energy consumption, up from 21% today. In comparison, the United States currently accounts for 19% of worldwide energy consumption but in 2035, this share is projected to decline to 15%. See Exhibit 11. By 2035, Chinese consumption could reach eight times the levels in Japan, seven times the use in Brazil and close to four times India's consumption.

Exhibit 11: China's energy demand is expected to continue on an upward trajectory
Projections by the EIA



Source: US Department of Energy, Energy Information Administration (EIA).

[4] "Preparing for China's urban billion," McKinsey Global Institute, March 2009.

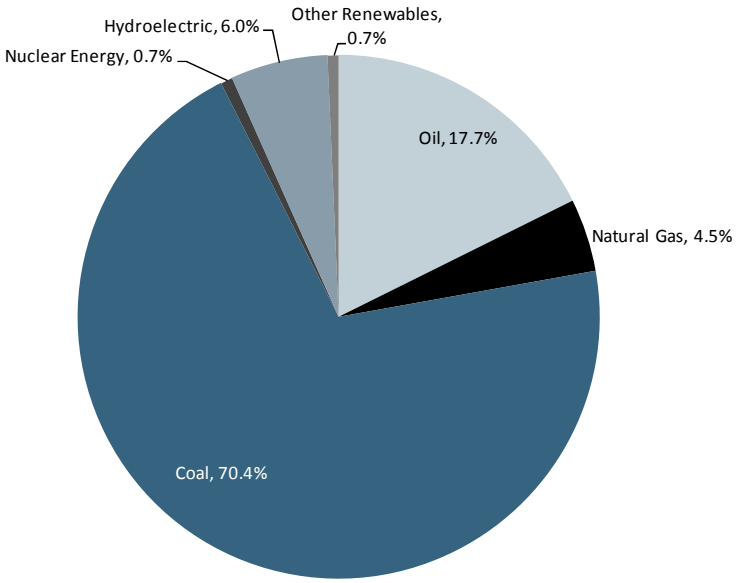
Energy mix remains heavily dependent on coal

Coal is the dominant source of energy in China, accounting for 70% of total energy.

Snapshot of China's energy mix

The rise in demand for energy in China has been met primarily by "dirty" sources, in particular coal.[5] In 2011, approximately 70% of the country's primary energy consumption came from coal. By contrast, oil, the second largest energy source, represented only 18% of consumption (see Exhibit 12).

Exhibit 12: China's primary energy consumption by fuel type
Coal is the dominant source



Source: BP Statistical Review of World Energy 2012.

China is both the largest producer and consumer of coal in the world.

Coal is the dominant source of energy in China

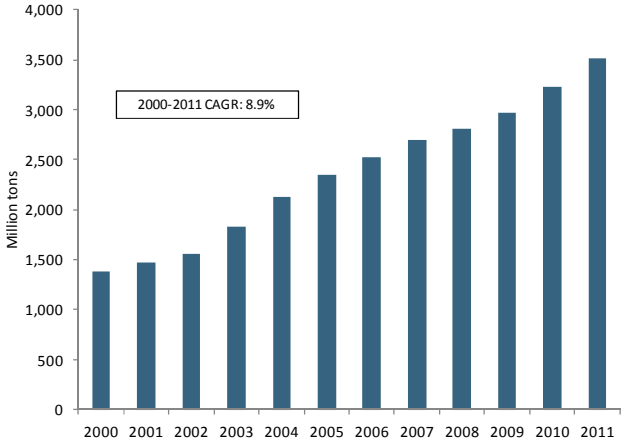
Chinese coal consumption increased by roughly 200% in the past decade and China accounted for close to half of global total coal consumption in 2011. In order to meet this growing demand for coal, domestic production has more than doubled over the past decade (see Exhibit 13). As a result of this robust growth, China is the largest coal producer in the world, contributing to nearly half of total global coal production (see Exhibit 14).

With an estimated 114.5 billion short tons of recoverable coal reserves (roughly 13% of global reserves), China has a deep supply to meet the country's energy needs. However, it became a net importer of coal in 2009 as the cost of importing became competitive with domestic production. As part of national efforts to curb reliance on coal, the Chinese government has indicated plans to cap production and demand at about 3.9 billion tons a year by 2015. The proposed cap is ambitious as the country's coal production has

[5] Coal is considered a "dirty" energy source from the standpoint of emissions. The burning of coal emits large amounts of pollutants into the air, including carbon dioxide, sulfur dioxide, nitrogen oxides and particulates.

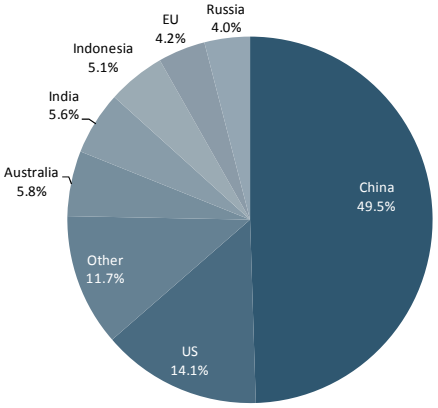
increased by an average of 200 million tons per year over the past decade, totaling 3.5 billion tons in 2011.

Exhibit 13: Coal production in China has grown rapidly
Coal production in China reached 3.5 billion tons in 2011



Source: BP Statistical Review of World Energy 2012.

Exhibit 14: Breakdown of global coal production
China is the largest coal-producing country in the world



Source: BP Statistical Review of World Energy 2012.

