CHAPTER FOURTEEN

"Beautiful China": "Chinese Dream" of Green Development

Since the reform and opening-up, with the industrialization and urbanization speeding up, China's economy has achieved a high-speed growth, making hundreds of millions of people shaking off poverty. But at the same time, the problem of environmental pollution has become increasingly prominent due to the expansion of the economic scale, the extensive mode of development, the substantial increase of coal-based energy consumption, and the low energy efficiency. The problems, such as ecosystem degradation, sharp increase of sulfur dioxide and carbon dioxide emissions, water pollution, and air pollution, are becoming more and more serious. For example, the problem like pollutants such as PM10, PM2.5, and haze has drawn great attention and criticism at home and abroad.

In order to solve serious environmental problems, Chinese government put forward such concepts as "scientific development" and "ecological civilization," vigorously promoting energy conservation and emission reduction by developing new industries such as new and renewable energy. The low-carbon economy has evolved from a high-end concept to a nation-wide initiative. Many fields such as new energy vehicles, industrial energy saving, low-carbon buildings, solar energy, wind energy, biomass energy, and geothermal energy have all witnessed rapid development. Despite many challenges such as high energy consumption of GDP and air pollution, China does not lag behind the developed countries in green economy. With the transformation of economic structure, the innovation of energy, and environmental management mechanism, China is expected to become the leader of global green economy and the pioneer of global "smart energy."

Environment problem in energy development is closely related to the economic development stage, especially the economic structure. With the industrialization process basically completed, the industrial structure upgrading accelerated and the proportion of service industry substantially increased, the total amount and structure of energy demand in China will undergo an important change, and the pressure on the environment will also be relieved to some extent. In order to promote the transition to

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clean energy, in addition to drawing on the experience of developed countries, it is crucially important to promote the implementation of the revolutionary strategy of energy production and consumption, and the innovation of relevant market mechanism and energy system. China's current efforts to promote reform and mechanism innovation are expected not only to alleviate the problems such as domestic abandonment of wind and light and lack of subsidies, and thus promote clean energy transformation, but also to give impetus to global green economic innovation and development. With the deepening of the new round of energy reform, the coordinated development of electric power trading market, green certificate trading market, and carbon trading market is expected to be the important system and mechanism guarantee of energy revolution and green development in China.

SERIOUS ENVIRONMENTAL CHALLENGE

In recent years, China's economic development has entered a new normal state with comparatively slow growth, which is objectively conducive to alleviating environmental pressure. With the continuous optimization of the economic structure, the accelerated conversion from the old to new growth momentum, and the transformation of the extensive growth mode, energy consumption has stepped into the medium and low speed growth period. In 2016, China's energy consumption increased by 1.3%, less than one-fourth of the average growth rate of the past decade. Relevant forecasts show that during the "Thirteenth Five-Year Plan" period, the output of China's crude steel, cement, and major nonferrous metal products will reach a peak. The new increment in traditional pollutants will decline and resource consumption growth rate will also drop off. However, to achieve the goal of building a moderately well-off society and realizing modernization in an all-round way means that energy consumption per capita will continue to go up, so the rigid demand for consumption will last for a long time. In particular, in light of China's current conditions such as the heavy industrial structure, the seriously overloaded ecological environment, the large total energy consumption, and the inefficient use of resources, it is still a great challenge for China to make a fundamental change in the short term, so China will still face enormous environmental pressure in economic growth.

First, the overall situation of large resource consumption and inefficient utilization will last in the short term. China's total energy consumption and carbon dioxide emissions respectively increased from 990 million tons and 2.29 billion tons in 1990 to 4.26 billion tons and 9.93 billion tons in 2014, both increasing 3.3 times. In 2013, China's GDP accounted for around 12% of the world but consumed 21.7% of global energy, 46.5% of steel, and 58% of cement. Among them, coal consumption amounted to 3.8 billion tons, equivalent to the rest of the world's total, three times more than that of America that ranked the second in the world. Meanwhile, China's energy consumption per unit of GDP is nearly 2.5 times more than that of global average, twice more than that of the Asia-Pacific region's average. According to BP's *World Energy Statistics*, China remains the world's largest energy consumer by 2017, accounting for 23% of global energy consumption and 27% of global energy demand growth.

Second, environmental carrying capacity will still be in severe overload stage. Since the "11th Five-Year Plan," China began to control the total emissions of SO_2 and COD, which decreased from 25.494 and 14.142 million tons in 2005 to 19.744 and 11.757 million tons respectively, cutting down 22.6% and 16.9%. From "Twelfth Five-Year Plan," China started the total control of nitrogen oxides (NOX) and ammonia nitrogen (NH3-N), then the total amount of NOX and NH3-N decreased from 24.043 and 1.758 million tons in 2011 to 20.78 and 1.613 million tons in 2014, declining 13.6% and 8.3%, respectively. However, China's main pollutant emissions are still very large, and most of the regional environmental carrying capacity has reached or exceeded the upper limit. Atmospheric pollutants can be taken as an example. According to what is calculated following the secondary standard of ambient air quality (GB 3095—2012), the maximum allowable emissions of SO_2 and NOX (i.e., the atmospheric environmental capacity under the situation that the average annual concentration of PM2.5 in 333 prefecture-level cities of the whole country reaches the target level) are 13.63 and 12.58 million tons, respectively. The total emissions of the two pollutants in 2014 exceeded 45% and 65% of the environmental capacity, respectively [1]. Even if the total amount of pollutants discharged during the "Thirteenth Five-Year Plan" reaches the peak value and falls rapidly, it is difficult for the environmental quality to improve comprehensively in the short term.

Third, the ecological and environmental issues have entered the period in which numerous kinds of ecological environmental issues interweave with each other and ecological environmental risks frequently occur. The environmental problems in China are characterized by combination and compression. Traditional pollutants, such as nitrogen, phosphorus, and heavy metals, have not yet been effectively controlled, and new pollutants, such as POPs and EDCs, are continuously poured into water. The urban air quality has not yet been improved, and the rural environmental pollution has not been effectively controlled. As a result, environmental issues have become complex, with the superimposition of rural and urban environmental problems, of the land and marine environmental problems, of the degradation of ecosystem functions and environmental pollution problems, and of the international and domestic environmental issues. At the same time, China still needs to absorb the accumulated environmental pollution stock in history and deal with the increasingly prominent environmental risks. Environmental pollution accidents and other hidden dangers caused by new pollutants, heavy chemical industry layout, and other problems become increasingly prominent. The eastern coastal areas have become one of the most intensive heavy chemical industry areas, and heavy chemical industry tends to spread to the Midwest. In particular, the unreasonable layout of the industrial parks and the chemical enterprises along the major rivers may contain potentially significant environmental risks [4].

POWERFUL POLITICAL WILL

In terms of promoting sustainable development, Chinese government has a strong political will and attaches greater importance to environmental issues. The concepts China has proposed, such as construction of "harmonious society," scientific outlook on development, low-carbon development, energy production, and consumption revolution, are basically consistent with China's development strategy, that is, the sustainable development and green economy.

