ENERGY ECONOMICS

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Understanding Energy Security in China

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Yi-Ming Wei is Distinguished Professor of Energy and Environmental Economics at the Beijing Institute of Technology (BIT). He is the Founding Director of the Center for Energy and Environmental Policy Research at BIT. His recent research and teaching focuses on energy policy and energy economics, CO_2 emission and climate policy, and energy and climate policy modeling. He has performed over 40 research projects for various Chinese governmental agencies including National Development and Reform Commission (NDRC), Ministry of Science and Technology (MOST), National Energy Administration (NEA), National Natural Science Foundation of China (NSFC), China National Petroleum Corporation (CNPC), STATE GRID Corporation of China (SGCC), and Chinese Academy of Sciences (CAS), and international organizations such as the World Bank and The Seventh Framework of European Commission (EU-FP7). He has published 20 books and over 300 papers in peer-reviewed journals including *Nature-Climate Change*, *Nature-Energy, Climatic Change*, *Energy Economics,* and *Ecological Economics*.

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Preface

Since the Industrial Revolution, fossil energy such as coal and oil has gradually replaced fuel wood as the main body of energy consumption. With the restraints in natural endowment and distribution of fossil energy resources, the international energy trade has emerged and expanded rapidly. The issue on how to ensure sustainable and stable energy supply in the complex international energy trade has aroused general concern among energy-importing countries. As the first world oil crisis caused by the oil embargo movement launched by Arab countries in 1973 led to huge economic losses of industrialized countries such as in European and American countries, the global economic growth rate decreased from 6.8% in 1973 to 2.8% in 1974. In order to cope with the oil supply shortage, the Organisation for Economic Co-operation and Development (OECD) established the International Energy Agency (IEA) in 1974 and initially defined the concept of energy security as the uninterrupted availability of energy sources at affordable prices, which means that the energy supply shortage amount shall not exceed 7% of energy imports in the last year, and there shall be no continuous and unaffordable high oil prices.

Based on the long-term attention to and research on the energy security issue, we consider that the national energy security can be divided into two levels, energy economic security and energy eco-environmental security, among which economic security refers to traditional energy supply security, and eco-environmental security refers to energy use security. **In this book, energy security is defined as reliable, affordable, and uninterruptible energy supply that can meet the demands of national economic development and ensure the production and use of energy never destroys the sustainable development of ecological environment.** In fact, the national energy security is just like a roof consisting of several tiles, and each tile represents an influencing factor of energy security, such as geopolitics, energy transport, energy prices, energy reserves, armed conflicts, sabotage, strikes, technologies, accidents, natural disasters, and pollutant emission of energy consumption. Just like any defective tile may affect or cause rain leakage of a house to some extent, any factor may affect the national energy security.

Since the beginning of the industrialized development stage, energy, similar to capital and labor, has become a production factor with significant influence on the national economy. In particular, in the current period with high oil prices, the energy crisis has become one of the important blasting fuses for evolution and development of the economic crisis. Therefore, energy security has been an important part of national security, arousing general concern among all countries in the world.

In recent years, the international energy market has been turbulent frequently. In 2008, the global financial crisis caused by the US subprime mortgage crisis led to collapse in international crude oil prices, sharp decrease in investment, and reduction in energy demands. However, the international oil prices

returned to the high level of USD 80/bbl rapidly when many international forecasters and investment banks reduced their future energy expectations in succession. The price fluctuation like a "roller coaster" had strong impact on the energy supply security of all energy-importing countries. With the outbreak of "Jasmine Revolution" in North African countries from the end of 2010 to the beginning of 2011 hitting the international energy market again when the countries hadn't gone out of the shadows of global financial crisis and European debt crisis, the crude oil prices rapidly broke through USD 100/bbl and 110/bbl in succession. The turbulent political situation in North African oil-exporting countries such as Sultan and Libya caused huge fluctuation to the oil investment, production, and trade. As the Gaddafi government was overthrown in August 2011, the storm of "Jasmine Revolution" blew over temporarily, and the international oil market went smoothly by a rare chance. *However, good times didn't last long. As the Iran nuclear crisis broke out again, with the further worsening of relationship between US and Iran, Iran claimed the use of force to block the Strait of Hormuz in case of any conflict between the United States and Iran. As the United States and Europe jointly carried out economic sanctions to Iran at the beginning of 2012, Iran responded intensely and threatened to interrupt the oil supply to all European countries. Meanwhile, the three main Asian oil-importing countries including China, Japan, and India successively reduced their oil import volumes from Iran under international pressure. In this case, the international oil market has been trapped in turbulence again, and the geopolitics of international energy has been increasingly complex and changeable.