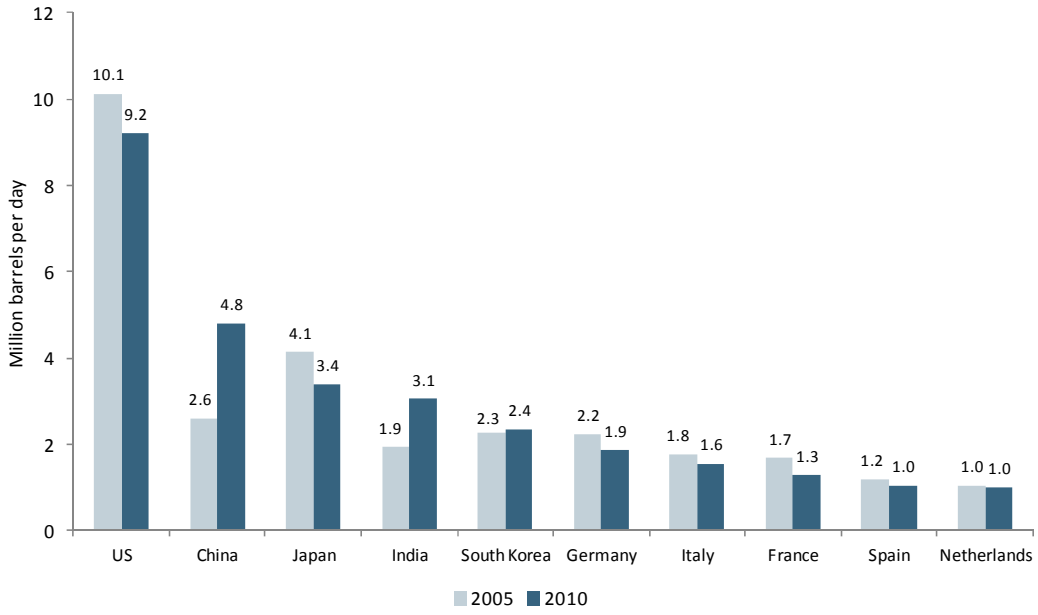
Oil is a distant second

Oil is China's second-largest source of energy at 18% of the fuel mix. While domestic oil production has been increasing (reaching 4.1 million barrels per day in 2011), it has been vastly outpaced by the rapid growth in consumption (about 9.8 million barrels per day in 2011). In addition, many of China's largest oil fields are mature. Exploration and production work is ramping up to increase production, in particular in offshore fields, but imports play an important part in helping China meet its demand for oil.

China imports approximately 50% of the country's crude oil supply.

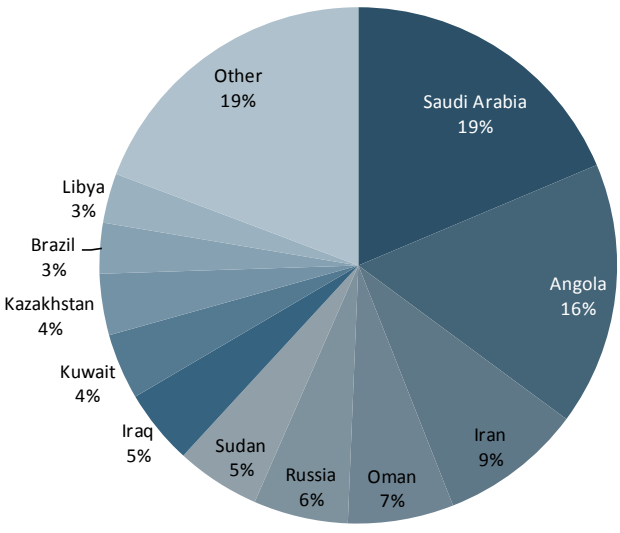
Approximately half of the country's crude oil supply is imported, propelling China to become the world's second-largest importer of oil in 2010 (see Exhibit 15). As Exhibit 16 illustrates, the majority of the crude oil imports in 2010 came from the Middle East. Some African countries, in particular Angola, are also becoming significant sources of oil. The EIA forecasts that imports will rise from half to nearly three-quarters of total Chinese crude oil consumption by 2035. The reliance on foreign suppliers has implications not only for the country's energy security, but also for Chinese foreign policy.

Exhibit 15: Top ten oil importers in 2010
China was the world's second largest importer of crude oil in 2010



Source: US Department of Energy, Energy Information Administration (EIA).

Exhibit 16: China's crude oil imports by source
The Middle East and some African countries are significant suppliers of crude oil to China (2010 data)



Source: US Department of Energy, Energy Information Administration (EIA).

Natural gas is a small but growing energy source

Natural gas demand is rising rapidly, driving both domestic production and imports.

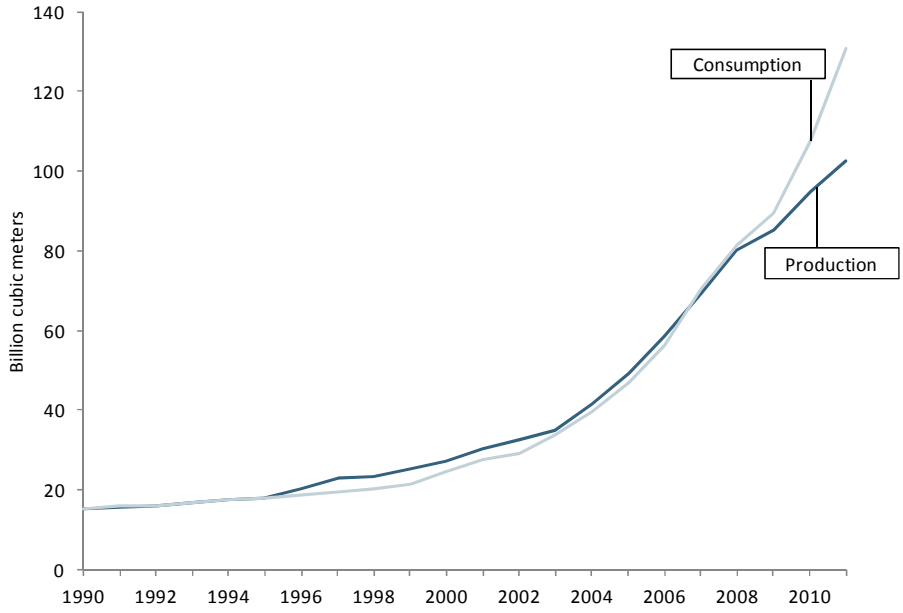
Natural gas is currently a small part of the country's fuel mix (at 4.5%) but China has announced plans to increase this to 10% of total use by 2020. China had 3,100 billion cubic meters (bcm) of proven natural gas reserves as of year-end 2011, just 1.5% of the global supply. While domestic production of natural gas has been rising (reaching an estimated 102.5bcm in 2011), it is outpaced by the country's consumption (roughly 130.7bcm that same year) (see Exhibit 17). Some estimates indicate natural gas consumption could grow by more than 2.5X to total 350bcm by 2020.