The status of energy conservation and environmental protection has risen significantly in the domestic political agenda. Morris Strong, Secretary General of the World Conference on Environment and Development in 1992, remarks that China is the only country to integrate the performance in environmental protection into official

performance assessment. Since 2005, China has promulgated a series of laws concerning energy conservation and emission reduction, such as Energy Conservation Law, Environmental Protection Law, Renewable Energy Law, Cyclic Economy Law, and so on. In June 2007, Chinese government issued "China's National Climate Change Programme" for the first time. On September 8, 2007, at the 15th APEC Global Leaders Summit, President Hu Jintao states clearly that he advocates "developing low-carbon economy." In October 2007, General Secretary Hu Jintao lists the issue of environmental resources as the primary challenge for China's development in the 17th CPC report and proposes the task of constructing "ecological civilization." In November 2012, the General Secretary Hu Jintao elaborates "ecological civilization" at the 18th CPC National People's Congress and further put forward the goal of building a "Beautiful China." This is the first time for him to discuss such a topic specially in a single paper.

After the 18th CPC National Congress, the General Secretary Xi Jinping repeatedly stresses that protecting the ecological environment is to protect the productive forces and improving the ecological environment is to develop productive forces, and entering the new era of ecological civilization and building a beautiful China are the important contents of realizing the Chinese dream of the great rejuvenation of the Chinese nation. In 2016, Xi Jinping delivered a keynote speech at the opening ceremony of the G20 Business Summit (B20 Summit). He remarks that it is the fundamental state policy to unswervingly implement the sustainable development strategy, adhere to the green, cyclic, and low-carbon development, and conserve resources and protect environment. On May 26, 2017, in supporting the 41st collective study organized by the Political Bureau of the CPC Central Committee, Mr. Xi Jinping emphasizes promoting green development mode and lifestyle, and creating a good production environment and living surrounding for people.

Energy conservation and environmental protection are highly valued by the government. In 2010, Chinese State Council issued "Decision on Accelerating the Fostering and Development of Strategic Emerging Industries," and listed the energy conservation and environmental protection as the top one of seven strategic emerging industries. During the "Twelfth Five-Year Plan" period, Chinese State Council issued a series of documents, such as "The Development Plan for National Strategic Emerging Industries During the 12th Five-Year Plan Period" and "The Plan for Developing Energy Conservation and Environmental Protection

Industries during the 12th Five-Year Plan Period," to promote the development of energy conservation and environmental protection industry. During the period of "13th Five-Year Plan," green development has become "one of five important development ideas." In December 2016, National Development and Reform Commission (NDRC), Ministry of Science and Technology, Ministry of Industry and Information Technology, and Ministry of Environmental Protection jointly issued the "The plan for Developing Energy Conservation and Environmental Protection Industries during the '13th Five-Year Plan' Period" to further clarify the strategic intention of the state to accelerate the green development to the whole society.

A number of grand goals have been set up. During the "11th Five-Year Plan" period, the government established the goal of reducing the energy consumption per unit GDP by 20%, and the total emission of two major pollutants of chemical oxygen demand and sulfur dioxide by 10%. In the "12th Five-Year Plan," it is further clarified that the energy consumption per unit of GDP will be reduced by 16% less than that in 2010, with the per unit GDP carbon dioxide emissions decreased by 17%, the national chemical oxygen demand and total sulfur dioxide emissions by 8%, respectively, and the national total amount of ammonia nitrogen and nitrogen oxide emissions by 10%, respectively. In December 2009, Chinese government clearly set the goal of reducing CO_2 emissions per unit of GDP by 40%–45% in 2020 less than that of 2005. According to China's intended nationally determined contribution made in *Paris Agreement*, China's carbon dioxide emission per unit of GDP in 2030 is expected to be 60%–65% lower than that in 2005, and carbon dioxide emission must reach the peak before 2030 and strive to reach its peak in advance.

China's Renewable Energy Support Policies, 2016

Renewable Energy Targets	Renewable Energy in INDC or NDC	REGULATORY POLICIES							FISCAL INCENTIVES AND PUBLIC FINANCING			
		Feed-in tariff/Premium payment	Electric utility quota obligation/RPS	Net Metering	Transport Obligation/Mandate	Heat Obligation/Mandate	Tradable REC	Tendering	Investment or production tax credits	Reduction in sales, energy, VAT or other taxes	Energy production payment	Public investment, loans, grants, capital subsidies or rebates
R	○	R	○		●	○		H	○	○	○	○

Sources: *Renewables 2017 Global Status Report*, REN21, Page131

○EXISTING NATIONAL (could also include sub-national)

●EXISTING SUB-NATIONAL (but no national)

RREVISED (one or more policies of this type)

H TENDERS HELD IN 2016, AS IN PAST YEARS

According to *Strategy of Energy Production and Consumption Revolution (2016—2030)*, by 2020, the total energy consumption will be controlled within 5 billion tons of standard coal, and the proportion of coal consumption will be further reduced. Clean energy will become the main sources of energy increment, and energy structure adjustment will achieve significant progress, with non-fossil energy sources accounting for 15%. Carbon dioxide emissions per unit of GDP will fall by 18% less than that in 2015. The efficiency of energy development and utilization will increase significantly and the energy efficiency of major industrial products will reach or approach the international advanced level, with energy consumption per unit of GDP 15% lower than that in 2015. By 2030, total energy consumption will be controlled within 6 billion tons of standard coal, with non-fossil energy accounting for about 20% of total energy consumption and natural gas for about 15%. By 2050, the total energy consumption will be basically stable and non-fossil energy will account for more than half of total energy consumption.

Chinese government has invested huge sums of money in environmental protection in recent years. In terms of pollution control, during the "6th Five-Year Plan" period, the state invested 16.6 billion Yuan in environmental protection, accounting for 0.5% of the GDP at that time. By the "10th Five-Year" and "11th Five-Year Plan," this proportion has risen to 1.18% and 1.41%. In terms of air pollution control, PM10 and PM2.5 have become hot words. Ministry of Environmental Protection releases that nearly 1500 monitoring sites was constructed during the "12th Five-Year Plan" period, with an initial investment of 2 billion yuan and an annual additional cost of over 100 million yuan. In protecting and governing major river reaches and important water source areas, the central government allocated 71.4 billion yuan during the period from 2007 to 2011. Thanks to its allocation, over 3200 water pollution control projects in major river reaches were constructed and over 110 ecological and environmental governance projects in 8 lakes gained support. From 2008 to 2015, the total investment of the central and local governments in the projects of traditional energy replacement in Tibet agro-pastoral areas was 2.459 billion yuan, including the small-scale and medium-scale projects of hydropower replacing firewood, rural biogas projects, and solar energy application projects.

China is not only the largest investor in the world's industrial and building energy efficiency sector but also the largest investor in renewable energy for several years. In 2015, China's renewable energy investment amounted to $102.9 billion (about 710 billion yuan), accounting for

one-third of the world's renewable energy investment, equivalent to the total investment of the United States and Europe in renewable energy. According to the "'13th Five-Year Plan' for Renewable Energy Development" issued by the National Energy Bureau, China will invest about 2.5 trillion yuan in renewable energy in that period. "The plan for Developing Energy Conservation and Environmental Protection Industries during the 13th Five-Year Plan Period" puts forward that the proportion of the added value of energy conservation and environmental protection industries in GDP will increase from 2% in 2015 to 3% in 2020, building 20 clusters of energy conservation and environmental protection industry.

REMARKABLE ACHIEVEMENTS IN GREEN DEVELOPMENT

In recent years, China has achieved positive results in promoting green development by eliminating backward production capacity, developing energy conservation and environmental protection industry, increasing investment in environmental pollution control, promoting green consumption, and so on. In particular, renewable energy, such as wind energy and solar energy, has developed rapidly, taking the lead all over the world in many indicators.

