

# Power and productivity

China's challenges

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With more than 1.3 billion people, China is the largest country in the world today, being home for 20 percent of the world's population. As a consequence of that China is emerging as one of the largest global energy consumers, second only to the United States. Since 1980, rapid economic growth has stimulated an equally remarkable growth in energy production and consumption. China's demand for primary energy is likely to more than double between today and 2030.

A country with such strong growth needs energy to increase its standard of living and its industrial productivity if the consumption of goods and supply to the infrastructure are to contribute to the country's prosperity.

## ABB in China

The Chinese power industry is struggling to satisfying demand – growth in energy demand has out-paced supply growth. This represents a shift compared to the late 1990s, when problems were with oversupply. China's rapid development, changing demographics and economic restructuring have driven a relentless growth in energy consumption and present new challenges for power suppliers.

China's main source of energy by far is coal. Such heavy reliance on a "dirty" source has been costly; the government is planning to diversify the industry through increased use of cleaner sources such as nuclear, hydroelectric and natural gas. China is rich in many of the resources needed for energy production, but the regions where these are concentrated are far away from the main centers of consumption. The further growth of industry and commerce thus calls for heavy investment in both generation and transmission infrastructure.

The government is committed to such goals as diversifying energy sources, improving efficiency, expanding coverage and limiting the human and environmental costs of the rapid growth.

#### Energy demand: trends and forecasts

Since the late 1990s, when oversupply in the energy industry led to a moratorium on the approval of new coal-fired plants, supply and demand have shifted radically.

During the summers of 2003 and 2004, supply shortages led to about two thirds of Chinese provinces imposing brownouts and rationing ener-

gy. Electricity production has then been increased with highest pace <sup>1</sup>. The Energy Information Administration (EIA) predicts that Chinese electricity consumption will grow twice as fast as the world average in the years to come until 2030<sup>1)</sup>.

### The further growth of industry and commerce calls for heavy investment in both generation and transmission infrastructure.

This rapid growth is positioning China among the giants in energy consumption – a trend that will continue for the next five, 10 or even 20 years.

#### What is driving energy demand?

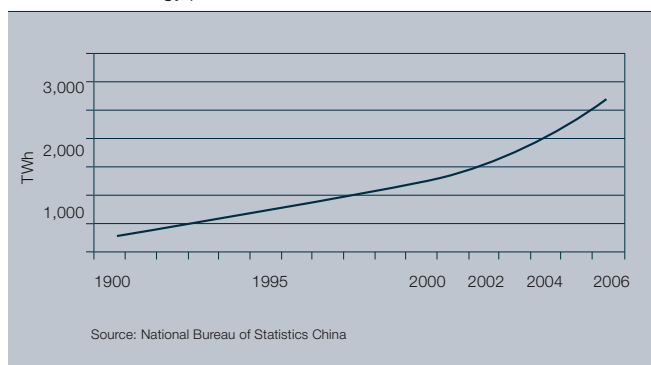
Increasing living standards, especially in eastern China, have substantially changed consumption patterns to include modern goods and services. This, combined with China's position in global export manufacturing, have in turn created opportunities of which the most important is rapid industrial growth – around 10 percent a year since 1980. Over the last years in particular, following heavy focus on areas such as construction and infrastructure, industrial energy demand has been very high. The scale of fixed asset investment in buildings, roads and factories has been huge in the last few years, and is by nature highly

energy-intensive. The construction boom and – by international standards – still low energy efficiency in China explain the scale of the energy demand increase.

Though industrial consumption accounts for roughly two-thirds of the growing energy needs in China, domestic consumption is also an important force to consider. This has grown steadily, a trend that is likely to continue through the coming decades. The rise of the middle class in China is starting to impact energy needs. As China becomes increasingly wealthy, factors such as demand for cars and more electricity in bigger houses will continue to increase. Likewise, oil and electricity demand will rise. Urbanization also has a huge role to play in this equation <sup>2</sup>. Only 42 percent of the Chinese population currently lives in urban areas, which is well under the global average of about 50 percent and far below the developed world average of over 70 percent. As the country develops, this balance is likely to shift towards heavier urbanization.