To meet the large demand, China became a net importer of natural gas in 2007. A major bulk of the country's natural gas imports is in the form of liquid natural gas (LNG). LNG imports totaled 16.7bcm in 2011, about 13% of that year's consumption. Significant sources of LNG imports include Australia, Indonesia and Malaysia. China is also trying to build up imports of natural gas via pipelines. In late 2011, an agreement was reached with Turkmenistan to increase annual gas supply to 65bcm annually; this amounts to roughly half of total Chinese natural gas consumption in 2011. Negotiations with Russia on pipeline proposals are also ongoing, though the timing of the outcome is uncertain.

Shale gas is a promising resource for China, but development is still in early stages.

Shale gas is another promising resource in China, where there is an estimated 36.1 trillion cubic meters of recoverable reserves,[6] about 2.5X the size of US shale gas resources. While this resource has enormous potential, exploration and development are still in early stages. Established technology used in North America is not directly transferable to China due to the differences in geology. Nonetheless, the Chinese government recently set a target for shale gas production to reach 6.5bcm by 2015 and 60bcm by 2020.

Exhibit 17: Natural gas consumption is outpacing the country's domestic production
Imports are expected to help fill in the gap



Source: BP Statistical Review of World Energy 2012.

[6] US Department of Energy, Energy Information Administration (EIA).

Alternative sources are small but growing parts of the fuel mix

Alternative sources, including nuclear and hydroelectric, are expected to have larger roles in the country's future energy policy. For example, China's 12th Five-Year Plan (2011-2015) included a target to increase the proportion of non-fossil fuels in energy consumption to 11.4% by 2015 and to 15% by 2020, from 8.3% in 2010.

These goals are extremely ambitious, with some estimates indicating China would need to add 320-480GW of non-fossil fuel energy over the next decade to meet the 15% by 2020 target. This is estimated to equal roughly one-third to one-half of total new global non-fossil energy capacity over the next ten years.[7] We discuss renewable energy in more detail in a later section of this paper (see page 18).

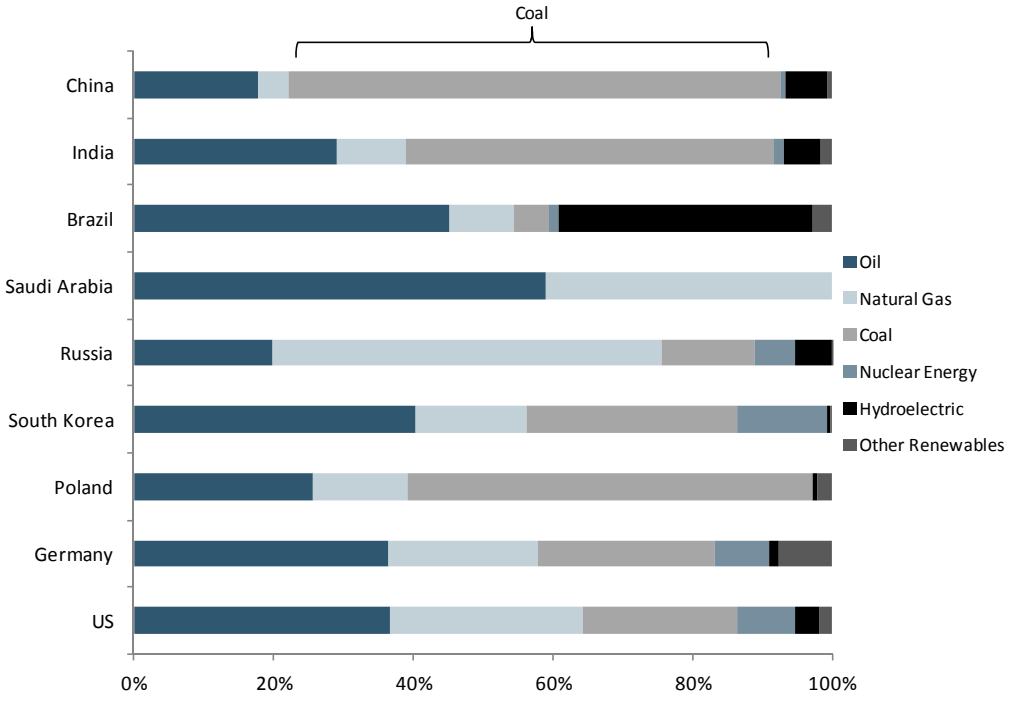
Coal is expected to remain the dominant energy source in China.