As the largest energy-consuming country and the second largest oil-importing country in the word, China has faced with the net import of all fossil energy since 2009. With the increasing external dependence of energy year by year as well as frequent occurrence of "oil shortage," "coal shortage," and "electricity shortage," the energy security issue has been increasingly serious. What is the level of energy security in China? How to improve the national energy supply security and reduce the energy trade risks? All of these hot issues have attracted the common attention of decision-makers and researchers.

This book carries out systematic research starting with the history of world energy geopolitics and domestic energy security, focusing on hot issues such as the complexity of the international energy market, domestic energy import trade risks, domestic strategic energy reserve strategies, impact of energy crisis on the domestic economy, problems of domestic energy poverty, effects on the environment and health by energy consumption, potential analysis on key energy-saving industries, development potential of renewable energy, energy security early-warning and contingency plan, international comparison of energy security, etc. in order that national relevant decision-making departments provide decision-making reference and information support. The main issues discussed in this book include the follows:

- World energy supply and demand and evolution of China's energy security

  The distribution of world energy consumption and supply is significantly imbalanced. On the one hand, with the turbulent political situation in Middle

East and North Africa, the world energy production and trade patterns have been changing; on the other hand, under the impact of global financial crisis and European debt crisis, the world energy consumption pattern has also been changing quietly, and energy consumption in emerging countries such as China and India has expanded rapidly. All of these factors lead to a trend of increasingly diversified world energy trade. Meanwhile, the global climate change is attracting more and more attention. As various countries have taken actions and measures to mitigate the global climate change in succession, the world energy consumption structure is transforming into one focusing on clean and renewable energy. Based on the systematic analysis of the world's energy supply and demand situation, this chapter comprehensively elaborates the history of and current challenges for domestic energy security.

- World energy geopolitics and China's energy diplomacy

  The development history of energy, especially the development history of oil, is actually a history of local wars. In the history, wars caused by scrambling for oil resources broke out one after another, leading to the intricate and complex world energy geopolitical relations. China has gradually transformed from an energy-importing country to an energy-exporting country since the founding of the People's Republic of China (PRC), but has become an energy net-importing country again in recent years. The energy diplomacy policies of China have also constantly varied with its role in energy trade. Starting with the development history of the world energy geopolitics, this chapter discusses on the role and influence of energy diplomacy in national energy security.
- Oil price and China's energy security

  Since the financial crisis broke out in 2008, the international oil price has experienced steep rise and fall like a roller coaster due to the linkage between oil market and financial market, causing great impact on the energy security of oil-importing countries. In addition, the soaring oil price since 2002 has significantly stimulated the biofuel development in America and Europe, causing contradictory dispute between oil security and food security. This chapter carries out quantitative research on the complexity of oil market, impact of oil price fluctuation on the energy supply and demand and the economy, financial oil development risks, future trend of international oil price, China's energy security, etc.
- China's energy trade and transportation risk research

  In particular, the significant imbalanced distribution of world energy resources, the highly concentrated and monopolistic international energy trade, and the long-distance energy transportation bring unpredictable risks to energy trade. At present, China's energy trade is mainly based on the oil import trade, which is frequently accompanied with unreasonable phenomena such as "buying when price rises and not buying when price drops" and "price-volume increase." Based on the systematic analysis of main transportation corridors for China's energy import, this chapter carries out quantitative research on the composite risk of China's oil import, risk comparison of crude oil trade between China and America, characteristics and transportation risk

analysis of China's coal trade, and characteristics and transportation risk analysis of China's natural gas trade, so as to provide decision-making support for the reduction of energy trade and transportation risks in China.

- Research on China's energy reserve strategies

  To ensure national energy supply security, China is accelerating the construction of the national strategic oil reserves and emergency coal reserves. In the face of intensive fluctuations of the international crude oil price, how can we minimize the total security cost through timely establishment and dynamic supplement of strategic reserves? In case of oil supply shortage in the future, how can we release the national strategic oil reserves to defuse the crisis? Which are the reserve strategies that should be taken to China's energy reserves according to different storage characteristics of oil, coal, and natural gas? For the problems above, this chapter sets up the optimization model and carries out quantitative research on China's energy reserve strategies.
- Research on key energy-saving regions and industries on the premise of ensuring energy security

  Significant energy saving is important to slow down the growth rate of energy imports and ensure national energy security. The energy-saving and emission-reduction work in different regions shall be adjusted according to the local conditions due to the extremely imbalanced regional economic development and energy consumption in China as well as the relatively large difference of marginal energy-saving costs in different economic regions. This chapter carries out quantitative research on the issues including the key energy-saving departments in the regions, the degree of inter-provincial difference of energy intensity among the departments, the key energy-saving regions of the departments, and the differences of energy-saving in residents' lives between rural and urban regions and among different regions, with the hope to provide decision-making information support for energy-saving and emission-reduction work of the 12th Five-year Plan.
- Role of clean and renewable energy in the national energy security

