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Understanding and Interpreting Energy Poverty in China

BY

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INVESTOR IN PEOPLE

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Abbreviations

AGECC	UN Secretary General's Advisory Group on Energy and Climate Change
ARPH	Annual Review of Public Health
BERR	UK Department for Business, Enterprise and Regulatory Reform
BMJ	British Medical Journal
CDM	Clean development mechanism
CO_2	Carbon dioxide
DECC	The Department of Energy and Climate Change, UK
DEFRA	UK Department of Environment, Food, and Rural Affairs
EEA	European Environment Agency
EHP	Environmental health perspectives
EHS	English Housing Survey
GBD	The Global Burden of Disease
IEA	International Energy Agency
JAMA	Journal of the American Medical Association
LWS	Living in Wales Survey
MME	Ministry of Mines and Energy of Brazil
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NEJM	New England Journal of Medicine
NGO	Non-governmental organization
NIHCS	Northern Ireland House Condition Survey
NO_X	Nitrogen oxides
OECD	Organization for Economic Co-operation and Development
PNAS	Proceedings of the National Academy of Sciences
PPP	Purchase power parity
REN21	Renewable Energy Policy Network for the Twenty-first Century
SHCS	Scottish House Condition Survey
SO_2	Sulfur dioxide
UN	United Nations
WHO	World Health Organization

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Preface

In response to the challenges that were posed by energy poverty, a myriad of international organizations, such as the United Nations, the World Bank, and the World Health Organization, are in the process of legislating policies and plans. China, as the largest developing country, is being challenged with more complicated and severer energy poverty problems.

Energy consumption, energy structure, and energy capacity are the three key indicators of energy poverty measurements, which reflect economic development, resident health, and social equity of a specific country or region. There has been a discernible difference among various countries and regions. Most developing countries have a serious problem that their energy consumption per capita is far below the level in developed countries, yet it does not mean that energy poverty has been eliminated in rich areas. Overall, the essential characteristics of energy poverty in those countries are embodied in the following three aspects: (1) lower energy consumption; (2) inferior energy structure; (3) weaker energy capacity.

Energy poverty has considerable, even irreversible consequences for resident health. Over one-third of the global population mainly relies on solid fuels, such as coal and firewood, and one-fifth has no access to electrical services. Besides, inefficient use of traditional biomass results in serious waste of resources. In 2010, more than one million people died of indoor air pollution caused by combustion of solid fuels; this accounts for 12.5% of the total premature deaths.

Human society could hardly proceed without energy. However, a series of problems caused by energy poverty constrain development, affect the social equity, and aggravate the environmental pressure. China has presented itself by structural and regional differences in energy production and consumption. It is of great significance to alleviate, even eradicate, energy poverty for a sustainable development in the long run.

"Energy Economics: China's Energy Poverty Research," is a new achievement of CEEP-BIT on the basis of our efforts that have been long devoted to the poverty-related research. We hope that this book serves to call academy and authorities' attention to energy poverty, and it could provide policy support and decision basis for the government to ultimately eliminate energy poverty. Based on the analytical framework of energy economics, this book discusses crucial perspectives of energy poverty around the following issues:

(1) The latest progress in energy development in the world and in China has been comprehensively summarized and sortied out.

    Analysis of the research shows that: (1) the global economy is heading upwards and the uncertainties in international energy market are decreasing; (2) the global energy pattern is changing profoundly, and the US has taken

substantial steps in seeking energy independence; (3) China is challenged with energy saving and carbon reduction by both total amount control and intensity control; and (4) China is taking great efforts in tackling the increasingly worse air pollution. Furthermore, the world's energy poverty is mainly with the following characteristics: (1) developing countries have a low level of electricity service, which adds more difficulties to addressing global poverty; (2) household energy in developing countries relies on traditional biomass, which causes prominent environment and health problems; and (3) energy poverty population living in developed countries is with a high proportion of energy expenditure, which affects the overall social equity.

(2) Proper measurement and assessment methods for China have been proposed.

