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The Principle and Application of Ecological Modernization in China

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This paper is the overview of the China Modernization Report 2007, which focused on the ecological modernization. The report conduct time-series analysis, section analysis and case analysis of the ecological effects of modernization and the 300-year-long (1700—2001) historical process of ecological effects and transformation of modernization. It had discussed the principle and application of ecological modernization in China at 21 century.

Key words Ecological modernization; China

We have been living in the natural environment ever since we were born. The natural environment provides us with life support and material and cultural services. Without the natural environment, there will be no human civilization. With the increase of population and the improvement of living standard, the material demand of mankind will gradually approach the limits of the tolerance of the natural environment and an irreversible degradation will occur to the natural environment if we stick to the traditional mode of development. In fact, mankind already has the ability powerful enough to destroy the globe, which has become increasingly incapable of satisfying the demand of mankind. In the world modernization process, one unavoidable and growingly prominent issue is how to scientifically handle the relationship between the natural environment, economic development and social changes and how to realize a mutually beneficial coupling between the advance of civilization and the natural environment.

Currently, there are many schools of theories and thoughts and countless numbers of academic papers on the relationship between mankind and nature. Among the numerous theories, the ecological modernization theory put forward by German sociologist Joseph Huber in the 1980s has become a main theory of the environmental sociology in the developed countries. Ecological modernization requires that the principles of prevention and innovation should be adopted to promote a decoupling between economic growth and environmental degradation and seek win-win results for both the economy and the environment. Over the past two decades or so, many developed countries have chosen ecological modernization and have made noticeable achievements. We believe China should learn from their experience and pursue ecological modernization.

1 Historical facts about world ecological modernization

Ecological modernization is an important aspect of modernization, and represents a mutually beneficial coupling between modernization and the natural environment and an ecological transformation of world modernization. Ecological modernization began roughly in the 1970s. Although the history of ecological modernization is only a little more than three decades, the ecological effects of modernization have been in existence for about 300 years ever since the Industrial Revolution. This report will conduct time-series analysis, section analysis and case analysis of the ecological effects of modernization and the 300-year-long (1700—2001) historical process of ecological effects and transformation of modernization. These analyses cover three fields (ecological response, ecological economy and ecological society) and four aspects (ecological efficiency, ecological structure, ecological institution and ecological concept). The contents of these analyses include the long-term trends, world frontiers, international disparities and statistical analysis. The time-series analysis has 15 sample countries (eight developed countries and seven developing countries), the 2001 section analysis has 131

sample countries and 102 ecological variables, and other samples for section analysis are the main countries that have data for that year. The report summarizes 36 basic facts and six historical experiences.

1.1 Thirty-six basic facts about the ecological effects and ecological transformation of world modernization

(1) Ten basic facts about ecological response: The population size and density have risen, the fossil energy production and ecological footprint have expanded, the per capita cultivated land, grassland and freshwater resources have decreased, the per capita forest resources and biodiversity have declined, the per capita steel production has risen and then declined, the per capita mineral production has become regionally diversified, the per capita air pollution has risen and then declined, the per capita industrial wastewater biochemical oxygen demand (BOD) has risen and then declined, and the greenhouse gas emission has increased but decreased in some countries since the 18th century. The number of nature reserves has risen since the 19th century.

(2) Ten basic facts about ecological economy: The material productivity and land productivity have risen, the ratio of the material economy in GDP has declined, the per capita material output value has risen and the grain per unit area yield and modern organic agriculture have been on the rise since the 18th century; the intensity of chemical fertilizer use in agriculture has risen and then declined, the economy's energy and resource density has risen and then declined, the CO2 emission for unit GDP has risen and then declined, the rate of waste recycle and use has been higher, the proportion of natural resource consumption in GNI has been regionally different, and the Environmental Kuznets Curve (EKC) has been on the rise since the 20th century.

(3) Ten basic facts about ecological society: The ratio of material labor force in total labor has declined since the 18th century; the per capita service income has risen, the ratio of population with longevity has risen, and the safe drinking-water and sanitary facilities have increased in the urban and rural areas since the 19th century; the rate of urban wastewater treatment has risen, the urban air pollution has risen and then declined, the per capita urban wastes have increased, the efficiency of energy use has declined and then risen, and the environmental risks have been regionally different since the 20th century.

(4) Six basic facts about ecological modernization: Since the 20th century, the ecological efficiency and ecological structure have constantly changed, the ecological institution and ecological concept have constantly changed, and the ecological transformation has been highly uneven and asynchronous, the international environmental agreements and international pollution transfers have had global impacts, the correlation between economic development and many per capita natural resources has been unnoticeable in the 20th century; the modes of natural resource production and consumption have been different from variety to variety and from region to region. For example, the population size, the per capita land area, the per capita agricultural land and the per capita grassland had no tangible relationship with the per capita national income in the last 40 years of the 20th century; the per capita arable land, the per capita freshwater resources, the per capita forest resources and the per capita mineral production had no tangible relationship with the per capita income in 2001; but the per capita energy production had a tangible positive correlation with the per capita income and so did the population density with the per capita income.

The above are only partial facts about ecological modernization. Over the past two decades or so, the developed countries have posted both sustained economic growth and marked environmental improvement. The decoupling between the economic and environmental indicators in the OECD countries has reached 52 percent at average level (OECD 2002).

1.2 Six historical experiences of world ecological modernization

The history of ecological modernization has been more than three decades if it began from the first United Nations Conference on the Environment held in 1972. During this period, ecological modernization advanced amid disputes and conflicts. In the developed countries, especially in some West and North European countries, the progress in ecological modernization has been remarkable. The historical experiences of world ecological modernization are thought-provoking.

(1) Ecological modernization is an inexorable historical trend. The growing population density on earth, the material demand of human beings and the discharge of wastes will all gradually approach the limits of the tolerance of the natural environment. Although technological advance can partially ease the pressure on the environment, technological advance alone is not enough. An ecological transformation of

the living and modernization modes of mankind is indispensable. With the development of globalization and with the advance in ecological modernization in the developed countries, the developing countries cannot ignore the international and domestic pressure for ecological modernization. Therefore, ecological modernization will gradually become an irreversible world trend.