Energy conservation and environmental protection has gotten outstanding results. As the energy consumption level further declines and the total amount of some pollutants drastically decreases, environmental pollution is preliminarily controlled. From 1986 to 2006, the intensity of carbon dioxide per unit of GDP in China dropped by 66%. During the "Eleventh Five-Year Plan" (2005–10), the annual energy consumption increased by 6.6%, supporting 11.2% economic growth. The intensity of carbon dioxide emission decreased by 19.1%, equivalent to a reduction of 1.46 billion tons of carbon dioxide emission, exceeding the total emission reduction promised in *Kyoto Protocol*. In 2010, the national chemical oxygen demand and sulfur dioxide emissions were 12.45% and 14.29% respective decrease compared with 2005, and both exceeded the target set in "11th Five-Year Plan." In 2011, the national chemical oxygen demand and sulfur dioxide emissions decreased by 2.04% and 2.21%, respectively, compared with 2010, and the ammonia nitrogen emission decreased by 1.52%. In 2011, the average concentration of permanganate in

state-controlled sections of China's surface water was 4.7 mg/L, and the average ammonia—nitrogen concentration was 1.17 mg/L, down 48.9% and 50.4%, respectively, as compared with that in 2002. The sulfur dioxide content in air of 113 key cities for environmental protection in China was 0.041 Mg/m^3, a drop of 29.3% as compared with that in 2002. In 2016, the total primary energy consumption in China was 4.46 billion tons of standard coal, and the energy consumption level is reduced by 70% compared with that in the 1980s and over 30% lower than that in 2000.

According to the calculation, China's investment in environmental pollution control in 2011—13 boosted GDP by 2.56 trillion yuan, accounting for 1.64% of GDP in the previous three years. The "Action Plan for Air Pollution Prevention and Control" and "Action Plan for Water Pollution Prevention and Control" implemented in 2013 and 2015 boosted GDP by 1.94 trillion yuan and 5.7 trillion yuan, respectively [2]. China's total investment in environmental pollution governance showed an upward trend, which increased by more than 7 times from 110.66 billion yuan in 2001 to 903.72 billion yuan in 2013. With the implementation of "Action Plan Air Pollution Prevention and Control," "Action Plan for Water Pollution Prevention and Control" since 2013, and the future "Action Plan for Soil Pollution Prevention and Control," the investment in environmental pollution control during China's "13th Five-Year Plan" period has obviously exceeded the "12th Five-Year Plan" period to about 2 trillion yuan annually, and the total investment in social environment protection during the "13th Five-Year Plan" period is expected to exceed 17 trillion yuan.

The proportion of the added value of energy conservation and environmental protection industry in GDP has increased sharply in recent years. Since the "11th Five-Year Plan," a series of policies and measures implemented in China to promote energy conservation and emission reduction and cyclic economy have created tremendous demand for the development of energy conservation and environmental protection industry, so it witnessed rapid development. The energy conservation and environmental protection industry has grown from 2 trillion yuan in 2010 with more than 28 million employees to 4.5 trillion yuan with more than 30 million employees at the end of 2015, and emerged more than 70 leading enterprises with more than 1 billion yuan in operating income [3]. Assuming that the energy conservation and environmental protection industry accelerates during the "13th Five-Year Plan" period, reaching a growth rate of

20%−30%, and the value-added rate increases to 40%−45% by means of policy incentives and technological innovations, the proportion of the added value of energy conservation and environmental protection industry in GDP will be likely to reach the target of 5%. In 2016, the total output value of China's energy-saving service industry reached $52.2 billion, and its industrial scale was 75 times larger than that in 2005.

The clean energy industry has achieved an all-round and rapid development. In recent years, China has ranked first in the world in the scale of clean energy investment for many times. The installed capacity of clean energy power generation has increased rapidly with a significant increase in the proportion of total power generation. In 2016, China contributed 40% of global renewable energy growth. In 10 years China's share of renewable energy consumption in the global total has grown from 2% to 20.5% in 2016. China has replaced the United States as the world's largest producer of renewable energy [4]. According to "Forecast Report on National Power Supply and Demand for the year 2016 to 2017," released by China Electricity Council, it was expected that in 2017, newly installed generation capacity of national infrastructure construction may reach about 110 million kWh, of which nonfossil energy generation reaches 60 million kWh. At that time, the cumulative installed capacity of nonfossil energy generation will reach 660 million kW, accounting for 38% of the total installed capacity, with hydropower, grid-connected wind power, and solar energy reaching 340 million kW, 170 million kW, and 97 million kW, respectively. The International Energy Agency predicts that by 2021, China will account for more than one-third total global solar PV power generation and onshore wind power generation [5].

China's global ranks of annual investment/net capacity additions/production in 2016

	China's ranks
Investment in renewable power and fuels (not including hydro >50 MW)	1
Hydropower capacity	1
Solar PV capacity	1
Concentrating solar thermal power (CSP) capacity	2
Wind power capacity	1
Solar water heating capacity	1
Fuel ethanol production	3

Source: Renewables 2017 Global Status Report, REN21, page 25.

The wind power industry starts earlier and has stepped into a fast development period for more than 10 years. In 2005, the installed capacity of wind power was only 1.2 million kW, but by 2011 it had increased to 50 million kW, over 40 times. During the "12th Five-Year Plan" period, the installed capacity of wind power in China ranked at the top of the world. In 2016, the wind power installation all over the country was 19.3 million kW, with a cumulative grid-connected installed capacity of 149 million kW, far ahead of other countries in the world. According to the "'13th Five-Year Plan' for Electric Power Development" and "'13th Five-Year Plan' on Wind Power Development," the wind power installed capacity will reach 210 million kW by 2020, and the annual wind power generation will reach over 420 billion kWh, accounting for 6% of the total power generation all over the country [6].

Solar photovoltaic power generation also develops very drastically. Traditionally, China has an absolute advantage in the manufacturing of photovoltaic solar panels and the production and use of solar water heaters. In 2016, the production of photovoltaic panels in China reaches 53 GW, accounting for 70% of the global market demand. In recent years, the previous weakness in photovoltaic power generation has also been greatly changed. By the end of 2016, the newly installed capacity of photovoltaic power generation in China had reached 34.54 million kW, with a cumulative photovoltaic installed capacity of 77.42 million kW, ranking the first in the world. Among them, the accumulative installed capacity of photovoltaic power station was 67.1 million kW, and the distributed accumulative installed capacity was 10.32 million kW. In 2016, China's photovoltaic power generation reached 66.2 billion kWh, accounting for 1% of the total power generation of the whole year in our country [7]. In December 2016, National Energy Administration issued the "'13th Five-Year Plan' for Solar Energy Development" and put "promoting distributed photovoltaic and 'photovoltaic +' applications" at the top of the "13th Five-Year Plan" solar energy development key tasks, proposing to vigorously popularize the distributed photovoltaic power generation on the roof, expand the "photovoltaic +" comprehensive utilization projects and innovate distributed photovoltaic application modes.