In China, there are significant differences between urban and rural energy consumption. Presently rural residents use below 40 percent of that of their city-dwelling counterparts. Due to high costs and poor access to commercial energy, this population currently supplements its commercial consumption with biomass and direct coal burning. If this inefficient and polluting non-commercial energy use is included in the energy balance, rural residents are using one-third more energy than their urban peers. In order to cut back on the current

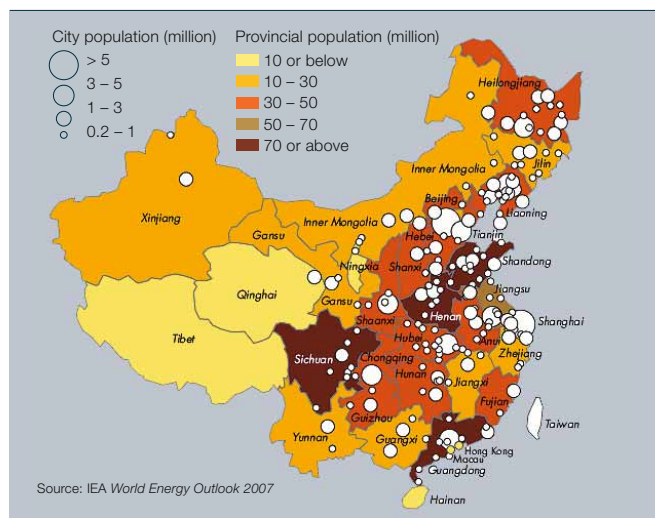
<sup>1</sup> Electrical energy production in China



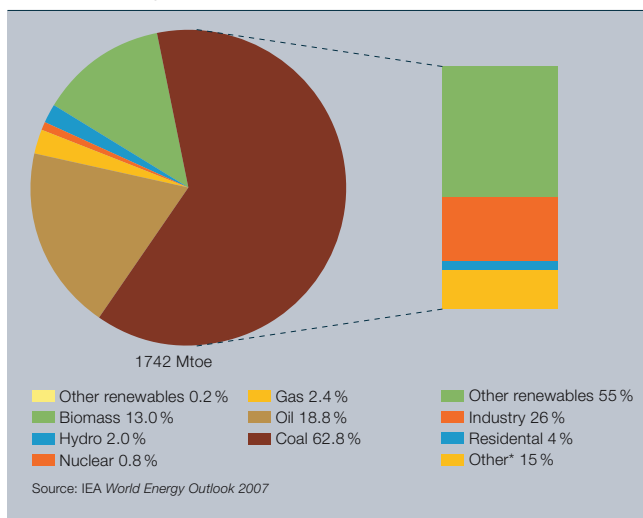
#### Footnote

<sup>1)</sup> Most of the data reported here are taken from the IEA *World Energy Outlook 2007* with a special emphasis on China.

2 Major cities in China



3 Primary energy demand in China



waste, pollution and health hazards of biomass and coal burning, rural provision of commercial energy is a government target. Growing urbanization will also contribute to this shift. The scale of the Chinese population means that changing demographics such as urbanization, rural electrification, and rise of the middle class are likely to have a huge impact on the Chinese and global energy market.

Demand-side changes are being facilitated through fundamental shifts in the energy supply. Rising energy needs are being accommodated through a variety of government efforts and private-sector developments.

### Energy efficiency

Among those efforts energy efficiency has attained even greater prominence over the past few years as the main approach to addressing energy security and environmental issues at the same time. Already in 1998, the Energy Conservation Law for more efficient use of energy resources and the promotion of energy-saving technology was launched. In 2004, Medium and Long Term Plan for Energy Conservation with specific energy efficiency improvement targets for the industrial, transport and building sectors came into place. These and other initiatives shall give guidance on technical measures to achieve the 20 percent reduction of energy intensity targeted for 2010, which is a feature of the 11<sup>th</sup> Five-Year Plan for energy. The subsequent national programs are strongly

driven by politicians who strive for a consequent implementation.

### From coal to “clean” energy

The primary source of Chinese energy is coal **3**. China possesses vast coal reserves and is both the largest producer and consumer of coal in the world. The government is working to decrease this heavy reliance on coal relative to other fuels, but coal will continue to grow in absolute terms and will definitely remain the country's largest energy source through 2025. The 11<sup>th</sup> Five-Year Plan seeks to increase the coal contribution in the energy mix to 66 percent from 63 percent in 2005.

### China possesses vast coal reserves and is both the largest producer and consumer of coal.

The coal resources in China are huge and distributed across the country **4**. In the coastal regions, however, where the electrical energy demand is highest, less coal is available. As a consequence, long transmission lines for electrical power are required to connect the power plants in the West with the centers of energy consumption in the East.