(2) Ecological modernization will not be a smooth sailing. Ecological modernization requires a rational handling of the relationship between the economy and the environment. With economic fluctuations and environmental changes, the people's concept will also undergo changes. In an economic recession, environmental awareness will be challenged. In an environmental crisis, economic growth will be questioned. Cars or blue skies? There will be different answers under different conditions. Of course, it is better to have both cars and blue skies. Ecological modernization has been advancing in disputes.

(3) Ecological modernization requires innovation and learning. Ecological modernization requires environment-friendly technology innovation and institution innovation, and requires ecologically-rational structural changes and mode changes. In this course, conceptual changes are the most important. In the countries pioneering ecological modernization, innovation and conceptual changes are of essential importance. In the countries trying to catch up in ecological modernization, learning and conceptual changes are the priority tasks and regional innovation is also indispensable. Innovation and learning are two leverages to push forward ecological modernization.

(4) Ecological modernization requires domestic cooperation. Ecological modernization is an ecological revolution, which involves the ecologically-rational changes in economy, society, politics, culture, environmental management and personal behaviors. In the history of human civilization, each revolution triggered a re-distribution of social interests and fierce social conflicts. The same is true to the ecological revolution. The governments, enterprises, societies and environmental groups all have to face the attack of the ecological revolution. They are both forces for the revolution and also the objects of the revolution. They need to change other people as well as themselves. Conflicts and cooperation are inevitable. In the 1960s and 1970s, conflicts and confrontations constituted a striking feature of the environmental movement. Since the 1980s, environmental cooperation has become the mainstream though environmental struggles have continued. People's cooperation and democratic participation in the environmental agenda constitutes a typical feature of ecological modernization.

(5) Ecological modernization requires international cooperation. The solar system has only one earth, on which all human beings live. The air circulation, water circulation, carbon circulation, material flow and energy flow on earth all happen on a global scale. They cross the boundaries of countries and nations. The global climate change, the ozone layer depletion, the air pollution spread, the waste pollution transfer, the biodiversity protection and the rational development and utilization of natural resources and energies all require full cooperation among all the citizens of the globe. Air knows no boundaries. Although global cooperation on an equal footing is still a slogan, international cooperation has taken place in many areas.

(6) Ecological modernization has no best mode. From the world perspective, ecological modernization can be divided into three major categories.

The first is the ecological modernization in Europe, which is relatively "idealistic". Most European countries have relatively small territories and are prone to the impact of the international environment. Besides, the West European countries boast of fine academic traditions. They were the first to put forward the ecological modernization theory, pressed for environmental cooperation within the European Union, and actively advocated ecological modernization to other countries in the world.

The second is the ecological modernization in North America, which is relatively "pragmatic". The North American countries have vast territories and rich resources, and enjoy exceptionally favorable natural conditions. They were the first to advocate industrial ecology, pushed forward environmental legislation and environmental improvement, cared about biodiversity protection, and emphasized environmental quality and economic growth. But they have had fewer theoretical innovations.

The third is the ecological modernization in the developing countries, which is relatively "realistic". Most developing countries pursued ecological modernization in light of their national conditions and in a selective way, and the roles of their governments and scientific communities were more prominent than their counterparts in the developed countries. In particular, some countries chose to pursue integrated ecological modernization and some others chose ecolog-

ical corrections to classical modernization.

Since the 1990s, while the developed countries have seen their economies growing and environment improving, the developing countries have come under dual pressure: economic development and environmental protection. Meanwhile, international environmental trade and diplomacy have been extremely active. In this course, some scholars emphasized the tolerance of the resources and the environment and the ecological transformation of world modernization. Some others adopted double standards and requested the developing countries to protect the environment and conserve the resources and the developed countries to maintain relatively high levels of resource consumption and per capita ecological footprint. As the developed countries are in an advantageous position in international competition, the developing countries need to distinguish right from wrong and avoid falling into the "pitfall of sustained poverty" in world development.

2 Basic principles of world ecological modernization

The ecological modernization theory is a theory exploring the interaction between modernization and the natural environment. It was born in the 1980s (Young 2000). But the ideological origin of ecological modernization dated back much earlier. In fact, the birth of human beings was a result of the interaction between the "animal ancestors" of human beings and the natural environment. Since the 1970s, most industrial countries have undergone the environmental reform and ecological transformation of their social institutions and production modes. The ecological modernization theory attempts to interpret and describe the nature, connotation and dynamics of this transformation process (Mol 2001). The ecological modernization studies roughly underwent three development stages.

2.1 European ecological modernization theories

Dutch scholar Arthur P.J. Mol believes that the ecological modernization theory was first put forward in some West European countries such as Germany, the Netherlands and Britain in the early 1980s (Mol, 2001). This theory is mainly based on European experience and describes a new mode, which pursues development that has economic effectiveness, social justice and environmental friendliness. It is a win-win mode for both the economy and the environment. Economic growth coordinates with environmental protection and is decoupled from environmental pressure (Christoff 1996, Young 2000, Andersen 2002).

Currently, there is no unified definition of ecological modernization. In general, it has four layers of meanings:

First, ecological modernization is a theory of environmental sociology, which provides a sociological interpretation of environmental reforms;

Next, ecological modernization is a new model (framework) for understanding and analyzing the technology-intensive environmental policies and ecological transformation;

Third, ecological modernization is a true reflection of the progress the developed countries have made in environmental and economic reforms since the 1980s;

Fourth, ecological modernization is a theory of social changes, which describes the process of economic and social transformation arising from environmental awareness, including the ecological transformation of the production and consumption modes, the environmental and economic policies, the modern technologies, the government administration and the modern institutions.