According to the status quo of China's economic and social development as well as the energy supply–demand relationship, along with the international understanding of energy poverty, "energy poverty" in this book is defined as the inaccessibility to modern energy services, especially to those abundant, affordable, high-quality, environmentally friendly energy services. Our research results show that: (1) differences of household energy use in urban and rural areas are notable and the energy poverty in rural area is prominent; (2) geographical differences in rural household energy use are obvious and the energy consumption is dominated by solid fuel; (3) rural energy facilities are inefficiently used, while clean cooking utensils are of low prevalence; and (4) household energy prices are increasing and there are disparities in the proportions of household energy expenditure between urban and rural.

(3) Energy poverty in different regions of China has been assessed.

Comprehensive regional assessment framework of energy poverty in China is constituted of 11 secondary indicators and 26 tertiary indicators by 4 categories. The assessment results indicate that: (1) overall energy poverty presents itself in a downward trend; (2) energy service availability has been improved; (3) there is no strong tendency toward a cleaner energy consumption structure; (4) Energy management system is not complete; and (5) affordability and high-efficiency in household energy use have been improved. Meanwhile, China's regional energy poverty is characterized by the following features: (1) comprehensive energy poverty situation in middle reaches of Yellow River and Yangtze River is relatively significant; (2) energy service availability of the middle reaches of Yangtze River is weak; (3) middle reaches of Yellow River have not performed well in using clean energy; (4) energy management systems of the eastern coastal and northwestern regions are not complete; and (5) the northeastern and southwestern regions have not performed well in achieving affordability and high efficiency of energy use.

(4) Impacts of energy poverty on residents' health have been estimated.

Similar to economic poverty, energy poverty has certain influences on residents' health. This book discusses the impacts of energy poverty on urban residents' health and finds that: (1) energy poverty still exists in China's urban areas to some degree, which has negative effects on residents' health;

(2) solid fuels' combustion, household energy inefficiency, and indoor thermal discomfort are the three critical factors which might influence residents' health in urban areas; and (3) it is crucial to improve energy structure and to induce household energy behavior to eliminate energy poverty.

(5) Utilization of solid fuels in rural areas and its impacts on rural people are investigated.

Compared to urban areas, China's rural areas are less developed and the situation of energy poverty is prominent. Based on the data of China Health and Nutrition Survey, the characteristics of the consumed energy for cooking in rural areas are investigated as follows: (1) rural people mainly rely on solid fuels; (2) household income has great impact on the choice of energy sources for cooking; (3) great differences occur in the energy consumption for cooking in different rural areas; (4) diversity of rural energy consumption for cooking has been progressively realized; and (5) dependence of rural people on solid fuels is decreasing.

Community health has been affected by solid fuels in rural areas. Toxic gas and inhalable particles, which are from solid fuels combustion in simple cooking stoves, are the primary threats to community health. Women chiefly in charge of cooking are faced with great harm. Besides, the impacts of solid fuels on human health are also usually determined by many other factors such as sanitation of living condition and personal preference.

(6) Relationship between energy poverty and economic development is analyzed.

Energy poverty is closely related to economic development and poverty. This book takes energy poverty and economy as a unit, discusses the impacts of per capita income, education, climatic condition, and energy price on energy poverty, and confirms the interactions between energy poverty and economic development.

The results demonstrate that: (1) there is an interaction between energy poverty and economic development; (2) the energy structure in developed countries and areas is becoming cleaner; (3) economic development promotes living electricity consumption, and the elasticity of per capita electricity consumption with respect to per capita GDP is 0.95; and (4) economic development is helpful in changing resident energy structure, and if other conditions stay as usual, the share of electricity consumption for living increases by 0.0617% as per capita GDP increases by 1%. Due to the positive correlation and casual relationship between energy poverty and economic development, it is an effective way to further alleviate or even eliminate energy poverty by keeping China's stable and rapid economic development and continuing to improve the living standards of the population.

(7) Relationship between clean energy development and energy poverty is discussed.

Energy poverty focuses on the availability of modern energy services, which is actually the imbalance in energy development. The results show that (1) wind energy develops fast, which contributes to energy poverty eradication; (2) hydropower is rich, which covers the areas of considerable

energy poverty groups; (3) solar energy is diversely used, which can deal with the energy consumption problem for energy poverty population; (4) biomass energy is effectively utilized, which helps in energy poverty eradication in rural areas; and (5) nuclear power has large potential, which may be a solution to energy poverty.

(8) Relationship between climate change as well as adaptation strategies and energy poverty is investigated.