Oil is the next biggest source. During the 1990s, oil production in China doubled but still failed to keep up with rising demand – currently the

fastest in the world. China has been a net oil importer for the past decade.

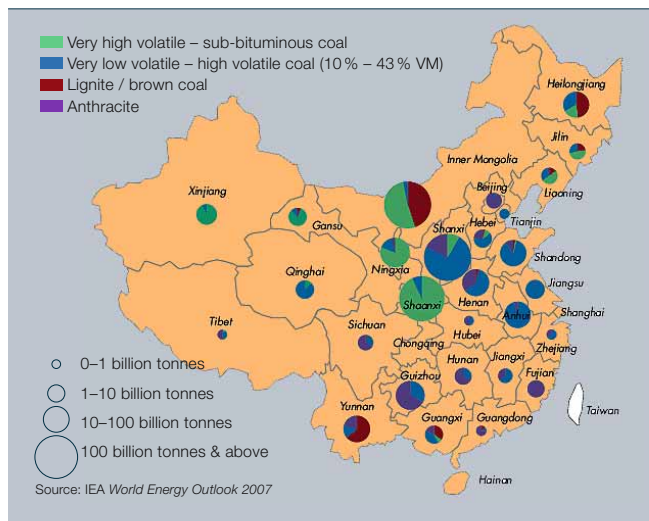
It is forecast the country will import 84 percent of its needs by 2030.

The next most important source of energy for China is hydroelectric generation. China possesses the largest hydroelectric resources in the world. This is a significant source of energy generation and will reach almost 7 percent according to the 11<sup>th</sup> Five-Year Plan. The Three Gorges project is probably the best known of China's endeavors to develop its hydroelectric resources. This 18,200 MW facility is meant to be completed by 2009 with a capacity to single-handedly supply 3 percent of current demand. Beside the Three Gorges, there are 25 smaller projects underway along the Yellow River (15,800 MW) and a 5,400 MW plant on the Hongshu River. Construction has also started on a 14,000 MW development at Xiluodu and 6,000 MW at Xiangjiaba.

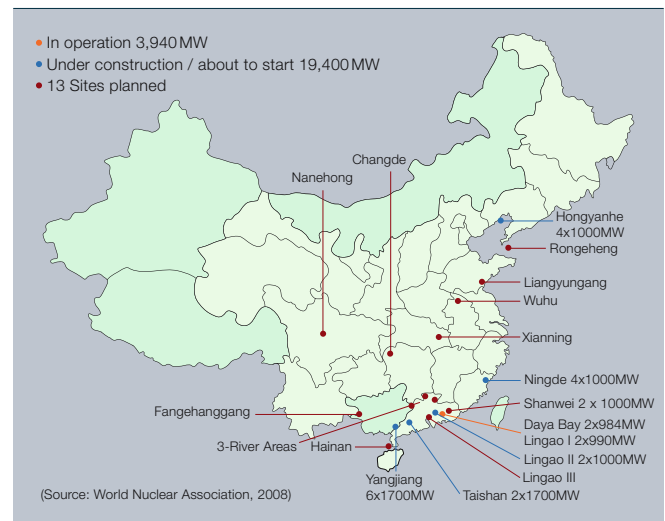
Natural gas is currently a very small power source. Both western China and neighboring countries, such as Russia, possess substantial natural gas reserves. Gas from areas such as Xinjiang as well as imports will see increasing use in power generation. One clear advantage of natural gas is that it burns much more cleanly than coal. As part of Beijing's preparations for its “green” Olympics this year, a substantial part of the city's power supply has been switched to natural gas.

## ABB in China

4 Coal resources in China



5 Nuclear power plants in China



Nuclear energy, like natural gas, constitutes only a small fraction of present energy generation, but will expand at a furious pace in the coming years [5]. Mainland China has 11 nuclear power reactors in commercial operation, six under construction, and several more about to start construction. Additional reactors are planned, including some of the world's most advanced, to give a six-fold increase in nuclear capacity to at least 50 GWe or possibly even 60 GWe by 2020 and then a further three- to four-fold increase to 120 to 160 GWe by 2030. The 11<sup>th</sup> Five-Year Plan has targeted an overall contribution of about 1 percent to the energy mix.