Total capacity or generation as of the end of 2016

	China's ranks
Renewable power(Including hydro)	1
Renewable power(Not including hydro)	1

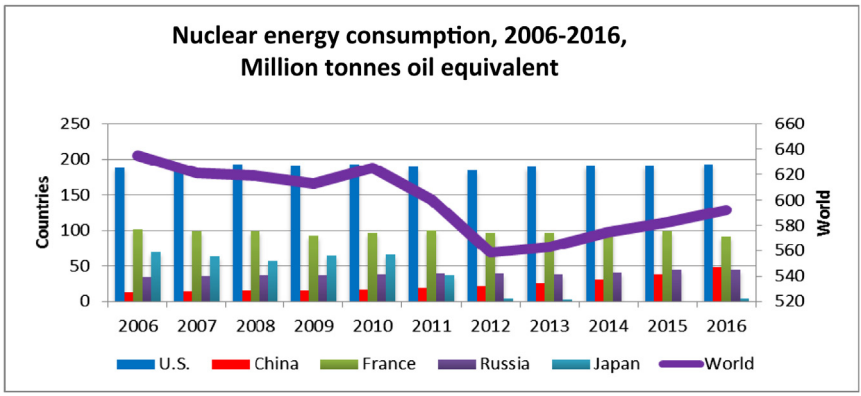
(*Continued*)

(Continued)
Total capacity or generation as of the end of 2016

	China's ranks
Renewable power capacity per capita	
Biopower generation	2
Geothermal power capacity	
Hydropower capacity	1
Hydropower generation	1
CSP capacity	
Solar PV capacity	1
Solar PV capacity per capita	
Wind power capacity	1
Wind power capacity per capita	

Source: Renewables 2017 Global Status Report, REN21, page 25.

In terms of nuclear power, by March 2017, in China there had been 36 operating nuclear power generating units with an installed capacity of 34.72 million kW, and there had been still 20 under-construction nuclear power generating units with an installed capacity of 23.11 million kW, accounting for one-third of the world's under-construction nuclear power generating units [8]. In 2016, the cumulative power generation capacity of nuclear power was 210.519 billion kWh, accounting for 3.56% of the country's cumulative power generation (the world's nuclear power averaging at 11%) [9]. The world's nuclear power generation increased by 1.3% in 2016, equivalent to about 9.3 million tons of oil, with all the net growth from China. According to the "'13th Five-Year Plan' for Energy Development," by 2020, China will strive for 88 million kW of nuclear power installed capacity, including 58 million kW in operation and 30 million kW under construction.



From BP Statistical Review of World Energy 2017, page 41.

In terms of biomass energy, China's annual biogas production capacity has reached 15.8 billion cubic meters in 2015, about 5% of the national natural gas consumption, and can replace 11 million tons of standard coal annually. According to the "13th Five-Year Plan," 172 large-scale bionatural gas projects and 3150 large-scale biogas projects will be constructed, and the biogas production capacity will reach 20.7 billion cubic meters by 2020 [10].

In terms of geothermal energy, the utilization amount of geothermal energy in 2015 was 20 million tons of standard coal, accounting for 0.5% of the total energy consumption (4.3 billion tons of standard coal) of the year. According to the "'Thirteenth Five-Year Plan' for Geothermal Energy Development and Utilization Program" issued in February 2017, by 2020, there will be 1.1 billion square meters of newly added geothermal energy heating (refrigeration) areas and 500 MW of newly installed geothermal power capacity. By 2020, the annual utilization amount of geothermal energy will reach 70 million tons of standard coal, accounting for about 1.5% of total energy consumption (4.8 billion tons of standard coal).

In addition, new energy vehicles have developed rapidly. In 2014 and 2015, the growth rate of China's new energy vehicle sales was over 300% for the 2 years. The sales in China, which accounts for more than half of the world's sales in 2015, have become the world's largest market for electric vehicles. In 2016, China's new energy vehicles earned more than 500,000 yuan, up 53% from the previous year.

The public and enterprises' environmental awareness has been significantly enhanced. In recent years, China's policies on low carbon and energy conservation as well as education measures are playing a positive role. As a result, corporate environmental awareness has improved, and capital investment has increased significantly. With the increasingly stricter standards of environmental protection laws and regulations, many enterprises are actively engaged in the development of new technologies needed for green economy, such as renewable energy and electric vehicles. The public's knowledge of environment and climate change becomes richer, and their environmental awareness is significantly enhanced.

On November 1, 2012, "Report on China's Public Cognition of Climate Change and Climate Dissemination" released by China's Climate Dissemination Project Center in Beijing indicated that the Chinese public's cognition of climate change was up to 93.4%, far higher than that in other countries. Among them, 76.3% agreed to respond to climate change by changing their behaviors and 87% were willing to pay more to

buy environmentally friendly products. Most public opinion goes that climate change is taking place mainly due to human activities, and China has already been endangered by climate change. In contrast, the same standard data survey in Yale University showed that America was only 62%, and that Britain was slightly higher, that is, 75%.

China's Climate Change Education Program was officially launched in Beijing on November 2, 2012, with the support of China Association for NGO Cooperation, and will work with 100 junior and vocational schools in 10 cities of five provinces to develop new textbooks on climate change and enhance the public awareness of climate change. June 13, 2013, was set as "National Low Carbon Day." During the National Energy Conservation Awareness Week from June 11 to 17, 2017, in the whole country, a series of activities were launched on the low-carbon day, and carbon trading has become the most concern of many enterprises with discharges.

THE CURRENT PROBLEMS AND CHALLENGES

China has made considerable progress over the past decade in terms of several indicators of relative green growth, such as carbon productivity, energy productivity, water resource productivity, and construction land productivity. However, the overall degree of green economy is still relatively low, burdened with the difficulties of slow internal adjustment of industrial structure and lack of overall driving force of green growth to economy. The slow internal adjustment of the industrial structure and the trend of heavy industrial structure will continue in the short term. Fossil energy, especially coal, will continue to be dominant, and it is harder to increase energy efficiency and reduce carbon intensity in the future.

The current environmental quality is still far from the green growth target. The Pollution Control Project under "Ambient Air Quality Standard," which began to be fully implemented on January 1, 2016, has been geared to the international standards. However, the level of economic and technological development determines that currently the emission limits of the pollutants such as PM10 and PM2.5 are only in line with WHO first-phase target, so there is still a longer way to go to meet with the guidelines put forward by WHO.

At present, the green growth has not penetrated into all the fields of national economy, and its overall pulling effect on the economy is still weak. Relevant researches show that the green component in China's

national economy is only 8%—11%, which still has great potential for development [4]. As China's GDP growth rate has been relatively fast, the proportion of investment for environmental pollution control in GDP has not increased significantly, only from 1.15% in 2001 to 1.59% in 2013. Over the same period, the investment for environmental pollution control in developed countries, such as America, Germany, and France, accounted for more than 3% of GDP, respectively 3%, 4.3%, and 5.3%.

In recent years, with the rapid growth of installed capacity of wind power, photo electricity, and other energy resources, the problem of new energy accommodation has become increasingly serious. Wind abandoning and power brownout is a tricky problem that has long been perplexing the development of wind power industry in our country, and they have begun to rebound since 2015. According to the National Energy Administration, the total annual wind curtailment in 2016 went up to 49.7 billion kWh, four times more than that in 2014, with a year-on-year increase of 15.8 billion kWh. In 2016, the average curtailment ratio was 17%, up by 2% over the same period of last year, among which Gansu, with the highest curtailment ratio, reached 34%. According to the average price of 0.5 yuan per kWh, the loss in electricity revenue in 2016 is nearly 25 billion yuan [6]. At the same time, the phenomenon of discarding light is more prominent. In 2016, in only five provinces and regions in northwest China, the abandoned photoelectric capacity was 7.042 billion kWh, with the discarding rate 19.8%, and the discarding rate in Xinjiang and Gansu reached 32% and 30%, respectively [11]. In 2016, the total amount of "discarding water, wind, and light" was nearly 110 billion kWh, which exceeds the power generation capacity of the Three Gorges Project by about 17 billion kWh. In the past 7 years, the accumulative total of "wind curtailment" reached 150 billion kWh, with direct economic loss over 80 billion yuan [12].