Climate change affects energy poverty through availability, that is, it may destroy stable operation of electricity grid, threaten regular energy production, and disturb exploitation of clean energy. According to future climatic scenarios, the vulnerability of China's hydropower keeps growing, especially in the primary hydropower provinces and western poor regions. The impacts of climatic extremes on China and Japan are compared and it is found that the negative effects on China are worse than Japan when the same degree of power failure happens. The reductions in GDP, total output, and employment of China are 2 to 3 times bigger than Japan, and those in resident welfare are 3 to 5 times. On the one hand, the differences in socioeconomic vulnerability between China and Japan are mainly caused by the structure factors. On the other hand, climate change adaptation policies have positive effects on energy poverty reduction; the emissions trading policy improves the structure of power generation; the fiscal taxation policy encourages clean power generation; the pricing policy ensures the equity of energy use; and the financial and trade policy allows a better energy consumption structure.

(9) Policies and actions for energy poverty reduction are summarized.

Governments around the world are concerned about energy poverty and have adopted a series of targeted policies and actions. However, due to the different national conditions and stages of development, the policies and instruments addressing energy poverty are not the same in different countries. China has made great efforts to reduce energy poverty and the achievements are distinguished. It is predicted that China would realize the overall electricity coverage by 2015. Grid infrastructure and distributed generation equipment are developed together to ensure commercial energy supply for most areas where electricity is inaccessible. Different regions use their own measures to exploit energy according to the actual situation. The coverage rate of clean energy such as natural gas, methane, solar energy, and wind energy has been greatly expanded, and residents are able to have an easier access to energy services that leads to cleaner energy consumption patterns. It would provide an adequate scientific basis to justify the energy poverty alleviation policies in China by scrutinizing the policies and instruments of China and other countries in addressing energy poverty.

Energy poverty might restrain economic development, harm human health, and hinder well-being improvement. Currently, China is in a transitional phase of rapid development; China is not only faced with the energy poverty problems

in developing countries, but also characterized by energy poverty features in developed countries. As a result, policymakers should attach great importance to energy poverty and try to eliminate it.

People's living condition in China has been improved significantly since the inauguration of the policy of reform and opening up. The share of poverty group in total population has decreased and energy poverty has been extensively relieved. However, barriers, such as regional imbalance in socioeconomic development, still occur, the continuing trend that energy structure featured by coal, and also risks in environmental and health detriment induced by climate change. Therefore, energy poverty will be remaining as a big challenge to China for a relatively long period.

China should make regional development strategies and new city planning, as well as aim at the equal development of regional and urban–rural economy. Clean energy and renewable energy should be promoted in accordance with the local situations. Meanwhile, it is necessary to advance industrial adjustment and support technical reconstruction in the energy field. Besides, the advanced and new technologies that are specific to certain sector or area should be appropriately introduced into China. Overall, we are determined to spare every effort to address the energy poverty, construct the ecology civilization, and finally realize our China Dream.

In 2006, Professor Yongfa Xu and Professor Keyu Liu from the CNPC Economics & Technology Research Institute and Professor Yiming Wei co-founded the Center for Energy and Environmental Policy Research (CEEP), and Professor Yiming Wei was appointed as the Director of the CEEP. In 2009, as invited by the Board of Trustees, Professor Yiming Wei joined the Beijing Institute of Technology (BIT) and then the CEEP was affiliated with the School of Management and Economics. CEEP-BIT is always dedicated to scientific research in environmental and energy policy, environmental education, community service, and international collaboration.

The overall deployment of this project was conducted under the leadership of Professor Yi-Ming Wei. Further, Hua Liao, Ke Wang, Yu Hao, Hao Chen, Yunfei Du, Jing-Li Fan, Yixuan Gao, Huanan Li, Kang Li, Mojie Li, Wenling Liu, Yiming Liu, Ye Ma, Zhifu Mi, Mengling Pei, Xin Tang, Bing Wang, Lu Wang, Qian Wang, Yaxuan Wang, Jiayin Yin, Hao Yu, Xiao-Chen Yuan, Jinliang Zhang, and Yan Zhang participated and completed the relevant sections of this book. Jiutian Zhang, Gang Wu, Rui-Gguang Yang, Kai Wang, Zhen-Hua Feng, Yun-Fei Yao, Lan-Cui Liu, Qiao-Mei Liang, Xiao-Wei Ma, Yue-Jun Zhang, Baojun Tang, and Zhaohua Wang participated in the research, discussion, and proof-reading of certain chapters. This book is the pearl of wisdom of the CEEP.