#### Moving the energy: power grids

China's vast energy resources are predominantly concentrated in areas far away from the booming coastal and southeastern cities where consumption is greatest. One of the problems with the current system is that it is regionally focused and has insufficient interconnection. The government is planning to establish a unified national power grid by 2020, selling power at market-determined rates. This is a major factor in the efforts to better match energy supply and demand in China. One key part of this plan is the "West to East Plan," with major lines in the North, Center and South connecting the production of the resource-rich West to the needs of the energy-hungry East. The 2020 strategy also envisages connections to Russia in the north and Thailand in the south.

#### Health and the environment

The Chinese government is very well aware of the serious environmental issues connected to the required energy system. These issues identify air, water and ground pollution due to production, transformation, transportation and burning of fossil fuels. All potential negative effects also recognized in other countries like waste disposal, greenhouse gas emission, changes in ecosystems caused by large hydro-projects, to mention a few, are carefully considered.

Air pollution remains a major problem in China and the efforts of the government are manifold; for example:

- Factories have moved to less populated areas.
- Fuel has been switched from coal to gas where possible.
- Some large projects not complying with environmental requirements have been stopped.
- New emission standards for vehicles have been introduced.

Emissions of critical pollutants like SO<sub>2</sub> shall fall by 10 percent below the 2005 level by 2010.

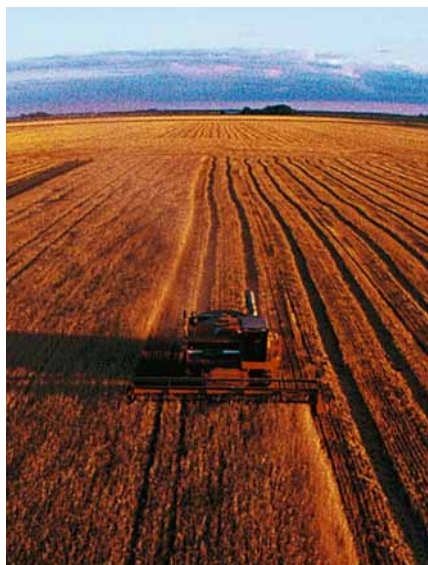
Renewable or CO<sub>2</sub> free energy resources have a high priority but will stay on a low percentage level for a long time. Hydropower still is the biggest alternative and there are plans to increase the capacity to about 300 GW by 2020. Hydropower of this large scale must overcome a number of difficult barriers, however.

China has installed a National Climate Change Coordination Office already in 1998, and in 2007, it released its first action plan to mitigate climate change, with a number of initiatives headed by the Premier.

#### Industrial productivity

In the last 10 years the major source of China's growth has been its industrial productivity [6]. Rapidly increasing consumption opens opportunities in the process and manufacturing industry to supply required products and services. Improving living standards demand better housing and transportation, better working conditions and a safer environment. Modern production technologies in combination with energy efficient equipment will enhance productivity, improve product quality and reduce energy demand per ton produced. These measures are all necessary in China's attempt to balance its growing demand with its capability to supply energy in the form of heat and electricity.

The leading sector in energy consumption is industry, representing 68 percent of total energy consumption. It is followed by the residential and commercial sector with a share of 11 percent, and transportation at 8 percent. It is expected that the industrial sector will continue to dominate energy consumption, though there will be a trend of rising transportation and residential sector share by 2020.



The major energy consumption subsectors in the industrial sector are chemicals (including petrochemicals) at 24 percent, metals (including smelting and pressing) at 20 percent and non-metals (including cement, paper and pulp; food; and textile) at 20 percent. The fertilizer, iron and steel, and cement industries are the major users in each of the three largest industrial subsectors.

#### China's fertilizer industry

China's largest industrial subsector from the energy consumption point of view is the chemicals industry with fertilizer production being the largest energy user within this subsector.

China's low production efficiency for fertilizers is due to almost 1,000 small plants and the use of coal as feedstock for its ammonia synthesis. Whereas the feedstock used in the United States is almost exclusively natural gas, coal is the main choice in China. The energy intensity for ammonia production is about 25 percent higher in China, a significant potential for energy savings.

#### China's iron and steel industry

The iron and steel industry accounts for 28 percent of total industrial fuel use. China is currently the world's largest producer of steel with about 500 million tons in 2007, being 34 percent of the world's steel production.

The energy required to produce the steel is comparably higher than in



other countries, however. Some of the reasons are that the production capacity per blast furnace is small, the continuous casting rate is low and the iron-to-steel ratio is high.