The core elements of ecological modernization are prevention, innovation and structural change. It has six main points:

(1) A modern industrial society requires sustained ecological restructuring to establish ecological modernity. This ecological restructuring represents the transformation and reform of the social practice and institutions arising from ecological and environmental awareness. Although the current process of ecological transformation cannot claim to be linear and irreversible, it is eternal and hardly reversible to a certain extent (Mol 2001).

(2) In the course of ecological restructuring, it is imperative to give play to the joint roles of modern technologies and the market economy. While modern technologies constitute the core mechanism for ecological reforms, the dynamics of economy and market are important to ecological reforms. The industrial innovations encouraged by the market economy and promoted by the governments can promote environmental protection.

(3) Environmental challenges should be correctly treated. Environmental challenges should be regarded as both crises and opportunities. Pollution reduction should be regarded as a tool to increase eco-

nomic competitiveness instead of requesting the addition and maintenance of the expensive terminal treatment technologies. Ecological modernization can be regarded as an opportunity for environmentally sensitive technologies (Christoff 1996).

(4) New environmental agendas should be established. The establishment of new environmental agendas can help surmount various conflicts and interests, form alliances for the environmental agendas, manage the natural resources and environmental risks, and solve the conventional contradictions between economic growth and related environmental management.

(5) Forward-looking and preventive environmental policies should be established. The principle of prevention should be adopted to promote environmental reforms and to push forward the long-term structural changes in the macroeconomic structure, the production and consumption modes, the technology structure and the environmental policies.

(6) The principle of industrial ecology should be adopted to establish participation-based strategic environmental management (Huber 2000).

2.2 Characteristics and laws of general ecological modernization

The general ecological modernization theory is an expansion and application of the European ecological modernization theories within a global scope and in the sense of modernization. It is the "third-generation theory" in ecological modernization studies. It believes that most of the environmental problems of modern society are man-made and these man-made problems need to be solved by men. Ecological modernization does not simply begin with pollution control. Instead, it should begin with a change in the mode of human behaviors and should achieve the win-win goals for environmental protection and economic development by changing the modes of economic and social development. The essential elements of the general ecological modernization are high efficiency, low waste, no toxicity, no hazard, decoupling, win-win result, mutual benefit and coexistence (mutualism).

(1) General ecological modernization is a highly integral concept.

First, ecological modernization is an ecological transformation of world modernization arising from modern ecology and environmental awareness. It is the mutual interactions between modernization and natural environment, and a mutually beneficial coupling between modernization and the natural environment. It includes a transition from material economy to ecological economy, from material society to ecological society and from material civilization to ecological civilization. It also includes an improvement of the natural environment and the ecosystem, a sustained enhancement of ecological efficiency and life quality, a profound change in ecological structure, ecological institution and ecological concept, and a tangible change in international competition and international status.

Next, ecological modernization is a long and phased historical process. From the 1970s to the end of the 21st century, ecological modernization experiences roughly four phases: the phase of being relatively dematerialization and greening, the phase of being highly dematerialization and ecologization, the phase of seeking win-win results for both the economy and the environment, and the phase of mutually beneficial coexistence between mankind and nature. Of course, this classification is in the relative term.

Third, ecological modernization is an international competition lasting for more than a century. It comprises the international competition in which various countries try to catch up with, to reach and to maintain the world's advanced level, and also the changes in domestic ecological efficiency, ecological structure, ecological institution and ecological concept.

Fourth, ecological modernization can be viewed from both the absolute and relative perspectives. If the domestic process of ecological modernization is defined as an absolute ecological modernization, the process of the changes in the international status of ecological modernization can be regarded as a relative ecological modernization. Ecological modernization is both a virtuous coupling between domestic modernization and the natural environment and an international competition in the areas where modernization and the natural environment interact.

In short, ecological modernization = ecological progress × ecological economy × ecological society × international competition.

(2) General ecological modernization has 15 basic features, 10 basic principles and three basic paths.

The 15 basic features of general ecological modernization are: relatively predictable, global, long, complicated, progressive, transitional, systematic, incremental, uneven, irreversible world trend, dematerialization, greening, ecologization, economic and environmental win-win result, and mutually benefi-

cial coexistence between mankind and nature.

The 10 basic principles of general ecological modernization are: the principle of prevention, the principle of innovation, the principle of efficiency, the principle of unequal prices, the principle of dematerialization, the principle of greenization, the principle of ecologization, the principle of democratic participation, the principle of polluter paying, and the principle of economic and environmental win-win result. In addition, many principles of natural science, technological science, social science, humanities and composite disciplines, such as the first law and the second law of thermodynamics, also apply to ecological modernization.

The three basic paths of general ecological modernization are: the path of comprehensive ecological modernization, the path of integrated ecological modernization and the ecological corrections to classical modernization. Ecological modernization has path dependence and starting-point dependence, but has no best mode.

(3) The basic requirements of general ecological modernization are "dematerialization, greenization, ecologization and decoupling".

First, it has to be dematerialization. The basic connotations are high efficiency, low waste, high quality and low density. High efficiency means higher material productivity, resource productivity, energy productivity and land productivity. Low waste means the economy and society consume less materials, resources, energies and carbon energy. High quality means the economy contains higher ratios of service, culture, information and knowledge and means the qualities of the economy and life is higher. Low density means the economy and society have lower material, resource, energy and carbon energy densities.

Next, it has to be greenization. The basic connotations are toxicity-free, hazard-free, clean and healthy. "Toxicity-free" means the lower production and emission of toxic materials and toxic wastes that are harmful to the environment and health and also means detoxification, low emission and pollution control. "Hazard-free" means the lower production and emission of hazardous materials and hazardous wastes that are harmful to the environment and health and also means hazard-free treatment, low emission and pollution control. "Clean" means the development of environment-friendly technologies, clean production, green products, green energies, green transportation, green living and lower emission. "Healthy" means the economy and society have higher ratios of green elements that are friendly to the environment, hazard-free to human beings, safe, and better in quality.