  With the rapidly decreasing reserve-production ratio of the global fossil energy as well as the increasingly serious negative effects of the use of fossil energy on the environment, energy security, especially fossil energy supply security, has become a great challenge for world economic development at present. Striving to develop clean and renewable energy and reducing the dependence on fossil fuels have become important ways for developed countries to improve their national energy security. This chapter carries out systematic analysis focusing on the utilization of clean and renewable energy, clean and renewable energy policies of major countries in the world, the potential of clean and renewable energy resources in China, and its influence on China's energy supply security.
- Energy poverty and energy use security

  Energy poverty is one of the three major challenges for energy development all over the world. The extensive existence of energy poverty restricts sustainable development in all countries in the world, especially the developing countries, hinders the establishment of the social justice systems, increases

the social environment pressure, threatens the health of residents, and further, influences the secure atmosphere of energy consumption. Energy poverty and energy use security are in a close relation of mutual restriction and mutual effect, so the energy poverty alleviation work will ultimately benefit the improvement of energy use security. China is one of the countries with concentrated population under energy poverty, but the composition of the population under energy poverty has certain specificity compared with other countries. This chapter carries out a systematic analysis on the influencing factors of energy poverty, the relation between energy poverty and public health, and the relation between energy poverty and energy use security, as well as quantitative research on the current situation of regional energy poverty in China.

- Research on the impact of energy crisis on China's macro-economy

  An energy crisis is always the blasting fuse of an economic crisis. The three energy crises since the 1970s have caused significant impacts on the world's economic growth, social inflation, employment, etc. As the world's biggest energy consumer and second largest oil importer, China relies more and more on foreign energy. In case of any energy crisis in the future, we cannot imagine how great the impact on China's economy will be. Based on a comprehensive analysis on the impact of historical energy crises on macro-economy, this chapter carries out quantitative research on the impact of oil supply shortage and oil price rise on China's macro-economy by the China Energy & Environmental Policy Analysis (CEEPA) system.
- Energy consumption and public health in China

  As the deterioration of urban air quality seriously threatens the health of urban residents, the urban air pollution in China has become an important influencing factor of national energy use security. Urban pollution in most cities of China is mostly as a result of coal burning, with pollutants mainly occurring from fossil energy consumption. Starting with the issue on how energy consumption influences the environment and public health, this chapter carries out quantitative research on the evaluation on health effect in the environment with urban atmospheric pollution, the economic evaluation on urban atmospheric pollution and public health effect, the evaluation on health effect in the environment with pollutant emissions from major energy consumption departments, and the influence of pollutant emissions from major energy consumption departments on public health as well as the economic evaluation.
- Research on the comprehensive comparison of energy security in typical countries

  Energy-importing countries are different in the energy consumption structure, energy import resources, energy reserve modes, and relevant energy policies depending on their different natural endowment, geographic locations, and geopolitics of energy resources. In order to ensure energy security, America and other developed countries have established the International Energy Agency, on the one hand, and successively prepared and introduced a series of policies and measures for ensuring the energy security, on the other hand. For both supply security and use security, this chapter establishes a set

of energy security evaluation index systems and carries out quantitative research on the changing trend of energy security in China, America, Germany, Japan, and India in recent years, so as to provide decision-making support for ensuring China's energy security.

- Outlook of China's energy security in 2020

  In the future, what will be the changing trend of China's energy supply and demand? How will energy trade and transportation risks change? How will energy reserves develop? Can energy poverty be controlled or solved? For the problems above, based on the quantitative researches in previous chapters, this chapter carries out forecasting analysis on China's energy security in 2020 and puts forward policy recommendations on China's energy security policies.

To further be committed to scientific research, personnel training, and international exchange of energy and environmental policies, in 2006, I cooperated with professors such as Yong-Fa Xu and Ke-Yu Liu of CNPC Economic and Technology Research Institute to found the Center for Energy and Environmental Policy Research[1] and served as the first Director of the center. In 2009, invited by Academician Hai-Yan Hu, President of Beijing Institute of Technology (BIT), and Professor Da-Cheng Guo, Secretary of the Party Committee, I together with the core members of my team joined BIT and established the Center for Energy and Environmental Policy Research, BIT (CEEP-BIT), subordinate to the School of Management and Economics, BIT, with the approval of the President's Office Will.