Coal will remain a major part of China's energy future

The availability of natural resources is an important factor in determining each country's energy consumption mix (see Exhibit 18). China, for instance, holds approximately 13% of the world's total coal reserves. As a result, 70% of the country's energy needs are met by coal. Similarly, Russia has a large portion of the world's natural gas reserves and accordingly, this resource makes up over half of the country's energy mix. Another key factor is the role of government subsidies. For example, in Saudi Arabia, as a result of heavily subsidized prices (and the abundance of oil reserves), oil accounts for roughly 60% of energy consumption—in fact, it is the largest oil consumer in the Middle East.

Thus, while China will continue to encourage the development of alternative sources, the abundance of Chinese coal reserves means coal will likely remain a major part of the country's energy future.

Exhibit 18: Energy consumption by fuel type in selected countries
Availability of natural resources and subsidies impact the consumption mix (2011 figures)



Source: BP Statistical Review of World Energy 2012.

[7] "China's Low-Carbon Development," Brookings Institute, May 2011.

The impact of rapid growth on electricity generation

Electricity generation has increased significantly to meet the demand from industrialization.

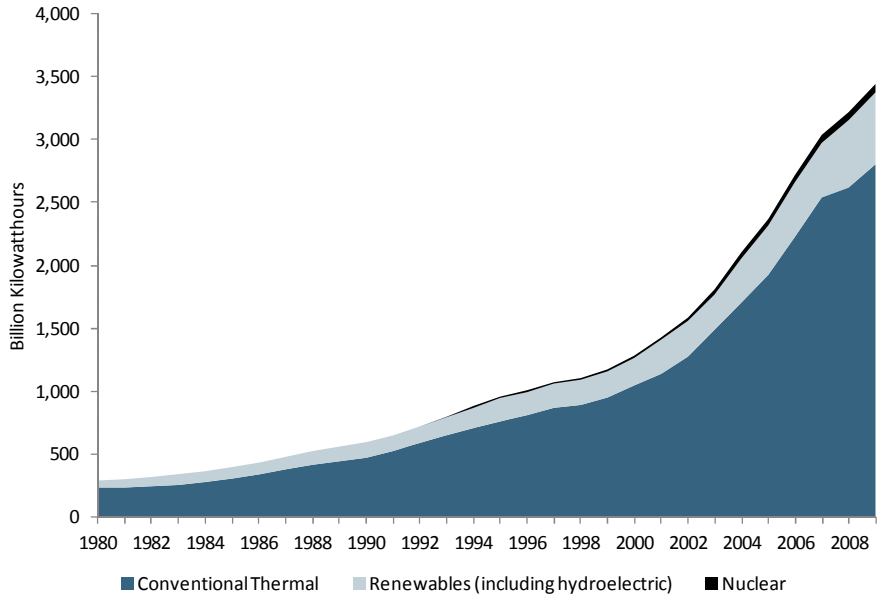
To meet the need from rapid industrial growth, electricity generation in China has ramped up quickly (see Exhibit 19). Mirroring the country's primary fuel consumption, China's electricity generation is dominated by conventional thermal sources, particularly coal. (Thermal sources refer to traditional fossil fuels like coal, natural gas and oil.) Conventional thermal sources currently make up about 75% of China's power capacity. While coal-fired generation continues to be a significant source of electricity, the Chinese government has increased focus on improving its efficiency. For example, small, inefficient power plants are being phased out, with investments now targeted toward larger-sized plants. In 2010, the government announced it had met its annual goal to remove 10GW of coal-fired generation from small capacity generators. According to Chinese government figures, about 70GW of smaller, inefficient plants have been phased out over the past five years.

Coal-fired generation is the dominant source for electricity and will remain a major force in the coming years.

China, with 669GW of installed coal capacity in 2010, has the largest operating coal-fired fleet in the world. The International Energy Association (IEA) estimates China will add close to 500GW of additional coal-fired capacity by 2035. Compared to developed nations with aging fleets who have no choice but to retrofit, Chinese planners have the ability to manage costs associated with retrofitting older plants. Instead, China is able to build capacity with newer, more efficient technology and increase average efficiency in that manner.

China's existing fleet is also among the youngest globally. The IEA estimates that 69% of China's total operating coal-fired power plants are fewer than 10 years old. In contrast, only roughly 5% of the coal-fired fleet in the United States have been in operation for fewer than 10 years—in fact about 92% of the US operating fleet is at least 20 years old.

Exhibit 19: China's electricity generation mix
Dominated by conventional thermal sources, especially coal



Source: US Department of Energy, Energy Information Administration (EIA).

As the Chinese government attempts to diversify the country's power generation mix away from coal, alternative sources are expected to grow in importance. Natural gas capacity, which currently totals just 5% of installed capacity, is expected to increase as the

government encourages investment in gas-fired power plants. Renewables and nuclear are also expected to become larger parts of the mix.

Renewable energy has been a major area of investment as the Chinese government aims to lessen dependence on coal.

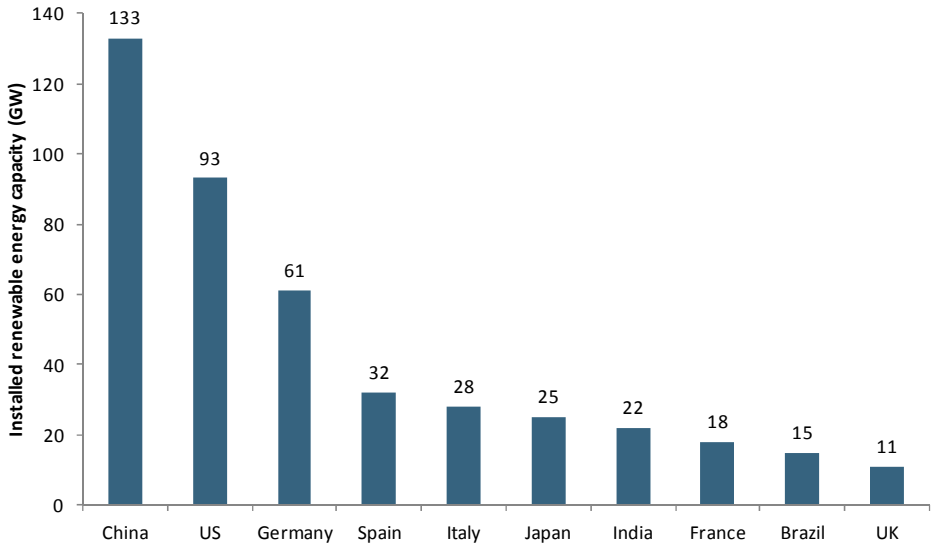
China's sizable renewable capacity remains a small part of the overall mix