Third, it has to be ecologization. The basic connotations are prevention, innovation, recycle and win-win result. Prevention means the principle of prevention that highlights the development of ecological agriculture, ecological industry, ecological tourism and ecological cities, and also the conservation of natural and biological resources. Innovation means the principle of innovation that highlights environment-friendly knowledge innovation, technological innovation and institution innovation, and also higher ecological efficiency and ecological culture. Recycle means the recycle economy that highlights higher ratios of waste recycling, reutilization, reproduction and treatment. Win-win result means the win-win principle that highlights intensified ecological reconstruction, reduced ecological degradation, and win-win result for both the economy and the environment in the course of economic development.

Fourth, the economy has to be decoupled from the environmental degradation. The basic connotations are inverse decoupling and direct coupling. Inverse decoupling means economic growth should be decoupled from environmental degradation. In other words, economic development should be decoupled from the growth of material demand, from the growth of natural resource consumption, from the growth of energy consumption, from the growth of environmental pollution and from ecological degradation. Direct coupling means a virtuous coupling between economic development and environmental progress.

3 Strategic considerations for China's ecological modernization

The starting phase of the world ecological modernization coincided with the period of China's reform and opening-up, during which China's industrialization and urbanization embarked upon a fast track and China's modernization drive scored remarkable progress. Accordingly, the environmental pressure arising from industrial modernization and the environmental protection required for ecological modernization formed dual challenges to China's modernization. There were three roads before us. The first was to repeat the old road passed by the developed industrial countries, meaning pollution first, control second and transformation last. The second was to di-

rectly adopt the current approach of the developed industrial countries, meaning ecological transformation required for comprehensive ecological modernization. The third was to adopt the principle of integrated ecological modernization, meaning that green industrialization, green urbanization and ecological modernization should advance in a coordinated manner. In light of the international and domestic conditions, we believe that integrated ecological modernization is a rational path. If this path is taken, China's ecological modernization is expected to reach the world's middle level around 2050.

3.1 International comparison of China's ecological modernization

First, the comparison between China's 121 ecological indicators and the world levels. In 2001, China's 15 indicators including the per capita grassland area and the ratio of environmental inputs in GDP were roughly at the same levels of the developed countries. China's 13 indicators including the ratio of urban safe drinking water were roughly at the world's average levels. China's 40 indicators including the land productivity and urban air pollution (SO2 density) had a more than five-fold relative gap with the levels of the developed countries. China's 26 indicators including the intensity of industrial energy consumption and the ratio of the availability of health facilities in the rural areas had a more than two-fold relative gap with the levels of the developed countries. China's 40 indicators including the rate of urban waste treatment had a less than two-fold relative gap with the levels of the developed countries.

Next, the comparison between China's 24 main ecological indicators with the levels of the leading countries. Currently, China's relative gap with the leading developed countries was more than 100-fold for three indicators including the ratio of natural resource consumption in GNI, more than 50-fold for five indicators including the freshwater productivity, more than 10-fold for four indicators including the density of industrial wastes, and more than two-fold for 11 indicators including the density of chemical fertilizer use in agriculture. For example, China's ratio of natural resource consumption in GNI in 2003 was roughly more than 100-fold higher than the levels of Japan, France and South Korea, more than 30-fold higher than the levels of Germany, Italy and Sweden, and more than two-fold higher than the levels of the United States and Britain. China's density of industrial wastes in 2002 was roughly 20-fold higher than the level of Germany, 18-fold higher than the level of Italy, 12-fold higher than the levels of South Korea and Britain, 11-fold higher than the level of Japan, and four-fold higher than the levels of France and Sweden. China's extent of urban air pollution in 2002 was roughly more than seven-fold higher than the levels of France, Canada and Sweden, more than four-fold higher than the levels of the United States, Britain and Australia, and more than two-fold higher than the levels of Japan, Germany, Italy, South Korea and Brazil. China's ecological degradation arising from agriculture and animal husbandry was also far higher than the levels of the developed countries.

Third, the international comparison of China's ecological modernization index. The ecological modernization index refers to the result of a comprehensive evaluation of 30 ecological indicators measuring ecological progress, ecological economy and ecological society. It can roughly reflect the relative level of a country's ecological modernization. In 2004 when China was in the start stage of ecological modernization, the country's ecological modernization index was 42 points, ranking 84th among the 98 leading countries in the world or 100th among all the 118 countries. China's ecological modernization index in 2004 had a 57-point absolute gap with the average value of the high-income countries. This was partly related to that China was in the phase of industrialization.

3.2 Ten challenges to China's ecological modernization

In the first half of the 21st century, China's ecological modernization will face 10 challenges. The first challenge is to enhance the people's modern ecological awareness and accelerate the transition from material society to ecological society. The second challenge is to speed up the ecological transformation of the mode of economic development and heighten the level of ecological economy. The third challenge is to expedite the ecological transformation of the mode of consumption and encourage green consumption. The fourth challenge is to formulate national energy strategies and prevent the outburst of energy crises. The fifth challenge is to establish long-standing prevention mechanisms and mitigate the impacts of natural disasters. The sixth challenge is to establish mechanisms for ecological compensation and allow modernization to benefit all citizens. The seventh challenge is to raise the level of environmental credit and establish

environmental responsibility institutions. The eighth challenge is to take full advantage of the opportunities arising from globalization to develop international resources and markets. The ninth challenge is to implement the *National Plan for Ecological Environment Construction* and quicken ecological modernization in the west region. The tenth challenge is to advocate the scientific approach to development and build a resource-saving and environment-friendly society.

Without modern ecological awareness, there will be no ecological modernization. Popularizing ecological knowledge and heightening the people's modern ecological awareness are crucial to the success of China's ecological modernization. Modern ecological awareness is based on the theories of modern ecology, environmental science, economics and ecological modernization. It advocates high efficiency, low waste, high quality, low density, no toxicity, no hazard, cleanness, safety, recycle, conservation, fairness, win-win result, green production, green consumption, prevention, innovation, health and environment-friendliness. It holds that the polluters should pay, the beneficiaries should supervise, the signers should be responsible and the wrongdoers should be punished. It opposes resource waste, environmental pollution, ecological damage and excess consumption, and tries hard to realize a complete decoupling between economic development and environmental degradation, a virtuous coupling between social progress and environmental progress, and a mutually beneficial coexistence between mankind and nature.