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We express our sincere gratitude to all of them for giving us great support and assistance. Special thanks are given to the administrators of Beijing Institute of Technology and the School of Management and Economics. We are extremely grateful to all the authors who were contributing to Energy Economics: China's Energy Poverty Research. Your questions, suggestions, and comments would be greatly appreciated. Thank you!

Chapter 1

Global Energy Development and Energy Poverty

In response to the challenges that were long posed by energy poverty, a myriad of international organizations, such as the United Nations (UN), the World Bank, and the World Health Organization (WHO), are in the process of legislating policies and plans. China, as the largest developing country, pays much attention to this issue. Energy consumption, energy structure, and energy capacity are three key indicators of energy poverty measurements, which mirror economic development, resident health, and social equity of a specific country or region. Over one-third of the global population mainly relies on solid fuels, such as coal and firewood, and one-fifth has no access to electrical services. According to the global burden of disease (GBD), indoor air pollution (IAP) caused by solid fuel use is the third leading cause of death, and it caused 3.48 million premature deaths in 2010. Although China has achieved universal electric service, solid fuel continues to play an important role in people's daily life. In 2010, more than one million people died of IAP caused by combustion of solid fuels, accounting for 12.5% of the total premature deaths, which is equivalent to the population of premature deaths caused by outdoor particles pollution (1.23 million). Based on features of "China Energy Report" series, this chapter focuses on the following basic issues:

- The basic features of the world and China's energy development.
- The adjustments that are taking place in the world's energy landscape.
- The main features of the world's energy poverty.
- Policies and actions of international organizations to address energy poverty.

1.1. General Situation of Energy Development in the World

1.1.1. Energy Consumption Increases Steadily, but the Growth Rates Vary among Countries

Worldwide, energy consumption shows a strong positive relationship with economic development. As can be seen in Figure 1.1, from 1980 to 2012, world primary energy consumption increased by 6.6 billion toe (ton of oil equivalent) to 12.5 billion toe, at an average annual growth rate of 2%. Gross world product (GWP) reached 73.3 thousand billion dollar (2005 constant prices, Purchase Power Parity (PPP) and similarly hereinafter) in 2012, an increase from 26.5 thousand billion dollar in 1980, at an average annual growth rate of 3.2%. Energy

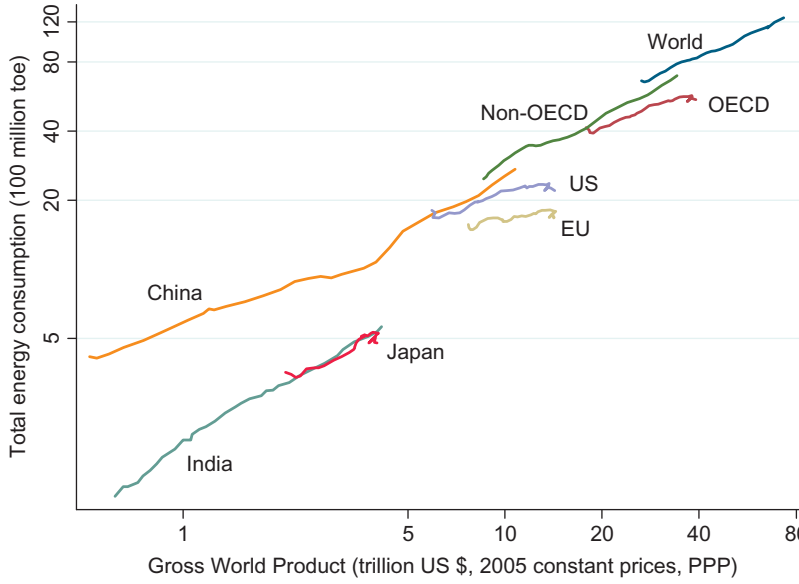

Figure 1.1. Gross World Product and Energy Consumption (1980–2012). *Sources*: IEA and World Bank.

consumption per GWP decreased from 0.25 kgoe (kilogram of oil equivalent) per dollar in 1980 to 0.17 kgoe per dollar in 2012, a decrease by 32.1%. Energy consumption per capita increased from 1.5 toe in 1980 to 1.8 toe in 2012, an increase by 18.5%. Every 1% growth of GWP increased the energy demand by 0.62%.