A key area of focus for China has been investment in renewables. According to the Pew Environment Group, China became the top global investor in renewable energy projects in 2010. The United States temporarily regained the top spot in clean energy investment in 2011 with $48 billion (versus $45.5 billion in China). Much of the US investment in 2011 was made to take advantage of expiring clean energy stimulus initiatives (such as the Department of Energy's loan guarantee programs). The lack of long-term policy certainty in the United States makes it unlikely that robust levels of investment can be sustained.

Supportive government policy has helped the Chinese build the world's largest renewable capacity.

In contrast, clean energy has been identified by the Chinese government as one of the country's key strategic emerging sectors. The supportive policy environment and steady stream of investment have helped China build up the largest renewable capacity[8] in the world, with 133GW installed in 2011. This constituted close to 25% of the global total. In comparison, the United States had roughly 93GW of installed renewable capacity in 2011, about 70% of China's capacity. See Exhibit 20.

Exhibit 20: Top 10 countries in installed renewable energy capacity
China is the global leader in installed renewable capacity, with about 45% more capacity than the US



Note: Renewable energy sectors include wind, small-hydro, solar PV, biomass and waste.

Source: Pew Environment Group.

Key sectors of China's alternative energy portfolio include:

Hydro and wind make up almost all of China's installed renewable capacity.

- Hydroelectric ("hydro") power:

  Hydro makes up over 80% of China's renewable portfolio (see Exhibit 21). As the world's largest producer of hydro, it accounted for roughly 20% of the country's installed capacity. Hydroelectric capacity totaled 231GW in 2011 and there are ambitious plans to increase capacity by 30% by 2015.

[8] Renewable energy sectors include wind, small-hydro, solar PV, biomass and waste.

The Three Gorges Dam, the world's largest hydroelectric project, will have an estimated capacity of 22.5GW when fully completed. However, the construction of the dam has also caused serious environmental damage including water pollution, sedimentation and landslides. In addition, the geological hazards caused by the construction have forced the resettlement of over 1 million people.

- Wind energy:

Grid connectivity is the key issue for wind power.

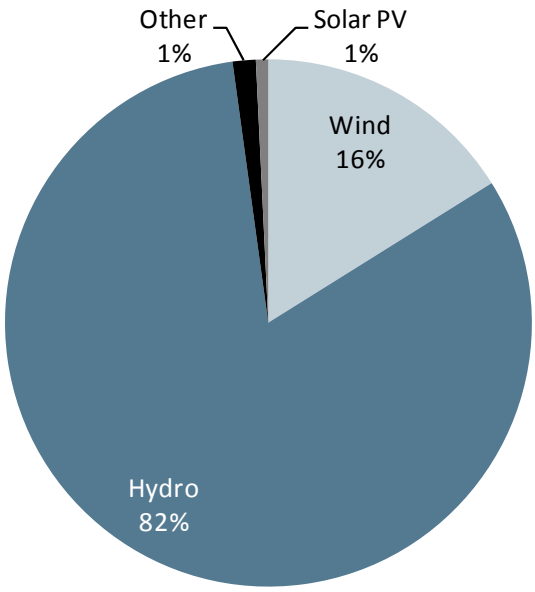
Installed wind capacity has doubled every year since 2006, totaling 45GW in 2011 (about 16% of the country's renewable portfolio). Continued growth in wind generation is expected given government goals to reach 100GW in capacity by 2015. However, wind expansion faces challenges with grid connectivity. Many wind farms are located in the western part of the country, where there is availability of land and resources for turbine construction, but these regions are also far from coastal cities with the highest electricity demand. Going forward, transmission will be a critical issue to address.

There is wide variation in electricity prices across the various energy sources. Solar power is the most expensive.

- Solar power:

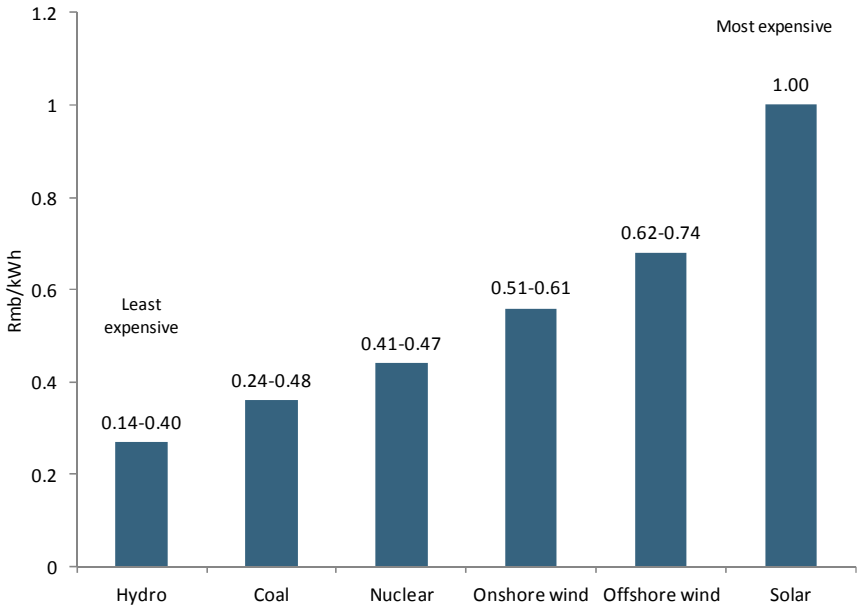
In terms of solar energy, capacity is currently a small portion of the generation portfolio but the government has announced targets for installed capacity to grow nearly six-fold to reach 20GW by 2015. Similar to wind technology, grid connectivity will also be a key issue for solar expansion. Another challenge for this sector is that costs remain uncompetitive relative to other energy sources. For example, Exhibit 22 illustrates the typical on-grid tariffs of electricity for various sources. These tariffs represent the prices paid by grid companies to the power generation firms. As shown in Exhibit 22, solar is the most expensive power source; its price is more than two times higher than the average prices of more traditional sources such as coal and hydro.