3.3 Strategic options for China's ecological modernization

In the next five decades, China's ecological modernization can make breakthroughs in three areas: ecological economy, ecological society and ecological awareness. Taking "dematerialization, greenization, ecologization and decoupling" (decoupling economic growth from environmental degradation) as the main thrusts, the country's ecological modernization will strive to complete the ecological transformation of the mode of modernization and to realize a strategic change in environmental management from the mode emphasizing emergency response to the mode emphasizing prevention and innovation. We suggest that in the first half of the 21st century, the following 10 measures should be taken to promote China's ecological modernization.

(1) A road map for China's ecological modernization and its national and regional ecological modernization should be formulated and implemented.

A road map for China's ecological modernization represents a collection of the strategic goals and canal path of China's ecological modernization. Its main contents can be divided into eight parts: the canal path, the strategic goals, the basic tasks, the monitoring indicators, the monitoring of ecological progress, the monitoring of ecological economy, the monitoring of ecological society, and the strategic measures for China's ecological modernization.

First, the canal path for China's ecological modernization: In accordance with the principle of integrated ecological modernization, efforts should be made to coordinate and push forward ecological modernization, integrated modernization, green industrialization, green urbanization; modernization should be knowledge-based, dematerialization, greenization and ecologization, should realize an absolute decoupling of economic development from environmental degradation and should seek win-win game for both the economy and the environment; China should try to catch up with the level of ecological modernization in the developed countries. China's ecological modernization can reach the world's middle level in 2050 and the world's advanced level at the end of the 21st century respectively.

Next, the strategic goals of China's ecological modernization: China's ecological modernization will reach the world's middle level in the first half of the 21st century, its economic growth will be absolutely decoupled from environmental degradation, ecological modernization will be largely realized, and its level of ecological modernization will be among the top 40 countries in the world. In the second half of the 21st century, a virtuous coupling between the economy and the environment progress will be realized, ecological modernization will reach the world's advanced level, comprehensive ecological modernization will be realized, and the level of ecological modernization will rank among the top 20 countries in the world.

Third, the basic tasks of China's ecological modernization: We have to accomplish three basic tasks in the 21st century. One, China's ecological modernization will go up three steps internationally. The international level of China's ecological modernization will move from the low level to the preliminary level around 2020, rise to the world's middle level by 2050 and reach the world's advanced level by 2100. Two, the historical process of China's ecological modernization will move through three phases. The historical process of China's ecological modernization

was in the starting phase in 2000, and will enter the developing phase around 2030, reach the mature phase around 2050, and reach the stable phase around 2080. Three, the international status of China's ecological modernization will advance by about 80 rankings. China's ecological modernization index will be about 40 rankings higher in the first half of the 21st century and another 40 rankings higher in the ensuing five decades.

Fourth, the monitoring indicators of China's ecological modernization: 36 monitoring indicators for ecological progress, ecological economy and ecological society; 36 monitoring indicators respectively for China's social modernization and for its economic modernization. In all, 108 monitoring indicators will be used to measure China's modernization drive.

Fifth, the monitoring of ecological progress in China's ecological modernization: 12 indicators including environmental quality and land quality, and the general goals, staged goals (2010—2020—2030—2040—2050) and tasks for the first half of the 21st century.

Sixth, the monitoring of ecological economy in China's ecological modernization: 12 indicators including ecological efficiency and ecological structure, and the general goals, staged goals (2010—2020—2030—2040—2050) and tasks for the first half of the 21st century.

Seventh, the monitoring of ecological society in China's ecological modernization: 12 indicators including green homeland and green living, and the general goals, staged goals (2010—2020—2030—2040—2050) and the tasks for the first half of the 21st century.

Eighth, the strategic measures for China's ecological modernization: three breakthroughs, namely ecological economy, ecological society and ecological awareness; three layouts, namely sectional arrangement, geographic arrangement and technological arrangement; three securities, namely resource security, energy security and environmental security.

The next two decades (2010—2030) will be an extremely crucial period for China's ecological modernization. During this period, China will gradually complete industrialization and urbanization, its population size will reach the maximum value, and its resource demand and environmental pressure will likely reach the maximum values. We suggest an expert group be set up to consider national and regional strategies for ecological modernization in the next two decades.

(2) Green development road should be adopted to control and reduce new environmental pollution.

The principles of the green development road are: high efficiency, low waste, high quality, low density, high standard, low emission, no toxicity, no hazard, cleanness, health, mutually beneficial coupling between green industrialization, green urbanization and environmental protection, and win-win result for both development and environmental protection.

First, the road of green industrialization. The CMR 2005 specified the features of new industrialization. Simply put, new industrialization means information-intensive, knowledge-intensive, greening and ecological corrections to the traditional industrialization, and also means a systematic integration of industrialization, information-based industry, knowledge-based industry, environment sound industry, ecological industry and globalization. By implementing the new industrialization strategies and by taking the green industrialization road, the environmental pressure from newly-built industries will be reduced. Green industrialization has 10 specific requirements and measures.

Next, the road of green urbanization. The CMR 2006 put forward the new strategies for urbanization and suggested that urbanization, suburbanization, information-based city, knowledge-based city, environment sound city, ecological city and internationalization develop in a coordinated way so as to build a green homeland that highlights urban-rural equilibrium. By implementing the new urbanization strategies and by taking the green urbanization road, the newly-added urban pollution will be reduced and controlled. Green urbanization has 10 specific requirements and measures.

Third, other environmental projects should be executed simultaneously, such as the green homeland project and the green consumption project, etc.

(3) The programs to control pollution and transform traditional industries should be continued so as to eliminate the environmental pollution left over from the past.