For this book, Yi-Ming Wei and Gang Wu were responsible for the overall design, planning, organization, and compilation; Gang Wu, Hua Liao, Jian-Ling Jiao, Qiao-Mei Liang, Lan-Cui Liu, Lu-Tao Zhao, Shi-Wei Yu, Zhong-Yuan Ren, Bin Fang, Kang Li, Liang-Qiong Xiong, Wei-Dong Zhao, Zhi-Shuang Zhu, Ke Wang, Bing Wang, Tao Wang, Qian Wang, and Yun-Fei Yao completed the contents of relevant chapters in this book. Zhao-Hua Wang, Ju-Liang Jin, Zhi-Yong Han, Jiu-Tian Zhang, Xiao-Wei Ma, Bao-Jun Tang, Yue-Jun Zhang, and Rui-Guang Yang participated in the discussion and proofreading of partial chapters in this book. This book is the manifestation of the collective wisdom of the Center for Energy and Environmental Policy Research.

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Thank to all authors mentioned in the citation of this book!

Inevitably, there might be some defects, deficiencies, and even mistakes in this book due to our limited knowledge. Please don't hesitate to criticize and correct us!

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Chapter 1

Review of World Energy Situation and China's Energy Security

The global climate protection, financial crisis, European debt crisis, "Jasmine Revolution" in North Africa, and Iranian nuclear crisis in the Middle East have given rise to quiet but profound changes in the world's energy trade and consumption patterns. With the emergence of energy trade in China, India, and other developing countries, as well as the decreasing energy consumption in the United States and some developed countries of Europe, the world's energy consumption structure is shifting to clean and renewable energy resources. In this context, how will the evolution of world energy supply–demand pattern impact China's energy security? What are the challenges against China's energy security? How to interpret energy security in the new situation? This chapter will address these issues from such aspects as:

- What are the new trends in world energy development?
- What are the changes in world energy trade?
- How does the world energy consumption structure evolve?
- What are the challenges against China's energy consumption and energy security?
- How to interpret the energy security in the new situation?

1.1. Review of World Energy Development

1.1.1. Global Fossil Energy Reserves Are Abundant but Unevenly Distributed

- Coal remains to be the world's most widely distributed fossil fuel with the largest reserves. The BP (2011a) statistics indicate global proved coal reserves of 860.938 billion tons by the end of 2010, about 4.6 times the crude oil reserves (188.788 billion tons). The world coal reserve-production ratio was 118 years in 2010, and coal was still the energy source with the largest reserve-production ratio among all the fossil fuels. According to *the Energy Resource Survey* data of World Energy Council (WEC), the coal resources in Europe and Eurasia, North America, and the Asia-Pacific region accounted for more than 95% of the world's coal resources. The recoverable proved coal reserves in Europe and Eurasia were 304.6 billion tons, accounting for 35.4% of the total reserves. The proved recoverable coal reserves in Asia-Pacific

region were 265.843 billion tons, accounting for 28.5% of the total reserves. The proved recoverable coal reserves in North America were 245.09 billion tons, accounting for 28.5% of the total reserves. The total proved recoverable coal reserves in Africa and the Middle East were 328.95 billion tons, accounting for 3.8% of the total reserves. And the proved recoverable coal reserves in Central and South America were 125.08 billion tons, accounting for only 1.5% of the total reserves. The distribution of global proved recoverable coal reserves is shown in Figure 1.1.

From the country point of view, the coal reserves of the United States were 237.3 billion tons, accounting for 27.6% of the total reserves and ranking first around the world, with a reserve-production ratio of 241 years. The coal reserves of Russia were 157.01 billion tons, accounting for 18.2% and ranking second in the world, with a reserve-production ratio of 495 years. China followed the United States and Russia to rank third in the world, with proved recoverable coal reserves of 114.5 billion tons, accounting for 13.3% of the total reserves, and a reserve-production ratio of 35 years. The low reserve-production ratio of China was, on the one hand, due to its coal yield of 2.85 billion tons in 2010, which was larger than other countries; on the other hand, the low recovery rate of China's coal mining resulted in serious waste of resources.

- From the perspective of reserve-production ratio, the global oil reverses are abundant. The BP (2011a) statistics indicate that the global proved oil reserves had been increased to 1,383.2 billion barrels at the end of 2010 from 667.5 billion at the end of 1980, at an average annual growth rate of 2.5%. The global proved oil reserves from 1980 to 2010 are shown in Figure 1.2. As of 2010, the reserve-production ratio was 46.2 years.