Exhibit 21: China's renewable energy portfolio in 2011
Hydro and wind account for almost all of the country's renewable capacity



Source: Pew Environment Group, Goldman Sachs Research estimates.

Exhibit 22: Cost competitiveness across energy sources
Typical on-grid tariffs of electricity



Source: National Development and Reform Commission (NDRC), Goldman Sachs Research estimates.

China is expected to move forward with plans to expand nuclear capacity.

- Nuclear energy:

  While nuclear capacity is approximately 12GW today, the government has plans to quadruple capacity to 40GW by 2015. As of 2011, China had 13 operating reactors and an additional 27 under construction. Japan's nuclear accident in March 2011 prompted a suspension of approvals for new plants, pending a review of nuclear safety and atomic energy regulation. As the country's nuclear resources are primarily located on the eastern coast (close to major cities and large populations), safety is a chief concern. However, industry analysts do not expect a long-term impact on China's nuclear policy, and China has confirmed that it will remain committed to nuclear energy. This is in contrast to policies in other countries like Germany and Switzerland, which have made significant cutbacks to their existing nuclear capacity amid concerns about reactor safety.

Investment in grid development has not kept up with the expansion of clean energy capacity.

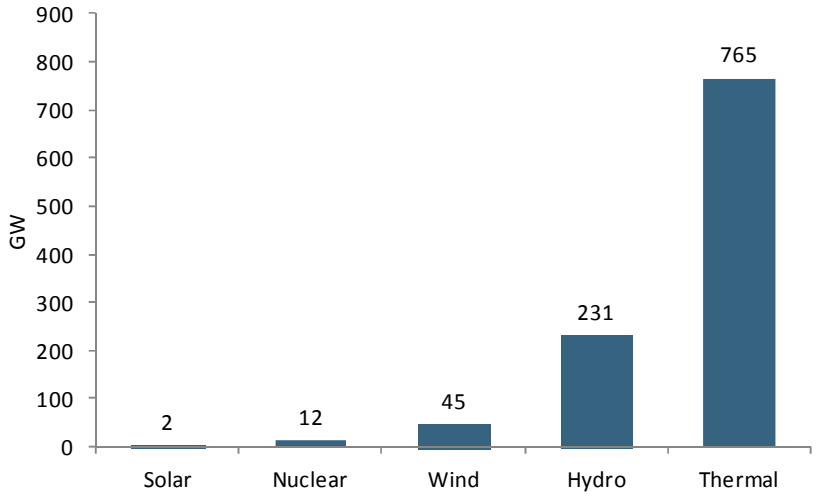
- Development of the grid:

  Grid development will prove crucial to the continued development of clean energy. While renewable capacity has been steadily increasing, transmission of the electricity has been slow to keep up. For example, some estimates indicate a quarter or more of the existing wind capacity may not be operational or connected to the grid. Transmission is a problem for wind energy in particular, as we mentioned previously, since turbines tend be located far from areas with high electricity needs. In response, in 2011, the State Grid of China announced plans to invest 500 billion Yuan (approximately $77 billion) over the next five years to extend the country's ultra-high voltage (UHV) electricity transmission system. UHV (defined as voltage of 1,000KV or above of alternating current or 800KV of above of direct current) is used to transmit large currents of power over long distances.

Despite efforts to expand alternative energy, these sources remain overshadowed by thermal capacity.

Despite the supportive government policy and heavy investment in alternative energy, these sources are currently still a relatively small fraction of China's coal-dominated generation portfolio. Capacity from thermal sources is over 2.5X the installed capacity for renewable and nuclear sources combined (see Exhibit 23).

Exhibit 23: Renewables and nuclear remain overshadowed by thermal sources such as coal and oil
2011 installed capacity



Source: Pew Environment Group, Goldman Sachs Research estimates.

Nonetheless, one point to keep in mind is that given the size of China, even modest growth in Chinese renewable capacity is still significant from a global perspective. While the 133GW of installed renewable capacity is a small fraction of China's electricity mix, it is equivalent to almost a quarter of the world's clean energy generating capacity.[9] As a point of comparison, Brazil, an emerging economy that has also identified alternative energy as an important area of investment, reached 15GW of installed renewable capacity in 2011, just 11% of China's levels. Similarly, installed capacity in China is two times that of Germany's, another country with ambitious renewable energy goals.

[9] Renewable energy sectors include wind, small-hydro, solar PV, biomass and waste.

Government policy puts emphasis on sustainable development

The 12th Five-Year Plan places emphasis on sustainable development and the environment.