Countries at different development stages showed different growth rates of energy consumption. The growth rates of energy consumption in developing countries were far higher than those in the developed. As can been seen from Figure 1.1, during the period of 1980–2012, the growth rate of energy consumption was 0.9% in OECD countries, 3.3% in non-OECD countries, 0.6% and 0.9% in the United States and Japan, respectively, and 6.1% and 5.5% in China and India, respectively. On one hand, most OECD countries had completed the process of industrialization, and their industrial structure had transformed to low-energy consumption type. On the other hand, the high-speed growth of economy promoted an increase in energy consumption, and then the proportion of energy consumption in developing countries increased significantly. In addition, developed countries keep importing energy-consuming products from developing countries, which is also a reason for the increasing share of energy consumption among the developing countries. Energy consumption of non-OECD countries was 7 billion toe in 2012, which showed an increase from 2.5 billion toe in 1980, with the share of global energy consumption increasing from 37.5% to 56.0%. The share for the US decreased from 27.3% in 1980 to 17.7% in 2012, while the share of China increased from 6.3% in 1980 to 21.9% in 2012. China's energy consumption surpassed the US for the first time in 2010 and China became the world's foremost energy consumer.

1.1.2. Fossil Energy Dominates World's Energy Consumption, while Renewable Energy Develops Rapidly

From the perspective of primary energy consumption structure, fossil energy still dominates world's energy consumption. Oil consumption was 4.1 billion toe, accounting for 33.1% of total energy consumption and coal consumption was 3.7 billion toe, accounting for 29.9%. The sum of hydroelectric, nuclear energy, and other renewable energies accounted for 13.1% in 2012, as can be seen in Figure 1.2. Due to resource endowment, geographical location, and stage of development, different countries had different energy consumption structures. US and Japan mainly consumed petroleum; China and India mainly consumed coal, accounting for 68.5% and 52.9%, respectively; Norway, Brazil, and Canada mainly consumed hydropower because of their abundant water resources, accounting for 67.2%, 34.4%, and 26.2%, respectively; and France mainly consumed nuclear power, accounting for 39.2% (see Figure 1.3).

In recent years, because of the rising cost of fossil fuels and serious situation of environment pollution and climate change, almost every country increased their investment in clean energy, as a result of which the production and consumption of clean energy continues to increase (Table 1.1). From 1992 to 2012, renewable energy consumption (except for hydropower) increased from 32 to 237 million toe, with an annual growth rate of 10.5%, and the proportion of total energy consumption increased from 0.39% to 1.9%. From 2000 to 2012, solar power generation capacity increased from 1.4 to 100.1 million kW, with an annual average growth rate of 25.9%.

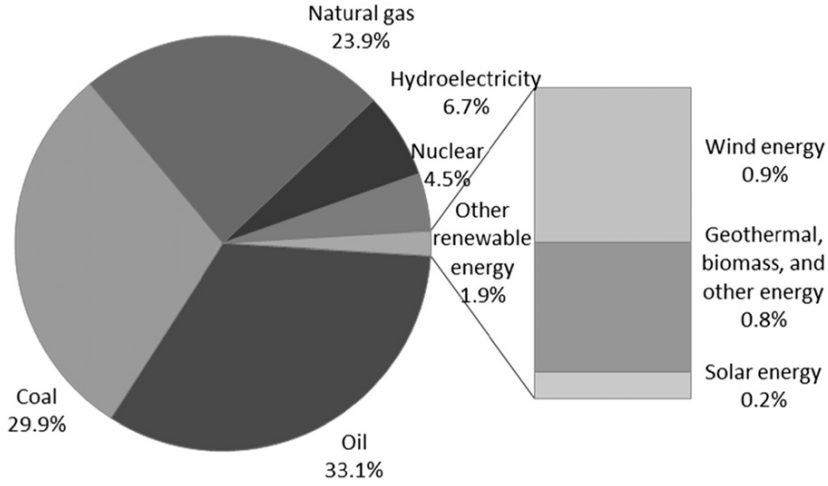

Figure 1.2. Structure of World Primary Energy Consumption in 2012.
Source: IEA.