China's vast energy resources are predominately concentrated in areas far away from the booming coastal and southeastern cities where consumption is greatest.

There are currently 6,686 steel companies in China, 58 percent of which are located in the coastal region. A consolidation process is driven by the government, however, so that in 2010 the top 10 steel companies should produce more than 50 percent of the national output. Just recently plans were launched to build a huge steel plant for up to 30 million tons of annual production near Fangchenggang, a port city in the Guangxi region in China's south with an investment of \$30 billion.

#### China's cement industry

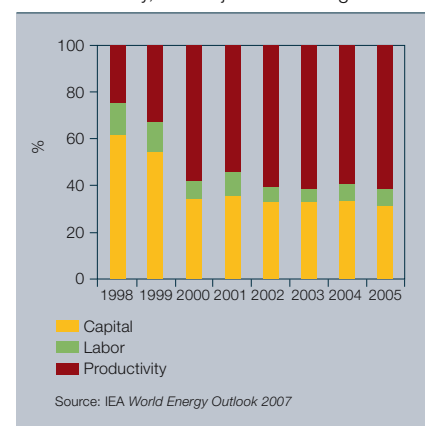
As the world's largest cement producer, with a share of around 40 percent, China has ranked first in terms of cement production for many years. The total cement consumption in China was 1.2 billion tons in 2006, up 14 percent almost every year; the cement output maintained the rapid



growth to 1.2 billion tons, increasing 15 percent. It was the strong demand in the cement market that cement industry recovered the prosperity in 2006. The industry has benefited from the growth in real estate and the rapid growth of the national economy.

However, the majority of China's cement producers are small plants using an inefficient process of vertical kilns – despite the Chinese government dramatically reducing the number of cement producers in the past. Only in 2020 are larger dry kilns expected to reach a share of 40 percent. No wonder the cement industry consumes around 77 percent of the energy in the non-metals sector. Energy still accounts for about 40 percent of the total production costs in this industry – a dramatic indicator of the industry's improvement potential.

6 Productivity, the major source of growth



## ABB in China



The demand for cement is expected to continue growing as China implements its strategies of developing the Western regions; reinvigorating the traditional industrial bases in north-east China, its urbanization drive and its projects for transporting natural gas from the Western regions to the Eastern ones; and projects related to a major international sporting event and the 2010 Shanghai World Expo.

#### China's pulp & paper industry

China's paper industry has experienced dramatic growth with consumption increasing by 45 million tons in 20 years to more than 60 million tons in 2006. China has become the second largest paper consumer in the world, only behind the United States, and is the world's largest paper importer with annual imports exceeding USD 7 billion.

There are several thousand paper and board companies in China, but only a handful of them have a capacity exceeding 200,000 tons per year. Some of the most modern mills in the world are operating in China today.

China's paper-making industry has experienced a rapid growth in consumption as well as in output; therefore, many leading Chinese paper-making enterprises started introducing new production lines, which resulted in an over expansion in production capacity, particularly in 2005 and 2006. In addition, the international paper-making giants have landed in China for investment and setup plants. China will

continue to expand its domestic paper production capacity and try to reduce its imports of paper. However, the country suffers from a shortage of pulp and pulp imports are expected to increase to 10 million tons by 2010.

In the last 10 years the major source of China's growth is its industrial productivity.

#### China's automotive industry

China's automotive industry has experienced a high growth period as well. The number of vehicles has increased by almost a factor of seven since 1990, from 5.5 million to around 37 million in 2006. Most of this growth is in cars. China overtook Germany in 2004 and Japan in 2006 and became the second-largest car manufacturer in the world. The step to number one, producing more than the United States is expected around 2015. The IEA projects the number of vehicles on Chinese roads to exceed 270 million by 2030. China is likely to become an exporter of cars, in line with the developments the world has witnessed in South Korea and Japan in the past.

#### Transportation sector

The total energy consumption for China's transportation sector amounted to 130 million tonnes of oil equivalents (toe) in 2006, about 8 percent of the country's total. It is estimated that the transportation sector will take a

larger share of final energy consumption in the future due to the high growth of transportation services. Total energy demand for the transportation sector is estimated to reach 240 million tonnes in 2015 and 460 million tonnes in 2030.