Environmental issues highlighted in 12th Five-Year Plan

The Chinese government has acknowledged the need to maintain sustainable economic growth. The 12th Five-Year Plan (FYP), which covers the years 2011 to 2015, emphasizes economic restructuring to achieve growth (by encouraging domestic consumption, developing the service sector and moving from manufacturing to higher-value industries) and doing so in an environmentally sustainable manner. Resource and environmental goals are highlighted in Exhibit 24.

Exhibit 24: Key environmental targets in the 12th Five-Year Plan (2011-2015)

Target	Achievements under the 11th FYP (% achieved between 2006-2010)	12th FYP Targets (% by 2015)
Reduction in energy intensity per unit of GDP	19.1	16.0
Reduction of water consumption per unit of industrial value added	36.7	30.0
Reduction in carbon emissions per unit of GDP	N/A	17.0
Non-fossil fuel as a % of primary energy consumption	8.3	11.4
Forest coverage	20.4	21.7
Reduction in chemical oxygen demand (COD)	N/A	-8.0
Reduction in sulphur dioxide	N/A	-8.0
Reduction in ammonia nitrogen	N/A	-10.0
Reduction in nitrous oxides	N/A	-10.0

Source: Goldman Sachs Global Markets Institute.

The national goals are divided into two types: restricted and expected targets. Restricted targets are "hard" required targets; the career progressions of local officials are often tied to achieving these goals. Expected targets are "soft" targets that are primarily meant to be accomplished through market forces along with government support. It is notable that all of the environmental indicators highlighted in Exhibit 24 are restricted targets. Of the eight restricted goals in the 11th FYP, seven were met, according to government figures and the country came very close to meeting the eighth. With each FYP, there has been an increasing number of restricted goals with measurable, quantified targets as Chinese policymakers recognize both the rising urgency in maintaining sustainable growth and the need to ensure greater accountability.

National goals in Five-Year Plans rely on implementation by provincial officials...

...but local leaders tend to favor economic growth over environmental goals.

It is important to keep in mind that Five-Year Plans are guidelines for regulators and provincial officials, who are then responsible for implementation. In fact, one significant obstacle in implementing previous FYPs has been the disconnect between central government planners and local officials. Provincial leaders have been inclined to focus primarily on GDP growth—for example, while the 12th FYP has set a goal for a 7% annual GDP growth rate, several provinces have announced growth targets exceeding the 7% mark, in some cases even aiming for growth as high as 13%. This conflict was an issue in the implementation of the 11th FYP. Some reports indicated that during the last few months of 2010, the central government sent officials to provinces to monitor the progress toward achieving energy intensity targets, leading to belated attempts to meet goals through black-outs and forced factory closures. In recent years, the performance indicators set by the central government for local officials have gradually moved away from being purely focused on economic growth to also include targets on areas like the environment and social housing.

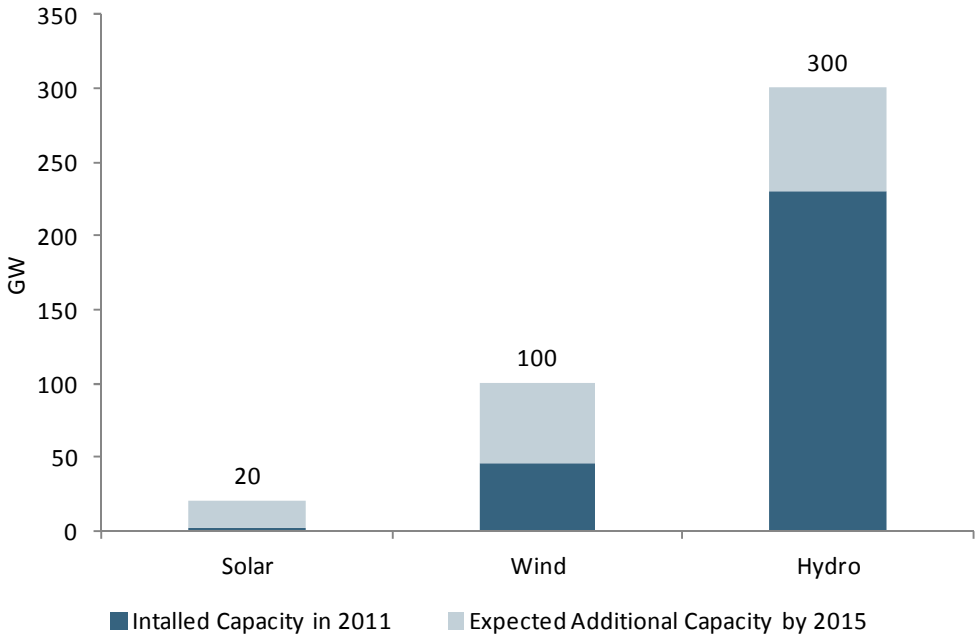
Diversity in environmental initiatives

The 12th FYP includes a range of environmental initiatives; some energy-related examples are highlighted below:

- **Build renewable energy capacity**: the 12th FYP increases the proportion of non-fossil fuels in energy consumption to 11.4% by 2015 and to 15% by 2020 (from 8.3% in 2010). Some estimates project China would need to generate between 320-480GW of non-fossil fuel energy over the next decade to meet this extremely ambitious target. Over the next five years, the Chinese government plans to achieve hydro capacity of 300GW, wind capacity of 100GW and solar capacity of 20GW (see Exhibit 25).

  Climate issues could pose challenges to China's renewable expansion plans, however. For instance, severe droughts in recent years have led to low water levels, causing problems for hydropower plants.

Exhibit 25: China's ambitious targets for building renewable capacity
Additional renewable capacity will help China meet 11.4% of its energy consumption from non-fossil fuels by 2015



Source: Pew Environment Group, US Department of Energy, Energy Information Administration (EIA), Goldman Sachs Research estimates.