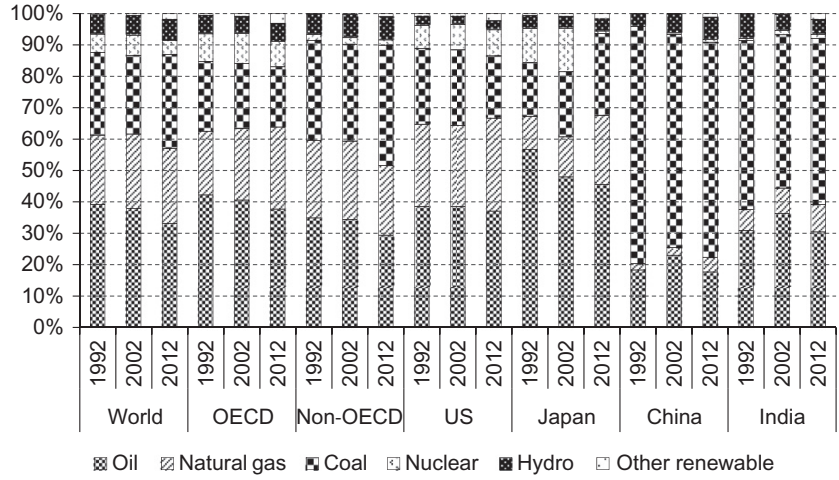

Figure 1.3. Structure of Primary Energy Consumption in Selected Countries. *Source*: IEA.

Table 1.1. World Renewable Energy Development (2010–2012).

Renewable Energy Development Indicators	**2010**	**2011**	**2012**
Annual new investment in renewable energy (100 million US$)	2,270	2,790	2,440
Renewable energy capacity (excluding hydro, GW)	315	395	480
Biomass power generation (kWh)	313	335	350
Hydropower installed capacity (GW)	935	960	990
Wind power installed capacity (GW)	198	238	283
Solar PV installed capacity (GW)	40	71	100
Concentrated solar power (GW)	1.1	1.6	2.5
Solar water heater capacity (GW)	195	223	255
Bioethanol annual production (100 million L)	850	842	831
Biodiesel annual production (100 million L)	185	224	225

Source: REN21.

1.1.3. World Fossil Energy Reserves Are Still Rich but Distribute Unevenly

The world's proven reserves of crude oil showed a steady upward trend. According to BP (2013) statistics, the world's proven reserves of crude oil were 146.8 billion tons at the end of 1992, 186.7 billion tons at the end of 2002, and 235.7 billion tons at the end of 2012, with an increase of 88.9 billion tons and an

annual growth rate of 2.4%, as shown in Figure 1.4. Oil resources' distribution was unbalanced in various geographical regions. The proven oil reserves of the oil-rich Middle East reached 109.3 billion tons, accounting for 48.4% of the world's total; Central and South America were next, whose proven oil reserves were about 50.9 billion tons, accounting for 19.7%; Asia Pacific had the least oil reserves, which was about 55 million tons, accounting for 2.5%. At country level, surpassing Saudi Arabia in 2010, Venezuela was the country with the world's largest oil reserves, whose proven oil reserves were 46.5 billion tons in 2012, accounting for 17.8% of the world's total reserves.

Natural gas is a relatively clean fossil energy, proven reserves of which have shown a rapid increasing trend during the past two decades. As shown in Figure 1.5, the world's proven reserves of natural gas were 117.6 trillion m^3 at the end of 1992, 154.9 trillion m^3 at the end of 2002, and 187.3 trillion m^3 at the end of 2012, with an increase of 69.7 trillion m^3 and an annual growth rate of 2.4%. The distribution of natural gas was much more unbalanced in geographical regions. The proven reserves of natural gas in Middle East and Europe and Eurasia, two natural gas-rich countries, were 80.5 and 58.4 trillion m^3, respectively, at the end of 2012, together accounting for 74.2% of the world's proven reserves. At the national level, Iran was the country with the world's largest natural gas reserves, whose proven natural gas reserves were 33.6 trillion m^3 in 2012, accounting for 18.0% of the world's total reserves; this was followed by Russia, whose proven natural gas reserves were 32.9 trillion m^3, accounting for 17.6%. In third position was Qatar, whose proven natural gas reserves were 25.1 trillion m^3, accounting for 13.4%.