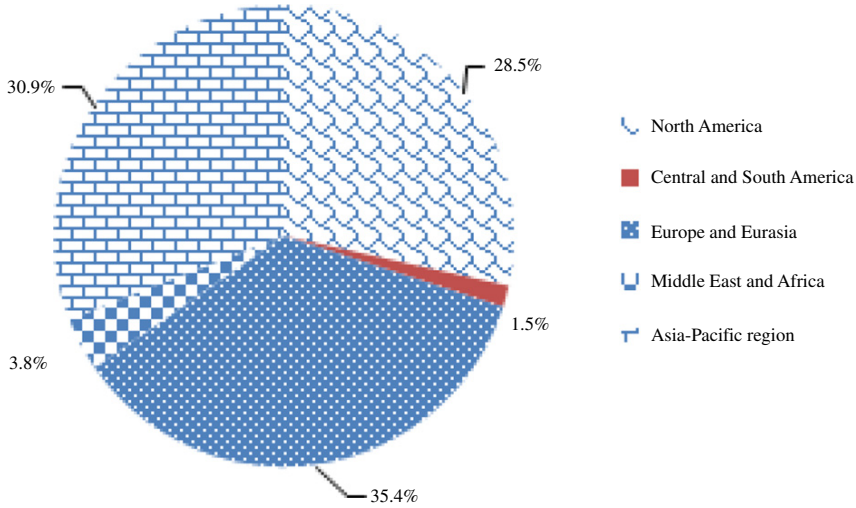

Figure 1.1. Proved Recoverable Coal Reserves in Different Regions (2010).

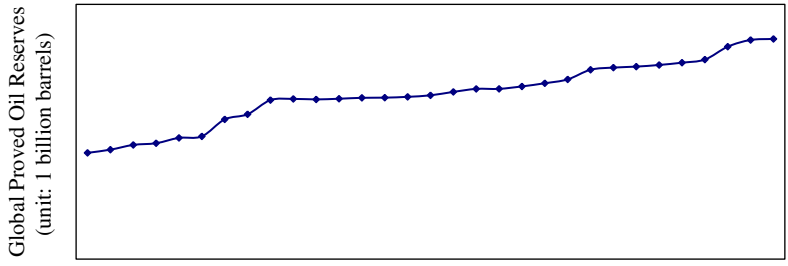

Figure 1.2. Global Proved Oil Reserves (1980−2010).

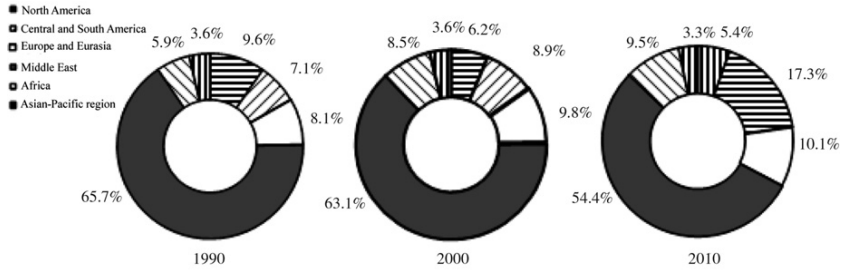

Figure 1.3. Proved Crude Oil Reserves in Different Regions.

The world's crude oil resources were regionally characteristic and unevenly distributed. According to BP (2011a) data, the percentages of proved crude oil reserves in different regions in 1990, 2000, and 2010 are shown in Figure 1.3.

It is observed from Figure 1.3 that crude oil was widely distributed in the world, which scattered in more than 50 countries of North America, Central and South America, Europe and Eurasia, Middle East, Africa, and the Asia-Pacific region. The oil reserves of the top 10 countries accounted for 81.5% of the global total reserves in 2010, among which Saudi Arabia, as the country with the largest oil reserves, took up 19.1% of the total. Central and South America surpassed Eurasia to become the world's second largest oil-producing region, with proved oil reserves of 239.4 billion barrels. This is mainly due to the significant increase of Venezuela's proved oil reserves, of which the 76.8 billion barrels of proved crude oil reserves accounted for 6.9% of the total reserves in 2000. The reserves surged to 211.2 billion barrels in 2010, accounting for 15.3% of the total. In the same year (2010), the proved crude oil reserves of Europe and Eurasia ranked third in the world and accounted for 10.1% of the total reserves. Africa followed Eurasia to account for 9.5% of the total reserves, while North America and the Asia-Pacific region had lower proved oil reserves accounting for 5.4% and 3.3%, respectively, only.