- **Expansion of Top-1,000 Energy Consuming Enterprises Program** (Top-1,000 program): the Top-1,000 program was established in the 11th FYP; it set energy-saving targets for the 1,000 enterprises which were identified as being large and inefficient energy users. These 1,000 companies were responsible for approximately one third of the country's energy consumption. There are plans to expand this into a Top 10,000 program, setting targets for a much larger group of companies. Monitoring and enforcing targets could prove challenging as the number of covered firms increases.
- **Investment in rail system**: the 12th FYP calls for extending the nationwide railway to 120,000km in 2015, from 91,000km in 2010. High-speed rail is meant to increase from 7,000km in 2010 to 12,000km by 2015. However, construction has slowed recently, after rail accidents heightened concerns regarding safety.

China is beginning to move away from regulated energy prices toward more market-based pricing systems.

Potential for energy price reforms

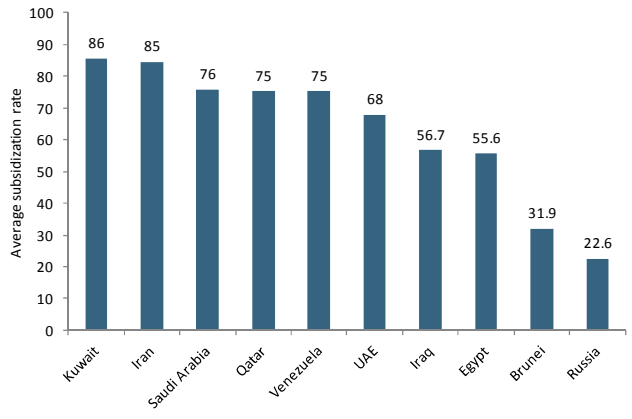
The Chinese government has also discussed plans to reform the country's energy pricing system and move away from state-controlled prices in order to "let the market play a role in helping users be more economical with their energy use."[10] Currently, the prices for both refined oil products and natural gas are regulated and are set at levels below international market rates. Moreover, wholesale and retail electricity prices are determined by the state. These price controls diminish the economic incentive for users to be energy efficient (see Box below).

Recognizing this, China has begun to introduce pilot schemes with market-oriented pricing mechanisms. In late 2011, pilot reform on natural gas pricing was launched in two southern provinces and there are plans to extend the trial program to additional regions in the second half of 2012. China also recently announced plans to gradually roll out a progressive electricity pricing scheme for residential households which would "help conserve China's natural resources and curb over consumption."[11]

Role of subsidies in energy consumption

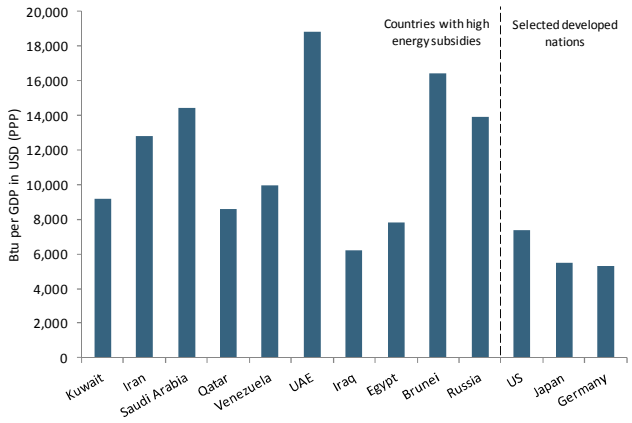
Government subsidies for energy are an important contributor to inefficient consumption, particularly in energy-producing countries. Countries with high fossil fuel subsidization rates (see Exhibit 26 for a selected group) also tend to have high energy intensities (see Exhibit 27). Subsidies incentivize fossil fuel consumption while also discouraging energy efficiency and the use of alternative energy sources.

Exhibit 26: Countries with high fossil fuel subsidization rates…
Average subsidization rate of selected economies



Source: International Energy Agency.

Exhibit 27: …tend to be inefficient energy users
Energy intensity levels of selected countries



Source: US Department of Energy, Energy Information Administration (EIA).

[10] "China to reform prices in energy sector," Xinhua, February 2012.

[11] "China NDRC to roll out progressive residential power price," Wall Street Journal, June 2012.

Opportunities arise for key strategic industries

Clean energy is among the industries expected to benefit significantly from accommodating government policy.

The 12th FYP also identifies seven strategic emerging industries (SEIs):

- Clean energy technology
- Alternative energy
- Clean energy vehicles
- Next-generation IT
- Biotechnology
- High-end equipment manufacturing
- New materials

These industries are seen as crucial in helping the Chinese industry move up the value-chain in manufacturing and to continue economic development sustainably. The goal is to grow these seven industries from 5% of GDP in 2010 to 8% by 2015 and 15% by 2020. Thus, these sectors, three of which are closely tied with clean energy and sustainable growth, are expected to gain significantly from substantial government support. News reports[12] indicate China plans to invest 10 trillion Yuan ($1.7 trillion, or the equivalent of roughly 20% of China's GDP in 2011) in the seven SEIs over the next five years. Sectors that could stand to benefit from the country's energy policy range from alternative sources such as nuclear power and natural gas, to efficient lighting (for example, LED lighting for public buildings).

Sectors aided by accommodating government policies in the past include telecommunications and coal, two of China's "pillar industries." A more recent example is clean energy technology, which was also recognized as a SEI in the 11th FYP. During that five-year period, investment in clean energy averaged close to $50 billion per year (equivalent to approximately 6% of central government spending in 2011), helping Chinese solar and wind companies become global leaders in their sectors.

[12] "China confirms $1.7 trillion spending plan: US," Reuters, November 2011.

Disclosures

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