In the process of promoting energy conservation, emission reduction, and low-carbon economy, although the marketization is getting higher and higher, in administrative methods there are still traces of planned economy, such as traffic restrictions based on the last digit of license plate number, vehicle registration via a lottery system, and so on. Some local governments have even taken measures such as power-rationing or shutting down factories to achieve the goal of saving energy or reducing energy consumption. In the rapid development of new energy, government subsidies play an important role, but in many cases enterprises cheat governments for subsidies. In December 2016, the Ministry of Industry

and Information Technology announced the first batch of four enterprises to cheat governments for subsidies, including Jinlong Joint Automobile Industry (Suzhou) Co., Ltd., and other enterprises. On February 4, 2017, the Ministry of Industry and Information Technology announced the decision again to punish seven domestic new energy auto enterprises for cheating for financial subsidies, such as Zhengzhou Nissan and other domestic new energy vehicles enterprises.

RENEWABLE ENERGY POWER QUOTA AND GREEN CERTIFICATE TRADING SYSTEM

In order to promote sustainable development of renewable energy and solve the problem of discarding wind and light, besides implementing "Strategy of Energy Production and Consumption Revolution (2016–2030)" and "'13th Five-Year Plan' for Energy Development," and increasing related investment, institutional reform, and innovation are indispensable, in which renewable energy power quota and green certificate trading are important institutional guarantee for energy restructuring.

Renewable energy power quota system and the supporting green certificate trading mechanism are worldwide adopted renewable energy industry support policies. At present, more than 20 countries, including Britain, Australia, Sweden, Norway, Italy, Japan, South Korea, and India, as well as 29 US states and Washington, DC, have all conducted quota system assessment and green certificate trading. In order to guide the green consumption of the whole society, promote the absorption and utilization of clean energy consumption, and accelerate the energy transformation, especially the marketization of renewable energy, China is actively promoting the establishment of renewable energy power quota and green certificate trading mechanism.

The "'13th Five-Year Plan for Renewable Energy Development" proposes that by setting up non-hydropower renewable energy quota indexes for coal-fired power generation enterprises and power selling enterprises, these enterprises are required to purchase green certificates as the proof of completing renewable energy quota obligation, so the environmental and social benefits of new energy generation will be compensated through the market-based trading of green certificates. In January 2017, NDRC, Finance Bureau, and Energy Bureau jointly issued "Notice on Trial Implementation of Renewable Energy Green Certification Issuance and

Voluntary Subscription Trading System," and encouraged governments, enterprises and institutions, social organizations, and individuals to voluntarily subscribe green certificates on the national green certificate issuance and subscription platform.

Green certificate trading is one of the important means of the target guiding mechanism of renewable energy, including mandatory trading and voluntary trading. Mandatory green certificate trading is a complementary policy of Renewable Portfolio Standard, which provides a commercial supplement in addition to the mandatory quota system. Voluntary green certificate trading refers to the way in which enterprises and individuals purchase green certificates through voluntary means, providing an effective channel for all sectors of society to participate in environmental protection undertakings and support the development of renewable energy. The green certificate is a power certificate that records which onshore wind farms or photovoltaic power stations across the country that the specific 1000 kWh of on-grid energy come from. The power generation enterprises can apply for green certificates to the National Renewable Energy Information Management Center. After the issuance, these green certificates can be sold on Chinese Green Certificate Subscription Trading Platform, and all levels of governmental departments, enterprises and institutions, social organizations, and individuals can subscribe.

According to the relevant plan, the core objective of this policy is to establish the voluntary subscription system of green certificate, promote efficient utilization of clean energy, and reduce the direct subsidy intensity of national financial funds. Thermal power bears external costs such as environmental pollution. Without the internalization of these external costs, renewable energy power cannot compete with thermal power and can only rely on subsidies. However, by the end of 2016, the cumulative gap of subsidies for renewable energy sources has reached more than 50 billion yuan and the period waiting for the subsidy to come in place will be very long. If the subsidy problem cannot be solved effectively, it will seriously affect the enthusiasm for investment and will ultimately affect the realization of clean energy development and emission reduction targets. The corresponding amount of electricity shall no longer enjoy the national subsidy for the additional electricity cost of the renewable energy after the wind power generation and photovoltaic power generation enterprises sell the green power certificates.

From June 12 to 27, 2017, the National Renewable Energy Information Management Center successively issued three batches of

green certificates, among which the second batch was 131,710 and the on-grid energy represented by the green certificate was 131.047 million kWh in total, involving 15 new energy power generation projects. The third batch was 2,546,235, involving 67 new energy power generation projects, and the green certificate featured a total of 2546.235 million kWh of on-grid energy. On July 1, 2017, the kick-off ceremony for the voluntary subscription of green power certificates was held in Beijing. At present, the green certificate market is still at a stage of cultivation and the major transactions on the platform are about wind power projects. Other generation projects about distributed photovoltaic power, offshore wind power, photo thermal power, and biomass power are expected to be gradually included in the future. According to market subscription, the renewable energy quota assessment and the compulsory trading of green power certificate will be launched in due course since 2018.

The voluntary subscription system of green certificate can help to build the social consensus on the use of renewable energy. In China, the main bodies that voluntarily subscribe to green certificates are foreign-funded enterprises, and the local enterprises' enthusiasm and sense of social responsibility are quite insufficient. In foreign countries, some powerful technology companies (such as Apple and Google) are proud of using clean energy and set the goal of utilizing 100% green power over the next time. However, at home, local enterprises have not reached consensus on the use of renewable energy. In addition, local protectionism is also one of the obstacles that green certificates need to remove. In order to protect their own thermal power, local governments are reluctant to accept renewable energy from other provinces. Therefore, how to break through the barriers between provinces and how to transport electricity to eastern provinces are also big challenges.

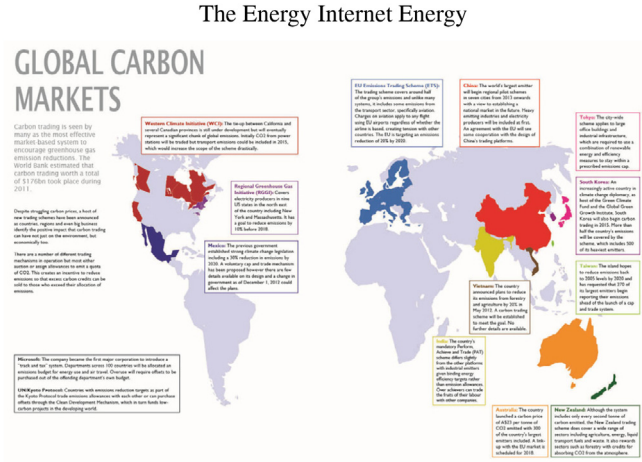
The trial green certificate voluntary subscription system can use the market-oriented mechanism to raise more sustainable funds for renewable energy development to promote energy transformation and provide consumers with effective support to practice green consumption. At the same time, it can also build up more experience for the future market-oriented mechanism. Through market-oriented approach, green certificates can provide necessary economic compensation for power generation enterprises that produce clean energy by opening up mutually motivated modes of green electricity consumption and production, which is an effective means for achieving sustainable and healthy development of the

renewable energy industry. Renewable energy power generation enterprises can gain benefits by selling green certificates, thus realizing the green value of renewable energy. Coal-burning electricity-generating enterprises can internalize external cost in environment by purchasing green certificates.