The world's top 10 countries showed different paces in the growth of proved oil reserves. The proved reserves of Venezuela, as the fastest-growing country in

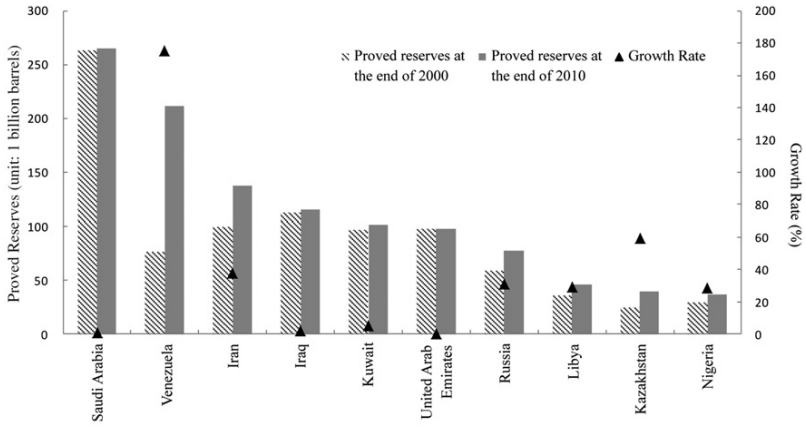

Figure 1.4. World's Top 10 Countries of Oil Reserves and Annual Growth Rate (2010).

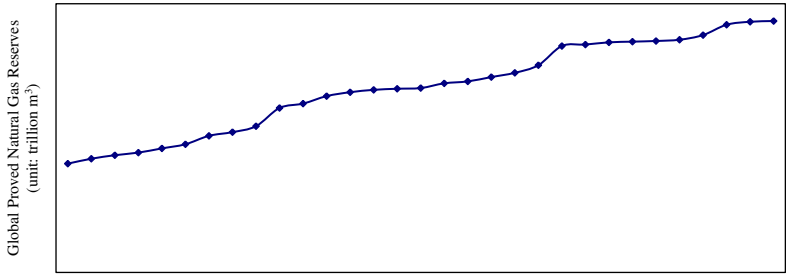

Figure 1.5. Global Proved Natural Gas Reserves (1980–2010).

the world, increased by 174.8% in 2000–2010, followed by 59.2% of Kazakhstan and 37.7% of Iran (BP, 2011a), as shown in Figure 1.4.

- The proved natural gas reserves grew with stability. As shown in Figure 1.5, the global proved natural gas reserves grew at an average annual growth rate of 2.7% from the 80.97 trillion m^3 in 1980 to 187.14 trillion m^3 at the end of 2010 (BP, 2011a), demonstrating a stable growth of proved natural gas reserves in the past 30 years. As of the end of 2010, the global natural gas reserve-production ratio was 58.6 years.

The world's natural gas was unevenly distributed, mainly in the Middle East, Europe, and Eurasia. According to the BP (2011a) statistics, the natural gas reserves of Middle East accounted for 30.2% of the world's total reserves, although it was not as absolutely dominant as oil reserves in the world; the proved natural gas reserves of Europe and Eurasia were 63.1 trillion m^3, accounting for about 33.7% of the total; and thus, the natural gas reserves of the

two regions accounted for about 75% of the total. The Asian-Pacific region and Africa were ranked third and fourth with respective reserves of 16.2 and 14.7 trillion m^3, accounting for 8.7% and 7.9% of the total. And the proved natural gas reserves in North America and Central and South America were 9.9 and 7.4 trillion m^3, respectively, accounting for only 5.3% and 4% of the total, as shown in Figure 1.6.

From the country's point of view, Russia maintained the largest reserves, accounting for 23.92% of the world's total, and Iran (15.82%), Qatar (13.53%), Turkmenistan (4.29%), and Saudi Arabia (4.28%) (BP, 2011a) followed successively. The reserves of the top 10 countries accounted for 77.34% of the world's total reserves, as shown in Figure 1.7.

1.1.2. Global Primary Energy Consumption Hits a Record High

The global energy consumption in 2010 reached the historical peak prior to the 2008 financial crisis. After the financial crisis caused a negative growth of 1.5%

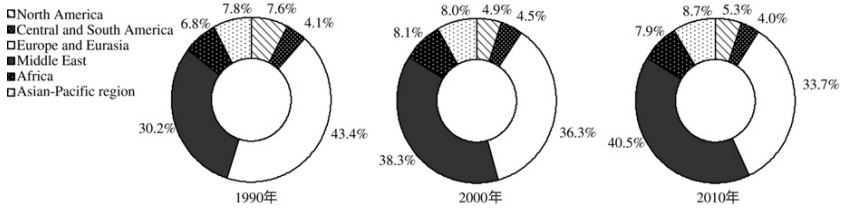

Figure 1.6. Proved Natural Gas Reserves in Different Regions.