#### China's harbors

The harbor industry has achieved fast growth with annual growth rates of 16 percent from 1999 to 2003. China's total trade of goods has surpassed \$ 2 trillion in 2007, with double-digit growth over the last years. Total seaborne port handling capacity has reached 5 billion tons. The large container facility in Shanghai is going to be the number-one container harbor after Singapore, and seven out of the 20 world's largest facilities are in China. China is becoming the biggest shipping center in the world.

#### The need for power and productivity

Economic growth is predicted to remain high for decades to come, which in turn means that the energy sector will continue to expand. Given the scale of the Chinese energy industry and its growth, efficiency in power generation and consumption is too low and environmental and health costs too high. The stakes are very large, but efforts by the central government to guide the energy industry's development are headed in the right direction. Diversifying energy sources, raising production standards, moving towards market-based prices, and improving interregional connectivity will

all help facilitate the healthy development of the Chinese energy industry.

Also in the foreseeable future the industrial sector will remain the largest energy consumer with residential and transportation rapidly increasing. There will be high demand to develop the energy supply infrastructure in the next 10 years. Coal will remain the dominant energy source followed by oil and natural gas.

The energy industry faces many challenges; some of these include: Energy supply resources are located far from the major demand centers. The largest and fastest growing indus-

trial centers are in the most developed eastern and southeastern areas. The transportation and transmission of energy will present a major bottleneck.

Industries must improve their energy consumption efficiency and move towards best-in-class productivity performance. This requires introduction and wide use of state-of-art technology in production and management.

All industries must make major efforts to reduce environmental pollution and focus on environmental protection.

ABB, with its broad portfolio of products, systems and services to support

utilities and industrial production, is best positioned to help Chinese customers in their challenging tasks.

This article is based on contributions in *ABB Review Special Report China* (2005).

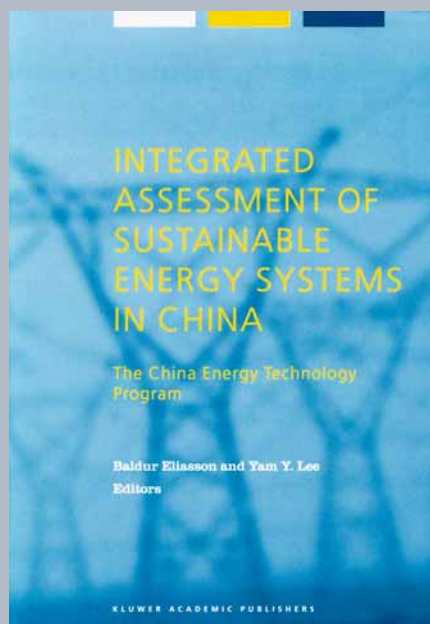
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## The China Energy Technology Program



The increasing global need for electricity – the largest part of which is generated from primary energy sources – is having a significant impact on the environment by the emission of anthropogenic greenhouse gases. Under the auspices of the Alliance for Global Sustainability, alternative strategies giving greater consideration to renewable energy sources have been the focus of a study, the China Energy

Technology Program or CETP. The work was led by ABB in cooperation with universities of world renown and three Chinese research centers. The aim was to identify and analyze the cradle-to-grave impact of a range of power generation options for sustainable growth, focusing on the needs of Shandong, a rapidly developing coastal province located between Beijing and Shanghai.

Some 70 scientists, engineers and academics of electricity from three continents contributed to this comprehensive three-year study, as did customers and consumers. The results were published in 2003 under the title “Integrated Assessment of Sustainable Energy Systems in China.”

In this publication, the CETP project group presents an integrated view considering not only the short-term techno-economic parameters but also the long-term environmental aspects of the available options. The encouraging results for Shandong province can be summarized in a few bullets:

- It is economically feasible and socially justifiable to generate more electricity with less air pollution.

- Cost-effective methods and technologies exist that reduce air pollution and stabilize green house gas emissions.

The technologies, the tools and the methodology developed within this program are certainly aimed at being universally applicable to situations similar to Shandong. Decision makers in China or elsewhere will be able to make better and more informed decisions related to the selection of appropriate technologies for electricity generation. As the Secretary General from the Ministry of Science and Technology of the People’s Republic of China, Mr. Dinghuan Shi, expressed: “The policy makers who read this book will most certainly find it invaluable in developing a sustainable system of energy production that will support China’s development goals. I am very glad to have been part of this successful project and look forward to continued international cooperation as the future unfolds.”