The implementation of the voluntary trading system will first play the role of reducing the direct subsidy intensity of national financial funds, but in terms of the purpose of promoting the efficient utilization of clean energy, it will depend on the successively activated renewable energy power quota assessment and mandatory green certificate trading. With the official launch of voluntary subscription system of green certificates, China will open a new era of advocating the whole society to consume green electricity, and more enterprises and individuals with a sense of social responsibility and environmental awareness will take the lead in the green power consumption trend and build social consensus on the consumption of green electricity, thus forming a new social fashion of consuming green electricity and sharing clean development nationwide.

BUILDING THE WORLD'S LARGEST CARBON TRADING SYSTEM

In 2005, *Kyoto Protocol* regards market mechanism as a new approach to solving the problem of greenhouse gas emission such as carbon dioxide and takes carbon emission right as a commodity, thus forming carbon emission right trading. The basic principle is that one party in the contract obtains the greenhouse gas emission reduction amount by paying the other party, and the buyer can use the purchased emission reduction amount to achieve its emission reduction target. After *Kyoto Protocol* came into force, the global carbon trading market exploded. From 2006 to 2007, the global carbon trading volume jumped from 1.6 to 2.7 billion tons, an increase of 68.75%. The market value of global carbon trading rose from 22 to 40 billion euros, up 81.8%. In 2012, the global carbon trading market reached $150 billion, surpassing oil trading as the world's largest market. The report released by Britain's New Energy Finance Company predicts that the global carbon trading market will reach $3.5 trillion in 2020.



From http://www.climatechangenews.com/files/2012/11/carbon-map-for-web.jpg.

Construction of carbon market is an important measure taken by China to promote green development and control greenhouse gas emission. China's carbon emission per capita surpasses the European Union for the first time in 2013, according to global carbon emission data released by the International Environmental Protection Organization's Global Carbon Program. In 2014, the world's total carbon dioxide emission reached 35.5 billion tons, and China's emission reached 9.76 billion tons, ranking first in the world. China's carbon emission dropped slightly in 2016, but still accounted for 28% of the world's total, notably 16% higher than that in the United States, which ranked the second of the world's total. In response to the increasing pressure on reducing emission, the Chinese government suggests that carbon dioxide emission will reach a peak around 2030, and carbon emission for per unit of GDP will be 60% to 65% lower than that in 2005. By 2030, nonfossil fuels will account for about 20% of primary energy consumption, and the forest reserves will increase 4.5 billion cubic meters compared with 2005. On April 22, 2016, China signed the *Paris Agreement*, promising to make great effort to reduce greenhouse gas emission and strengthen international cooperation on climate change.

The construction of China's carbon market started from seven trials. In October 2011, the NDRC agreed to launch pilot projects on carbon emission right trading in Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong, and Shenzhen for the implementation of "12th Five-Year Plan" on the establishment of a domestic trading market for carbon

emission. On June 18, 2013, Shenzhen Carbon Emission Right Exchange was officially opened to become the first carbon emission right exchange in the country. In 2014, the seven pilot projects started online trading. In 2015, China certified voluntary emission reduction is formally included in the transaction performance system. In 2016, 2391 enterprises and units with intensive emission were incorporated into the seven pilot carbon trading platforms, with a total of about 1.2 billion tons of allocated carbon emission quota. The total amount of carbon market trading of the seven pilot projects in 2015 was about 101 million tons, of which the quota online transaction was about 25 million tons of CO_2, the quota bulk transaction was about 33 million tons of CO2, and the complementary mechanism transaction was about 43 million tons of CO_2. China's carbon market as a whole has become the world's second-largest carbon trading system, although there is still a gap compared with the EU ETS's 10 billion tons of trading volume.

Since start-up, the seven pilot projects have basically completed the construction of the carbon trading market system with clear responsibility and right, smooth operation, active transaction, and active performance. In the course of operation, each pilot has accumulated a lot of experience and played an active role in energy transformation. These pilots have also greatly promoted the construction of carbon emission right trading mechanism and provided abundant experience and lessons for establishing the national carbon market. In January 2016, the NDRC made a unified deployment to construct the national carbon market that the national carbon market would start in 2017. China's carbon market will cover 4 billion tons of CO_2 equivalent, more than twice the size of the European carbon market and will become the world's largest carbon trading system, according to *China Carbon Market Research Report 2017* released by United Nations Development Program.

According to the deployment, the first stage of the national carbon emission right trading market will cover industries with intensive emission such as petrochemical, chemical, building materials, steel, nonferrous, paper, electricity, and aviation. The national carbon emission trading market is expected to be completed by 2020 with the access threshold from 10,000 tons of standard coal to 5000 tons of standard coal. At that time, more than 100,000 enterprises will be included in the carbon trading market. After 2020, the carbon tax will be levied on the enterprises with emission of less than 5000 tons of standard coal or those that are not included in the carbon market system, thus forming a

complete carbon management policy system. In 2017–20, the main goal of national carbon market will be market mechanism construction. It is estimated that the annual average price of carbon in the initial stage of the start-up of the national carbon market will be 30–40 yuan/ton. The spot trading of carbon emission quota for the first performance period will be from 200 to 500 million tons, with trading volumes ranging from 6 to 10 billion yuan. Optimistically, the trading volume will approach 20 billion yuan. After that, if the sectors covered by carbon market go beyond the eight industries listed and the threshold for the energy consumption of enterprises to be involved is lowered and various carbon financial products are introduced to the market at the same time, it is estimated that the trading volumes in the national carbon market will increase to 100 billion yuan.

The upcoming national carbon trading market will have a far-reaching influence. First of all, the unified national carbon trading market can bring a unified trading system, trading rules, emission quota, distribution methods, as well as methods of setting the defaults. Then, it is helpful to improve the status of our country in the international carbon trading market. In addition, it is conducive to strengthen regulatory control and reduce homogeneous competition among trading platforms. Furthermore, it is beneficial to the improvement of relevant laws and regulations. Since China acceded to the *Kyoto Protocol* in 2001, it has successively promulgated a series of laws and regulations, such as "*China's National Climate Change Programme*," "*Cyclic Economy Promotion Law*," and "*Interim Measures for the Administration of Carbon Emission Permit Trading*." Finally, it can attract more financial institutions to participate and further promote the development of carbon finance.

The development of carbon market has been hindered by the embarrassing situation in which the industry is devoted while the public is indifferent, so how to promote the development of personal carbon market business becomes a big challenge. According to the experience of European carbon finance development, products such as carbon funds and carbon capital management plans are helpful to attract individuals to participate in the carbon market. In recent years, in China, an Internet product, Ant Forest, has emerged, which is currently the world's largest scale individual carbon trading product, and the information technology will be applied to individual carbon management, the users of which have exceeded 200 million. This is the world's first large-scale product program by Chinese companies which can link personal low-carbon behaviors

with carbon management and will play an important role in promoting individuals contribution to climate change. In August 2016, Ant Financial provided a full online personal carbon account "Ant Forest" to 450 million users of its Alipay platform. The carbon emission saved by users' subway trips, online payment of hydro-coal, and buying tickets online will be calculated as virtual "energy" used to raise virtual trees in mobile phones. After the virtual trees grow, Ant Financial and the commonweal partners will plant a real tree on the earth to cultivate and inspire the users' low-carbon environmental awareness and behaviors. By the end of January 2017, the accumulated users had more than 1.11 million virtual trees in the Ant Forest.