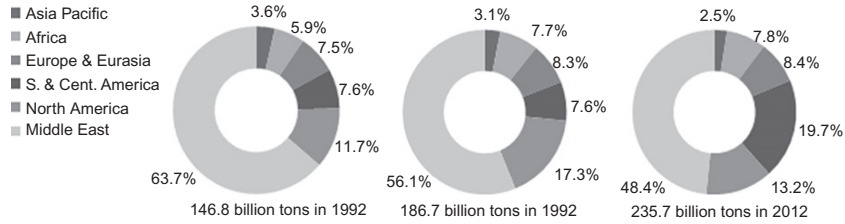

Figure 1.4. World's Proven Oil Reserves and Distribution. *Source*: BP.

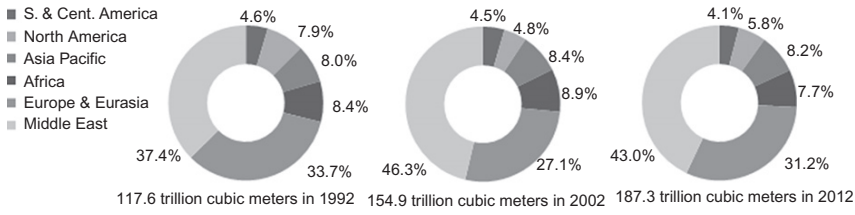

Figure 1.5. World's Proven Natural Gas Reserves and Distribution. *Source*: BP.

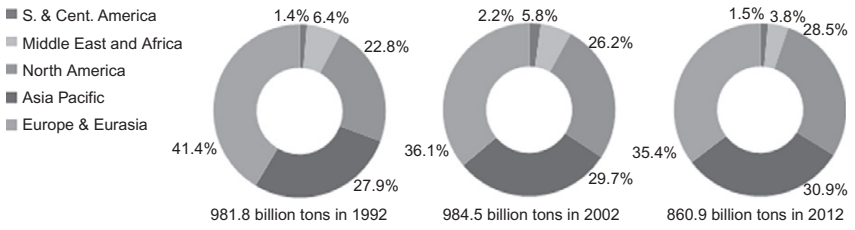

Figure 1.6. World's Proven Coal Reserves and Distribution. *Source*: BP.

The world's proven reserves of coal showed a slight decline in comparison to the level in 1992. As shown in Figure 1.6, the world's proven reserves of coal were 981.8 billion tons at the end of 1992, 984.5 billion tons at the end of 2002 after a slight increase, and 860.9 billion tons at the end of 2012. Coal owned the highest reserve-to-production ratio of fossil fuels – 109 years at the end of 2012. Coal resources are distributed mainly in Europe, Asia, and North America. Europe & Eurasia's proven coal reserves were 304.6 billion tons, accounting for 35.4% of the world's total proven reserves; Asia-Pacific region's proven coal reserves were 265.8 billion tons, accounting for 30.9%; North America's proven coal reserves were 245.1 billion tons, accounting for 28.5%; and the combined proven coal reserves for the rest of the world were 45.4 billion tons, accounting for 5.2%. At the national level, America had the world's largest coal reserves, whose proven coal reserves were 237.3 billion tons in 2012, accounting for 27.6% of the world's total reserves; this was followed by Russia, whose proven coal reserves were 157.0 billion tons, accounting for 18.2%. In third place was China, whose proven coal reserves were 114.5 billion tons, accounting for 13.3%.

1.1.4. Energy Trade Predominated by Crude Oil, but Natural Gas Trade Is Growing Rapidly

In 2012, global oil trade amounted to 2.73 billion tons, of which crude oil trade was 1.93 billion tons and product oil trade was 800 million tons. The US, as the world's foremost net importer of oil, imported oil mainly from Canada (27.9%), the Middle East (20.6%), and Central and South America (18.7%), and its net oil imports were 396 million toe in 2012, accounting for 14.5% of total global oil trade. China, the world's second leading net oil importer, imported oil mainly from the Middle East (40.8%), the former Soviet Union (16.8%), and West Africa (14.6%), and its net oil imports were 327 million toe in 2012, accounting for 12% of total global oil trade. Japan, the world's third leading net oil importer, imported oil mainly from Middle East (75%) and other Asia-Pacific countries (12.1%), and its net oil imports were 224 million toe in 2012, accounting for 8.2% of the total global oil trade.