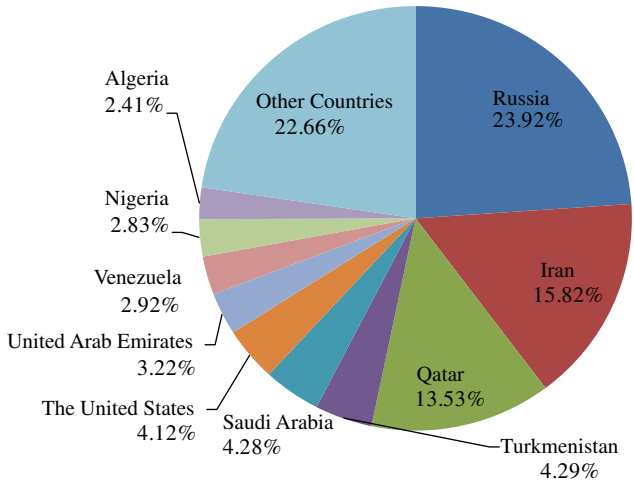

Figure 1.7. Proportions of World's Top 10 Countries of Natural Gas Reserves (2010).

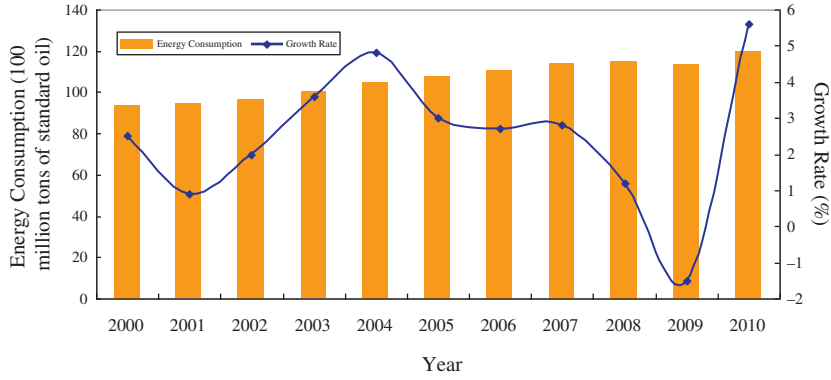

Figure 1.8. Global Primary Energy Consumption and Growth Rate (2000–2010).

to the global primary energy consumption in 2009, the world economy ushered in a periodical recovery in 2010, with a global primary energy consumption growth of 5.6% over 2009, as the fastest-growing year as of 1973 (see Figure 1.8) (BP, 2011a). The demands for all energy types were in robust growth, adding up to 12 billion tons of standard oil, which went beyond the peak reached before 2008 economic recession, that is the 11.5 billion tons of standard oil in 2007.

In 2010, China's energy consumption occupied the first place in the world, while that of the United States resumed growing. According to BP (2011a) statistics, China's primary energy consumption reached up to 2.432 billion tons of oil equivalent in 2010, accounting for 20.3% of the global total consumption and ranking first in the world. The proportions of other countries across the Asia-Pacific region (17.8%) and the Middle East (5.8%) in the global primary energy consumption also increased significantly. The primary energy consumption of the United States reached the oil equivalent of 2.286 billion tons in 2010, accounting for 19.0% of the global total and ranking second in the world. For the perspective of regional consumption proportion, North America, Europe, the former Soviet Union, Latin America, and Africa were 23.1%, 16.4%, 8.3%, 5.1%, and 3.1%, respectively. With regard to the growth rate, the primary energy consumption of China increased by 11.2% in 2010, compared with the 3.7% growth of the United States, as the first resumption of growth since 2008.

The global energy consumption growth was strongly consistent with the economic growth speed. As an important production and living resource, the global energy consumption is closely related to the economic growth, which increases and declines with the economy. According to the global gross domestic product (GDP) growth data of World Bank and global energy consumption growth data of BP (2011a), the global economic growth rate was higher than the energy consumption growth rate in most cases, as shown in Figure 1.9. Based on our calculations, every 1% growth of global economy drove about 0.7% of energy demand growth.

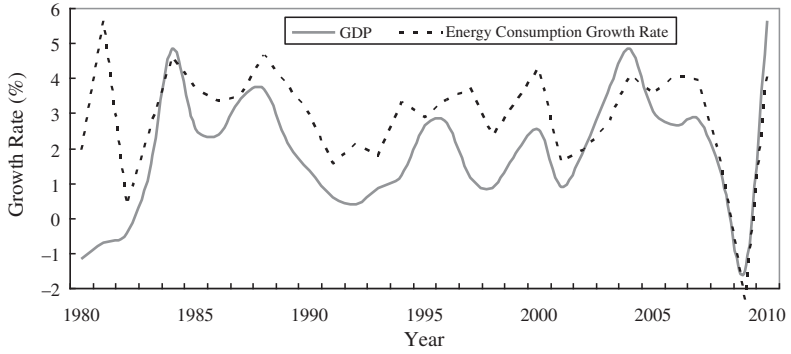

Figure 1.9. Global GDP Growth Rate and Energy Consumption Growth Rate (1980–2010).