BUILDING ENERGY INTERNET TO MEET THE AGE OF SMART ENERGY

Since the new century, the information technology represented by Internet has continuously infiltrated into traditional industries such as energy, while the energy industry has borrowed power from Internet to provide itself with information data attributes, transform the physical network configuration, and optimize the traditional organizational structure. The two industries have deeply integrated with each other and gradually developed into a new form of industry—Energy Internet. The Energy Network will integrate the roles of three networks—information network, energy web, and power grid. By taking electric power grid as the pivotal platform, prioritizing the main task of accessing renewable and distributed energy resources, and using information technology as tool, various forms of energy such as the cold, heat, gas, water, and electricity will be optimized and complemented. Based on big data and cloud computing, we will interconnect energy with many nodes in energy production, conversion, storage, transportation, and utilization to realize the free access, real-time flow, instant exchange, and sharing of information flow, energy flow, and energy source flow. In the process of developing energy internet, the human energy form will gradually transit from large-scale and centralized fossil energy to miniaturized, distributed, and intelligent renewable energy, and gradually evolve into self-organization, self-examination, self-optimization, self-adaptation, and other powerful functions similar to those of brain, which will open a new era of smart energy.

Around 2005, Europe began to put forward the concept of smart grid and made new designs mainly on power network upgrading and replacement. Then, the continuous development of renewable energy not only poses challenges to the power grid but has also attracted more and more attentions of various industries to renewable energy and promoted the integration of different industries, the expanding and deepening of the concept of smart grid. In 2008, the "E-Energy," Energy Internet Demonstration Project, was launched by the German federal government. Based on new ICT communication equipment and systems, smart grid demonstration projects with different focuses were piloted in six cities, by taking the most advanced control measures to cope with the increasing distributed power and a variety of loads on complex user terminals. Subsequently, with the continuous liberalization of the electricity markets in Europe and America, the rising of energy prices and the continuous development of IT technology, especially mobile Internet technology, a new entrepreneurial ecosystem, Energy's Web/App (Internet application of energy circle) has been evolved from energy internet in many countries. For example, Opower in the United States, Power Shop in New Zealand, and Green Packet in Germany are all new Internet start-ups that have emerged by making full use of the open and active market of electricity selling end under the background of energy saving and efficiency improvement.

The concept of smart grid entered China around 2009. In 2009, the international academia began to propose to "build a Smarter Planet," and the concepts like smart airport, smart banking, smart railway, smart city, smart power, smart grid, and smart energy. In the same year, some Chinese experts and scholars published such works as *When Energy Is Filled with Wisdom*, *Smarter Energy and Progress of Human Civilization*, and the concept of Smarter Energy was officially introduced to China. In early December 2013, many domestic media published the signed article entitled "Smart Grid and the Third Industrial Revolution" by Liu Zhenya, the chairman of the State Grid, in which he put forward "energy internet" and some other concepts. The article, combining the Smart Grid concept proposed by Obama administration in 2009 with the development experience of China, upgraded the theme to the level of social, economic, and cultural revolution, drawing a clear road map for the new generation energy development.

In China, the construction of the energy internet was quickly incorporated into government development planning. On July 1, 2015,

Chinese State Council issued "Guidelines on Actively Promoting the Action of 'Internet + '" and made detailed explanation on the actions of "Internet + " smart energy. It proposes to advance the flatness of energy system management through the Internet and promote energy production and consumption revolutions. It suggests to strengthen the construction of distributed energy network, increase the proportion of renewable energy, and promote the optimization of energy utilization structure. It also proposes to accelerate the intellectualized reconstruction of power generation facilities, electric facilities, and power grids, as well as the intellectualization of energy production, such as establishing a public information service network for monitoring, managing, and scheduling energy production operation. The other tasks proposed include building a distributed energy network, and a multi-energy coordinated and complementary energy network with renewable energy sources such as solar energy and wind energy as the main body, breaking through the key technologies on distributed power generation, energy storage, smart micro-grid, and active distribution network to construct a smart electric power operation monitoring and management technology platform to ensure two-way communication and smart control of power equipments and power terminals based on the Internet, and finally to realize timely and effective access to distributed power, and gradually build an open and shared energy network.

On February 29, 2016, in order to promote the development of energy internet, the NDRC issued "Guidelines on Promoting the Development of 'Internet + ' Smart Energy" and proposes that Internet + Smart Energy (energy internet) is a new form of energy industry with deep fusion of the Internet and energy production, transmission, storage, consumption, and market. Its main characteristics include smart equipment, coordinated multiple energy types, symmetric information, distributed supply and demand, flat system, and open transactions. In a new round of technological revolution and industrial transformation in the world, the Internet concept, the deep fusion of advanced information technology and energy industry, is beneficial for the development of new technologies, new models, and new formats of energy internet. Energy internet is an important strategic support for the energy revolution in China. It is of great significance to increase the proportion of renewable energy, promote the clean and efficient utilization of fossil energy, enhance the comprehensive efficiency of energy, advance the opening-up of energy markets and industrial upgrading, create new

economic growth points, and improve the level of energy international cooperation.

According to "Guidelines on Promoting the Development of 'Internet + ' Smart Energy," the construction of the energy internet should focus on the overall and long-term development of energy industry. With reform and innovation as the core, "Internet + " as the means and intellectualization as the foundation, we should strive to build a green, low-carbon, secure, and highly efficient modern energy system to promote the deep integration of energy with information and drive the development of new technologies, new models, and new patterns of energy internet. In addition, more effort should be exerted to make Internet play the fundamental role in the energy industry reforming, so as to promote the rational opening of energy infrastructure, accelerate the fusion of energy production and consumption, enhance the public participation level, and accelerate the formation of an open and shared new form of the energy industry. It is greatly encouraged to explore and to innovate but with demonstration as the first step. We should try best to adapt to the new ecosystem and the development of big data applications, improve the supervision mechanisms of safety and market under the condition of deep fusion of energy and information, and safeguard information security and legitimate rights of market participants. Attempts should be made to adapt to the development of the energy internet that technology contributes 30% and reform contributes 70%, deepen the energy system and mechanism reform, restore the commodity attribute of energy, and build effectively competitive market structure and market system.

In order to ensure healthy and orderly development of energy internet, two stages are planned: the short-term and mid-term. In the first stage, pilots and demonstrations should be launched first and generalization and application follow afterwards. From 2016 to 2018, China should promote pilots and demonstrations of energy internet, building a batch of pilot and demonstration projects with different types and sizes. Meanwhile, we should strive to make breakthroughs in a batch of key technologies and core equipment enhancing the energy internet technologies to international advanced level, establish preliminary market mechanisms and systems of the energy internet, build a preliminary technology standard system of the energy internet by establishing a batch of key technology specifications and standard, incubate a batch of business models such as energy finance, third-party energy services, etc., and cultivate a batch of competitive emerging market players. Overall, a batch of

sustainable and replicable development models should be explored, and a batch of important experiences in reform pilots will be learned and accumulated. From 2019 to 2025, diverse and scale development of energy internet should be promoted, for example, to establish a preliminary industrial system of the energy internet as an important driving force for economic growth, to build relatively complete market mechanisms and systems of the energy internet, to form a relatively integral system of technologies and standards to promote its internationalization and lead the Energy internet development in the world, to form an open and shared ecosystem of energy internet. As a result, the comprehensive efficiency of energy improves remarkably, the renewable energy penetration increases significantly, the clean and efficient utilization of fossil fuel energy makes active progress, and the public's participation increases remarkably. Overall, the energy production and consumption revolution will be strongly supported [13].