The programs to control environmental pollution in an integrated way in key regions and key industries should continue. First, in the regions and river valleys where traditional industries and polluting industries concentrate, the pollution-control projects should be executed to eliminate the environmental pollution left over from the past and to control and reduce new pollution. Next, the traditional industries and espe-

cially the resource-intensive, energy-intensive and pollution-intensive traditional industries should have their industrial processes transformed for environmental sound so as to control and reduce industrial pollution. Third, the total-amount pollution control regime and the emission permit institution should continue to be observed. Fourth, records and rankings should be established for the enterprises emitting toxic materials and pollutants, and should be published on a regular basis.

(4) The ecological improvement projects such as the one for natural forest conservation should continue and the national ecosystem assessments should be held on a regular basis.

The projects designed to protect natural forests, to facilitate forestation and to build planted forests should continue so as to increase forest coverage to about 35 percent in 2050 and about 40 percent in 2100. Construction of nature reserves should be sped up, the project to "revert cultivated land back to forestation" should be improved, and the natural grassland and pastures should be protected and improved. The goals and tasks specified in the "National Plan for Ecological Environment Construction" should be implemented in a comprehensive way.

(5) Active efforts should be made to promote the construction of ecological cities, ecological urban areas, ecological parks and ecological rural areas.

The construction of ecological cities has six priorities. First, planning should be done for ecological cities and ecological urban areas. Second, the ecological reconstruction of old urban areas should be encouraged and new ecological cities should be built. Third, the waste and wastewater treatment capacities of the cities should be expanded and the environment of the cities should be improved. Fourth, urban landscaping should be expanded and clean energy and green transportation should be developed. Fifth, urban residents should be encouraged to choose a green and ecological sound way of life. Sixth, the cities should be encouraged to adopt the environmental standards such as those for model environment city, model habitation environment and environmentally beautiful town and township.

The construction of ecological rural areas covers six aspects. First, the Plan of Action for Ecological Homeland and Enriching the People should continue to be executed, clean energies should be developed and rural sanitation projects should be promoted. Second, the Project to Improve Rural Water Supply and Toilets should continue to be executed so as to increase the coverage of safe drinking-water and health facilities in the rural areas. Third, the Project of "Reverting Cultivated Land Back to Forestation" and the construction of nature reserves should continue to be improved so as to enhance the ecological quality of the rural areas. Fourth, the structures of rural energy and transportation should be improved to enhance the quality of the rural life. Fifth, ecological agriculture, organic agriculture and pasture agriculture should be developed to increase the income of the peasants. Sixth, the process of urbanization should be expedited to reduce the density of the rural population and the pressure on the rural environment.

(6) Three ecological industries should be developed: ecological agriculture, environmental industry and recycle economy-based industry.

The ecological agriculture can be divided into four layers. First, the peasants, farms, pastures and agricultural enterprises should be encouraged to develop ecological agriculture, organic agriculture, natural agriculture, or pasture agriculture. Second, the development of specialized ecological agricultural zones or ecological agricultural towns and townships should be encouraged. Third, the organic food and green food industries should be developed. Fourth, the development of ecological agricultural counties should be encouraged.

The environmental industry can be divided into four aspects. First, the utilization of waste resources and the development of renewable energies should be encouraged. Second, the development of environmental technologies and the technical and commercial services for environmental protection should be encouraged. Third, the development of the enterprises that produce and provide environmental products and services should be promoted. Fourth, the development of environmental parks should be encouraged. All environmental industries should raise their own resource utilization efficiency and reduce their energy and material consumption and waste emission.

The development of the recycle economy-based industry can be divided into four aspects. First, the enterprises should be encouraged to increase waste reutilization, reproduction and recycle. Second, the development of the waste collection and service industries should be encouraged and the construction of the outlets engaged in sorted waste recycling and waste recycling should be encouraged. Third, the development of the enterprises that utilize wastes in an integrated way should be encouraged. Fourth, the development of recycle economic parks and ecological in-

dustrial parks should be encouraged.

(7) Three ecological institutions should be established: the institution of ecological compensation, the environmental responsibility institution for key posts, and the environmental risk evaluation system for key projects.

The functional service zones of China's eco-systems should be divided in accordance with the principles of ecology and the features of China's eco-systems. A *National Law on Regional Development* should be considered and enacted so that regional development can have legal foundations. The construction of national nature reserves and protected areas should be strengthened and the ratio of nationally protected areas should be raised. The central, provincial and municipal finances should establish ecological compensation funds at three levels, and scientific and rational ecological compensation mechanisms should be worked out to ensure that the local residents in the protected areas at various levels can reach the average living standards of the country or their provinces and cities and that their living standards can be raised largely in step with the average levels of the country or their provinces and cities. At the same time, the dependence mentality should be prevented.

Protecting the environment is a responsibility for all people. Different posts involve different responsibilities. We suggest the *Environmental Protection Law* be amended and an environmental responsibility institution be established for key posts. A letter of environmental responsibility should be signed by those who are appointed to key posts and a letter of environmental audit should also be signed by those who leave key posts. The environmental responsibilities for key posts should be valid for 20 years.

An environmental risk rating system for key projects should be established, which will have the following basic contents. First, the key projects (including fairly large projects) having fairly large environmental risks should be identified through environmental impact evaluation. Second, environmental risk evaluations should be conducted for key projects on a regular basis, with the evaluation cycle being 5—10 years long (an evaluation for every five years for the extremely key projects). Third, the environmental responsibility institution for key posts should be introduced for the key posts of key projects.

(8) Three ecological projects should be executed: the green homeland project, the green service project and the green consumption project.

In the existing urban areas and the densely-populated towns and townships, the green homeland project should be introduced to popularize the safe drinking-water and sanitary facilities, raise the ratio of domestic wastewater and waste treatment, increase the per capita landscaping area and raise the ratio of clean energies so that safe drinking-water and sanitary facilities can reach all people, that wastewater and wastes can all be treated, that the air quality can reach the national grade-1 standard and that the habitation environment can be completely improved.