Both the countries of Organization for Economic Co-operation and Development (OECD) and non-OECD member countries had an energy consumption growth rate above the historical average. According to BP (2011a) statistics, the energy demand of OECD member countries increased by 3.5%, as the largest increase rate since 1984, while that of non-OECD member countries increased by 7.5%, 63% higher than that in 2000. The global oil consumption increased by 2.7 million barrels every day in 2010 following a decline in two consecutive years, and the record of 87.4 million barrels per day was set with an increase rate of 3.1%. Wherein, the oil consumption of OECD member countries ushered in the first increase since 2005, at an increase rate of 0.9%, that is, an increase of 480 thousand barrels per day. The oil consumption of non-OECD member countries sets a new record to an increase of 2.2 million barrels per day at an increase rate of 5.5%. The primary energy consumption of non-OECD member countries accounted for more than half of the total, which increased from the 42.1% in 2000 to 50.9% in 2008 and surpassed OECD member countries for the first time, with a proportion of 53.6% of the world's total in 2010, as shown in Figure 1.10. This is mainly because of the following reasons: (1) with the completion of industrialization and urbanization in most OECD member countries as well as the transfer of energy-intensive industries from developed countries to developing countries, the industrial structure has gradually shifted to low energy consumption; (2) some developing countries, including China, India, Brazil, and Russia, showed up high economic growth rate and rapid energy consumption growth in recent years, while the OECD member countries presented low economic growth rate and slow energy consumption growth; and (3) developed countries attach great importance to energy saving and energy efficiency improvement.

1.1.3. Global Renewable Energy Production and Consumption Grow Steadily

In the context of dealing with climate change worldwide, reducing or mitigating fossil energy consumption while energetically developing renewable energy have

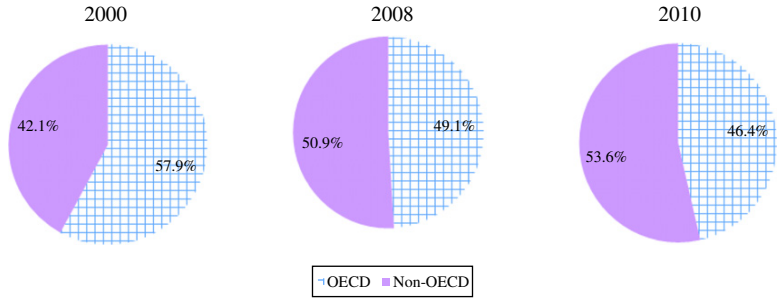

Figure 1.10. Changes in Proportions of Energy Consumption in OECD and Non-OECD Member Countries.

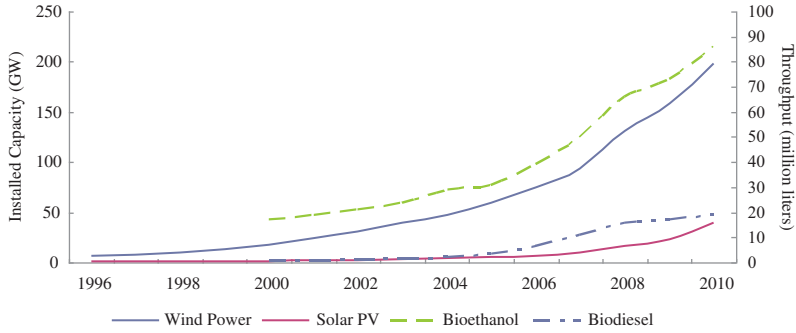

Figure 1.11. Global Renewable Energy Installed Capacity or Throughput (1996–2010).

been the concerns of all countries, which has resulted in a substantial increase of global renewable energy power generation and biofuel in recent years. According to the statistics of Renewable Energy Policy Network for the 21st Century (REN21), the global installed wind energy capacity, installed solar PV capacity, and bioethanol and biodiesel throughput increased steadily, as shown in Figure 1.11.

The world's major renewable energies ushered in substantial increase in the total investment, installed capacity, and throughput within 2008–2010 (REN21, 2011), as shown in Table 1.1.

According to the statistics of BP (2011a) annual report, the global biofuel throughput increased by 13.8% to about 240,000 barrels per day in 2010, becoming the one with largest throughput growth among the world's liquid fuels. In 2010, the United States and Brazil turned out to be the major biofuel-producing countries in the world, accounting for 69.1% of the total, as shown in Figure 1.12. Nevertheless, other countries showed up rapid growth in 2010, for example, India increased by 84.5%, Argentina by 60.0%, and Australia by 41.8%.