"Guidelines on Promoting the Development of 'Internet + ' Smart Energy" proposes that the key tasks of China's energy internet development include the following main contents: strengthening the construction of energy internet infrastructure, building a smart system for energy production and consumption, a synergic multi-energy comprehensive grid, and the information and communications infrastructure coordinated with the energy system, creating an open and shared ecosystem of energy internet, establishing a new energy market trading system and commercial operation platform, developing new models and new patterns, such as distributed energy resources, energy storage and electric vehicle applications, smart energy and value-added services, flexible trading of green energy, and energy big data application services, advancing the key technological breakthroughs in the construction of energy internet, the research and development of core equipment and a standard system, and promoting international application and cooperation of energy internet in technologies, standards, and models.

On June 28, 2017, National Energy Administration announced the notice about first batch of "Internet + " Smart Energy (energy internet) demonstration projects. In order to implement the documents about the development of Smart Energy, National Energy Administration organized the application and selection of the "Internet + " Smart Energy (energy internet) demonstration projects and finally identified the first batch of demonstration projects. The first batch of "Internet + " Smart Energy demonstration projects totaled 55, of which 12 were urban energy internet

comprehensive demonstration projects, 12 were industrial park energy internet comprehensive demonstration projects, 5 were trans-regional synergic multi-energy demonstration projects, 6 were energy internet demonstration projects based on electric vehicles, 2 were energy internet demonstration projects based on flexible resources, 3 were energy internet demonstration projects based on green energy flexible transaction, 4 were energy internet demonstration projects based on industry convergence, 8 were energy big data and the third-party service demonstration projects, and 3 were smart energy infrastructure demonstration projects.

In addition to the construction of domestic energy internet, the global energy internet construction initiated by China in recent years has attracted the attention of the international community. On September 26, 2015, at the United Nations Development Summit, President Xi Jinping proposed to discuss the construction of a global energy internet, to meet global power demand by means of clean and green energy and achieve global green energy sharing. To promote the initiative, China initiated the founding of the Global Energy Internet Development Cooperation Organization in March 2016, with members covering 32 countries on five continents. In 2016, at the G20 Hangzhou Business Summit (B20), "Global Energy Internet" was incorporated into the Policy Recommendation Report. In May 2017, at the "Belt and Road" Forum for International Cooperation President Xi Jinping proposes to follow the trend of new round of energy adjustment and energy technology transformation, so as to build a global energy internet and realize green low-carbon development. According to the strategic plan issued by the Global Energy Internet Development Cooperation Organization, by 2020, the countries of all continents will be pushed to realize the interconnection of the domestic power grids; by 2030, the transnational interconnection of power grids within the continent will be promoted, and by 2025, more emphasis will be placed on the development of electricity delivery from the Arctic and Equatorial energy centers, and the global energy internet will be basically built.

With the joint efforts of the Global Energy Internet Development Cooperation Organization and the relevant parties concerned, the Chinese initiative is currently implemented globally. Building the global Energy Network, through the extension of large power grids to interconnect with clean energy to solve the outstanding problems such as power popularization and energy supply guarantee has gained broad support from the neighboring countries and the countries along "the Belt and Road." In addition to the China–Pakistan Power Grid interconnection project actively promoted by

the Global Energy Internet Development Cooperation Organization, China's Yunnan–Myanmar's Mandalay–Bangladesh's Chittagong ±660 KV/5 million KW DC networking project, China's Yunnan–Myanmar's Burgundy–Thailand's Bangkok ±800 KV/8 million KW high-voltage DC networking projects, and Ethiopia–Kenya–Sudan and other transnational networking projects are in the process of intensive research or accelerated promotion [14]. The Interconnection Project of Mongolia–China–Korea–Japan Power Network is also put onto schedule. In March 2016, the State Grid Corporation of China signed *Memorandum of Cooperation on Northeast Asia Power Networking* with the Korean Electric Power Commune, Japan Softbank Group, and Russia Power Grid Corporation and established the joint working group of Mongolia–China–Korea–Japan Network Project in May to carry out the project implementation research. At present, the prefeasibility study has been completed.

In terms of transnational networking, Asia lags far behind Europe and North America, which has already formed a pattern of intracontinental networking, while the grid interconnection between Asian countries is severely underdeveloped. From 2000 to 2015, Asia's energy consumption grew from 3.6 to 7.5 billion tons of standard coal, an average growth of 5.1%, 2.8% higher than the global average [15]. In January 2017, at United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Energy Committee Top Forum held in Bangkok, Chinese experts called on Asia to accelerate the construction of energy internet, promote energy system reform and sustainable development. Liu Zhenya believes that the key to resolving Asian energy and pollution problems is to develop and allocate clean energy on a large scale and build an Asian Energy Internet. The general idea is to form a "1 + 5" networking pattern consisting of six major power grids, including the power grids of China, northeast Asia, southeast Asia, South Asia, central Asia, and west Asia. The network aims to accelerate the development of clean energy in northern China, Mongolia, and Russia, so as to transmit electricity to east China, South Korea, and Japan, forming the northeast Asia power network, and to accelerate the construction of power grids in South Asia and Southeast Asia and the interconnection of power within the regions, receiving clean energy from China, Central Asia, West Asia, and other regions to meet the power demands of India, Pakistan, Bangladesh, and Southeast Asian countries.

In May 2017, the Global Energy Internet Development Cooperation Organization signed cooperation agreements with five international

organizations: the United Nations Department of Economic and Social Affairs, the United Nations Economic and Social Commission, the African Union Commission, the League of Arab States, and the Network Authority of the Gulf Arab Countries, respectively. The agreements intend to deepen pragmatic cooperation in areas such as interconnected power grid planning, basic research, policy coordination, project promotion, and information sharing, so as to jointly promote the development of the global energy internet and the construction of "the Belt and Road." On May 9, 2017, World Hydropower Conference was held in Ethiopia with the theme of promoting the interconnection of the global grid and creating a good future for hydropower.

In July 2017, "The Belt and Road" Development & Global Energy Internet Construction Seminar was held in Rio de Janeiro to implement "the Belt and Road" initiative and South American energy integration strategy, thus promoting South American energy internet construction. The participants agree that the global energy internet will bring new opportunities for the development of clean energy and power grid interconnection in South America. They looked forward to the Global Energy Internet Cooperation Organization playing a platform advantage to deepen pragmatic cooperation among South American countries in policy coordination, planning and research, technological innovation and project implementation, and to promote the development of low-carbon energy in South America [16]. The first phase and the second phase of Beautiful Mountain Hydropower Projects undertaken by the State Grid of China are the first and second UHVDC transmission projects in Brazil and even the whole American Continent, as the demonstration projects of "UHV + Clean Energy" in Latin America. These two projects ran across three states and ended in the southeastern state of Minas Gerais, known as the "Brazilian power highway" and the first UHVDC transmission line in Latin America. The Beautiful Mountain hydropower station has not only prepared for the Brazilian electric power national network but also has laid a solid foundation for the interconnection between Brazil and the neighboring countries. According to the conception, the project will further provide support for Brazil−Venezuela−Colombia networking, and the Colombia−Panama (South America−Central America) networking in planning, which will lay an important foundation for interconnection between the Central American and Mexican networks and the interconnection of North and South American

networks. Currently, the energy sectors in Brazil, Peru, and Bolivia are conducting a feasibility study on electric power networks of the three countries.

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