The green service project should be introduced to encourage the development of the modern green service industry and make the economy dematerialization, greening and more ecologization. The project has the following basic contents. First, the development of the green service industry should be accelerated. Second, the energy and resource consumption of the service industry should be reduced. Third, the labor and resource productivity of the service industry should be enhanced. Fourth, the quality of the working environment of the service industry should be improved and enhanced. Fifth, the emission of wastes and toxic and hazardous materials of the service industry should be controlled and reduced. Sixth, the recycled use of wastes of the service industry should be promoted.

The green consumption project should be introduced to encourage the enterprises to develop and produce green products (such as organic foodstuffs) and provide green services, and to encourage the residents with financial capacity and environmental awareness to purchase and consume green products and green services, encourage government agency to purchase the green products and services. This constitutes the groundwork for expanding the green market. The key element of the green consumption project is honesty. Only when the green producers guarantee the quality of their green products and only when the government and the market establish mechanisms for preventing fake green products, will the green consumers be willing to pay the "green expenses" for their green consumption.

(9) Three ecological strategies should be introduced: the national strategy for resource security, the national strategy for energy security and the national strategy for environmental security.

The national strategy for resource security should include the regular evaluation of the natural resources in the world, the regular evaluation of the natural resources in China, the important ratings of the natural resources in China, the protection and national re-

serve of strategic resources, the strategy for international resource cooperation, and the strategy for strategic resource security.

We suggest that the import tariffs on key natural resources and primary products be lowered, with the average tariff being reduced to 1 percent from the 10 percent in 2004. The structure of foreign money reserves should be adjusted and a certain ratio of foreign money reserves should be turned from "currency reserve" to "strategic resource reserve". Besides, a progressive tax institution should be introduced for key resource consumption and possession so as to contain resource waste.

The national strategy for energy security should include the regular evaluation of the world energy reserves and energy markets, the regular evaluation of China's energy resources and energy markets, the national strategic energy reserve project, the national energy supply balancing regime, the contingency plan for energy crisis, the program for renewable energies and new energies, the guide for clean energies and energy technologies, and the strategy for international energy cooperation.

The national strategy for environmental security should include the regular evaluation of the world environmental status and development trends, the regular evaluation of the environmental status and development trends in China's neighboring countries, the regular evaluation of international environmental trade, the regular evaluation of China's environmental status and ecosystems, the regular evaluation of the environmental quality of China's key regions and key industries, the strategy for China's environmental security, the strategy for China's international environmental cooperation, the early warning and relief plan for natural disasters, the contingency plan for international and domestic environmental crises, and the plan of action for major environment improvements.

(10) Three government organizations should be established: the national ministry of environment, the national ministry of energy and the national agency for regional development.

Environmental security has become increasingly important. As environmental issues involve many aspects, as environmental pollution has major social impacts and as the government has a huge responsibility for environmental management, we suggest that a national ministry of environment be established to exercise unified leadership over the country's work in climate, air environment, water environment, forest and biological environment, industrial environment and human habitation environment and to formulate and implement the national strategy for environmental security.

The CMR 2005 suggested the establishment of a national ministry of energy from the perspective of economic modernization. From the perspectives of ecological modernization and the strategy for energy security, a national ministry of energy should be established to organize the formulation and implementation of the national strategies for energy security.

The CMR 2004 suggested the establishment of a national agency for regional development from the perspective of regional modernization. From the perspective of ecological modernization, a national agency for regional development should be established to guide and coordinate regional ecological modernization.

If all the above tasks are fully accomplished, China's ecological modernization will reach the world's middle level in 2050. While China's economic development will be completely decoupled from environmental degradation, the quality of the human habitation environment will be as good as that in the leading developed countries, the safe drinking-water and sanitary facilities will reach all people, the urban domestic wastewater and wastes will all be treated, the industrial wastewater and wastes will largely be treated, the productivity of resources and materials will be 10-fold to 30-fold higher than present, the density of industrial and economic wastes will be about 90 percent lower, and the density of industrial and economic energies will be about 80 percent lower. By then, 60 percent of the country's population will have green homelands with beautiful environment, 60 percent of its cities will have air of which quality meets the national grade-1 standard, and the ecological efficiency and service functions of the typical ecosystems will be completely restored. Meanwhile, about one-third of the national territory will be covered by forests (about 35 percent), one-third of the territory will be used for agricultural purpose (about 36 percent), and the remaining one-third will be used for construction and natural landscaping. In particular, land for construction purpose will account for about 9 percent of the national territory and land for natural landscaping will account for 20 percent.

If the above goals are achieved in 2050, China will reach the level of the developed countries by the end of the 21st century and the probability of comprehensive ecological modernization will reach 30 per-

cent. If comprehensive ecological modernization is realized, China's natural environment and the people's livelihood will have undergone earth-shaking changes. By then, China's skies will be blue, China's water will be clear, China's mountains will be green, and China's people will be healthy. China will become one of the most charming countries in the world.

With green mountains, clear water and clean air, people will be beautiful, things will be beautiful and life will be beautiful. China will be a place better than Arcadia, though it is not Arcadia.

4 Evaluation of world modernization

4.1 World ecological modernization index

This report covers the evaluation of ecological modernization in 131 countries from 1970 to 2004. As many countries had only limited statistical data about the environment, this evaluation can only serve as a reference. In 2004, evaluation results were available from 118 countries.

In 2004, the top 10 rankings in the order of precedence based on the ecological modernization index were Switzerland, Sweden, Austria, Denmark, Germany, France, Finland, Britain, the Netherlands and Italy.

In 2004, a total of 15 countries including Switzerland were at the world advanced level of ecological modernization, 37 countries including Spain were at the world's middle level, 40 countries including Brazil were at the preliminary level, and 26 countries including China were at the world's low level. China ranked 100th among the 118 countries.