Natural gas global trade amounted to 1.03 trillion m^3 in 2012, accounting for 31.2% of the total natural gas consumption, of which pipeline natural gas trade was 705.5 billion m^3 and liquefied natural gas trade was 327.9 billion m^3. The

top three net natural gas importers were Japan, Germany, and Italy, whose net natural gas imports were 122, 70, and 68 billion m^3, respectively (see Table 1.2). The top three pipeline natural gas exporters were Russia, Norway, and Canada, whose pipeline natural gas exports were 185.9, 106.6, and 83.8 billion m^3, respectively, accounting for 53.4% of the combined global pipeline natural gas exports in 2012. The top three pipeline natural gas importers were Germany, the US, and Italy, whose pipeline natural gas imports were 86.8, 83.8, and 59.7 billion m^3, respectively, accounting for 32.7% of the combined global pipeline natural gas imports in 2012. The top three liquefied natural gas exporters were Qatar, Indonesia, and Trinidad and Tobago, whose liquefied natural gas exports were 105.4, 25, and 19.1 billion m^3, respectively, accounting for 45.6% of the total global liquefied natural gas exports in 2012. The top three liquefied natural gas importers were Japan, South Korea, and Spain, whose liquefied natural gas imports were 118.8, 49.7, and 21.4 billion m^3, respectively, accounting for 57.9% of the total global pipeline natural gas imports in 2012.

Global coal trade is dominated by steam coal and coking coal. According to International Energy Agency (IEA, 2013a, 2013b, 2013c), from 1992 to 2012, steam coal trade increased from 300 million tons to 840 million tons – an average annual growth rate of 5.2% – and coking coal trade increased from 170 to 280 million tons – an average annual growth rate of 2.7%. Sub-bituminous coal and anthracite trade was growing rapidly. From 1992 to 2012, sub-bituminous coal trade increased from 3.4 to 50.5 million tons – an average annual growth rate of 14.5% – and anthracite trade increased from 2.3 to 102.4 million tons – an average annual growth rate of 20.9%. The top three net coal exporters were Indonesia, Australia, and the US, whose net coal exports were 380, 300, and 110 million tons, respectively, in 2012. The top three net coal importers are China, Japan, and India, whose net coal imports were 280, 180, and 160 million tons, respectively, in 2012.

1.1.5. Energy Poverty Exists Widely, Especially in Developing Countries

The energy consumption level and consumption pattern vary widely among countries worldwide. Annual energy consumption per capital in developed countries and oil-exporting countries was 3–10 tons of oil equivalent. Per capital energy consumption in most developing countries is far below those of developed countries, and US annual energy consumption per capita is four times more than the world's average. Among different social groups in the same country, the energy demand also is very uneven. In the majority of developing countries and regions, energy poverty is still a very serious issue. Currently, the world's energy poverty is mainly highlighted in the following aspects: first, energy consumption level is comparatively low in most developing countries; the second is the bad energy mix, such as lack of access to clean energy services, represented by electricity, while coal and traditional biomass are widely used; third, people living in poor areas can hardly afford the relatively expensive merchandise that run on modern clean energy. Energy poverty will lead to many adverse consequences on many sides such as health and education, and those are

Table 1.2. Producers, Net Exporters, and Net Importers of Natural Gas in 2012.

Country	Production (100 million m^3)	Proportion (%)	Country	Net Exports (100 million m^3)	Country	Net Imports (100 million m^3)
USA	6,810	19.8	Russia	1,850	Japan	1,220
Russia	6,560	19.1	Qatar	1,200	Germany	700
Qatar	1,600	4.7	Norway	1,090	Italy	680
Iran	1,580	4.6	Canada	570	Korea	480
Canada	1,570	4.6	Algeria	480	Turkey	450
Norway	1,150	3.3	Turkmenistan	370	USA	430
China	1,070	3.1	Indonesia	370	France	430
Saudi Arabia	950	2.8	Netherlands	340	UK	370
Netherlands	800	2.3	Nigeria	270	China	360
Indonesia	770	2.2	Malaysia	210	Ukraine	320
Other	11,490	33.5	Other	1,540	Other	2,830
World	34,350	100.0	World	8,290	World	8,270

Source: IEA.
Note: Net imports and net exports of natural gas including pipeline natural gas and liquefied natural gas.