In 2004, 58 countries including Germany entered the period of ecological modernization. In particular, 10 countries including Germany or 8 percent of all sample countries entered the developing phase of ecological modernization, and 48 countries including the United States or 41 percent of all sample countries entered the starting phase of ecological modernization.

In the 1970s, seven countries including the Netherlands entered the period of ecological modernization. In the 1980s, 11 countries including Italy entered the period of ecological modernization. In the 1990s, 40 countries including South Korea entered the period of ecological modernization. Over the past 34 years, a total of 58 countries or 49 percent of the 118 sample countries entered the period of ecological modernization.

4.2 World modernization index in 2004

In 2004, 24 countries including Sweden or 18 percent of all sample countries entered the period of second modernization. This ratio was identical to that in 2003. Another 30 countries totally completed first modernization and 41 countries basically realized first modernization. Together, the two categories accounted for 54 percent of all sample countries, which was 2 percentage points higher than in 2003.

In 2004, 20 countries including Sweden were developed class, 25 countries including Italy were moderately developed class, 40 countries including China were preliminarily developed class and 46 countries including India were underdeveloped class.

In 2004, the top 10 rankings according to the second modernization index were Sweden, the United States, Denmark, Finland, Japan, Switzerland, Australia, Germany, Belgium and Britain.

4.3 China's modernization index in 2005

In 2005, the level of China's first modernization was 87 percent. In 2004, the level was 86 percent, ranking 55th among 108 countries in the world. China's second modernization index was 39 points, ranking 51st among 108 countries in the world, and its integrated modernization index was 35 points, ranking 59th among these countries.

Of China's 34 provincial regions, Hong Kong, Macao and Taiwan completed first modernization in 2005. Also in the year, seven regions including Beijing realized more than 90 percent of first modernization and 14 regions including Fujian realized 80—90 percent of first modernization. Beijing and Shanghai had nine indicators reaching the standards of first modernization, Tianjin and Zhejiang had eight indicators reaching the standards, Jiangsu, Liaoning and Heilongjiang had seven indicators reaching the standards, and Guangdong, Fujian, Shandong, Jilin and Shanxi had six indicators reaching the standards. Compared with 2004, 11 regions including Chongqing saw their national rankings moving upwards and nine regions including Hubei saw their national rankings moving downwards.

If Beijing, Tianjin, Shanghai, Hong Kong, Macao and Taiwan were excluded, the top 10 rankings in terms of the level of first modernization in 2005 were Zhejiang, Jiangsu, Guangdong, Liaoning, Fujian, Chongqing, Shandong, Heilongjiang, Jilin and Shanxi.

Currently, China is in a period of rapid development in industrialization, urbanization and modern-

ization and thus faces considerable economic and environmental pressures. The ecological modernization theory provides a choice for scientifically handling the coupling between modernization and the natural environment. If we work together, we can succeed, can achieve win-win result for both modernization and the natural environment and can catch up with the world's advanced level. By then, the Chinese people will enjoy a rich and high-quality material and culture life like the people in other developed countries do.

References

[1] Andersen, M. S. 2002. Ecological modernization or subversion? The effects of Europeanization on Eastern Europe. *American Behavioral Scientist*, 45(9), 1394—1416.

[2] Christoff, P. 1996. Ecological modernisation, ecological modernities. *Environmental Politics*, 5 (3): 476—500.

[3] Cohen, M. J. 1998. Science and the Environment: Cultural Capacity for Ecological Modernization. *Public Understanding of Science*, 7(2): 149—167.

[4] Huber, J. 1985. Die Regenbogengesellschaft: Okologie and Sozialpolitik, Fischer, Frankfurt am Main.

[5] Huber, J. 2000. Towards industrial ecology: Sustainable development as a concept of ecological modernization. *Journal of Environmental Policy & Planning*, 2, 269—285.

[6] Mol, A. P. J. 2001. *Globalization and Environmental Reform: the Ecological Modernization of the Global Economy*. Cambridge: MIT Press.

[7] Mol, A. P. J. and Sonnenfeld D. A. (Eds.). 2000. *Ecological modernization around the world: Perspectives and critical debates*. London: Frank Cass.

[8] OECD. 2002. *Indicators to Measure Decoupling of Environmental Pressure from Economic Growth*. Paris: OECD.

[9] OECD. *OECD Environmental Data Compendium*, 1987—2004. Paris: OECD.

[10] World Resources Institute et al. *World Resources* 1986—2005. http://www.wri.org/.

[11] Young, S. (Ed.). 2000. *The Emergence of Ecological Modernization: Integrating the Environment and the Economy*? New York: Routledge.

[12] He Chuanqi. 1999. *Second Modernization: Inspiration From Human Civilization Process*. Beijing: High Education Press.

[13] He Chuanqi. 2003. *Orient Renaissance: Three Roads to the Modernization*. Beijing: Commercial Press.

[14] Luo Rongqu. 1993. *New Perspective of Modernization*. Beijing: Peking University Press.

[15] Research Group for China Modernization Report. 2001. *China Modernization Report* 2001: *Modernization and Evaluation*. Beijing: Peking University Press.

[16] Research Group for China Modernization Strategies. 2002. *China Modernization Report* 2002: *Knowledge Economy and Modernization*. Beijing: Peking University Press.

[17] Research Group for China Modernization Strategies. 2003. *China Modernization Report* 2003: *Modernization Theories and Prospect*. Beijing: Peking University Press.

[18] Research Group for China Modernization Strategies. 2004. *China Modernization Report* 2004: *Regional Modernization*. Beijing: Peking University Press.

[19] Research Group for China Modernization Strategies. 2005. *China Modernization Report* 2005: *Economic Modernization*. Beijing: Peking University Press.

[20] Research Group for China Modernization Strategies. 2006. *China Modernization Report* 2006: *Social Modernization*. Beijing: Peking University Press.

[21] Research Group for China Modernization Strategies. 2007. *China Modernization Report* 2007: *Ecological Modernization*. Beijing: Peking University Press.