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Preface

The China Council for International Cooperation on Environment and Development (CCICED) was established with the approval of the Chinese government in 1992. Consisting of senior Chinese and international officials and experts, it serves as a high-level advisory body with a mandate to conduct research and to provide policy recommendations to the Government of China on China's environment and development. The Council reports to the State Council and each year meets with a senior leader to discuss its recommendations.

Over the past 20 years, CCICED has witnessed significant change and marked progress in China in the field of environment and development policy. Over the Council's tenure, issues have evolved in number, complexity and significance from those discussed at the 1992 Rio UN Conference on Environment and Development to those demanding environmental challenges, such as climate change, that have become mainstream economic and political concerns throughout the world. CCICED continues to be a unique body, highly relevant to China's domestic needs and to fostering a better international understanding of China's contributions to global environment and development.

With ongoing support from the Chinese government, governments of many other countries, and international agencies, CCICED has completed four phases. Phase I (1992—1996) carried out initial policy studies and research on key issues in the field of environment and development, and disseminated and exchanged international experience and information on successful policies. Phase II (1997—2001) shifted the focus from policy research to policy and project demonstrations. Phase III (2002—2006) was established with broader priorities, and a number of major policy studies were conducted. Based on the successful experience of previous phases, Phase IV (2007—2011) drew support from a larger number of donors and focused concerted attention on issues that will determine China's pathway toward becoming an environmentally friendly society. China has entered into a new era, and CCICED will play a major role in promoting China's strategic transformation in environment and development.

2011 is the first year of the implementation of the "12th Five-Year Plan for National Economic and Social Development" marking the green transformation of China's economic development mode. At this new starting point, Chinese Government policy will be based on scientific development as the principal theme, transformation of the economic development mode as the main thread, promotion of ecological civilization as a new requirement, and the development of a resource-saving and environment-friendly society as the principal focus. China will make greater efforts to protect its environment and to promote ecological civilization.

Against this background, the China Council for International Cooperation on Environment and Development held its 2011 Annual General Meeting on the theme of "Economic Development Mode: Green Transformation" and its 20th Anniversary Forum on the theme of "Sharing the Achievements, Embracing the Future". The event focused on measures that will facilitate low-carbon industrialization, green investment and trade, and how to achieve green development through institutional and policy innovations.

This Annual Policy Report 2011 contains documents presented to, and policy recommendations approved by, the CCICED's Annual General Meeting in November 2011. It includes an Issues Paper, prepared as a discussion document addressing green transformation; final reports submitted by three task forces and two special policy studies; and the Council's 2011 Recommendations, which have since been forwarded to the State Council and other governmental agencies. The task force reports represent the views of the individual teams, which are not necessarily those of the Council as a whole, while the Recommendations reflect a consensus among CCICED members attending the 2011 Annual General Meeting.

The materials in this volume offer a great many options for China to consider as it continues to strengthen its governance of environment and development. We wish to share them within and outside of China, in the hope that they will lead to a better understanding of the environment and development challenges facing China and of China's contribution to resolving environmental issues domestically and internationally. Further information may be found on the CCICED web site (http://www.cciced.net/encciced), including texts of task force reports and special policy studies, on which this year's summary reports are based, as well as reports from past years.

We extend our thanks to those who support CCICED's work and China's environmental undertakings. We appreciate the financial and other support from the Government of China and generous donors, and the contributions of many Chinese and international experts who conducted the research reflected in this volume. The invaluable assistance of the Chinese and International Chief Advisors and their group of experts, who provided guidance to the research work, the assistance of the International Secretariat Support Office at Simon Fraser University in Vancouver, and the advice of Council members, who volunteered their time and expertise in support of this undertaking, are all gratefully acknowledged.

The Secretariat of CCICED
January, 2012

Acknowledgments

The China Council for International Cooperation on Environment and Development (CCICED) carried out a series of policy research studies on the theme "Economic Development Mode: Green Transformation" with strong support of CCICED Chinese and International Members, experts, and scholars as well as partners. Reports on and recommendations from these studies were presented to the CCICED Annual General Meeting in November 2011. An Issues Paper was also submitted, which summarized current issues related to environment and development in China. Based on these documents, Policy Recommendations were prepared by the Council's scientific advisors and approved by the Council for submission to the Government of China. These documents are presented as chapters in this current volume.

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Last but not the least, we would like to express our sincere gratitude to CCICED staff members for their hard work in editing and publishing this volume. They include: Zhang Menheng, Zhou Yubao, Ding Yangyang, Carolyn Weeks Tilney, Huang Ying and others.

Contents

Chapter 1 Policy Recommendations to the Government of China

The 5th Annual General Meeting (AGM) of the 4th Phase of the China Council for International Cooperation on Environment and Development (CCICED) was held from November 14-17, 2011 in Beijing. The theme of the 5th AGM was “Economic Development Mode: Green Transformation.”

The Council members noted that the Government of China has formulated the development strategy for the “12th Five-Year Plan” period (2011—2015), taking “Outlook of Scientific Development” as the main approach, with “transformation of development mode” as the main mechanism for achieving a “higher level of Ecological Civilization”. In addition to being the first year of the “12th Five-Year Plan” 2011 also marks the 20th anniversary of CCICED’s establishment. Moreover, global preparations are now underway for the June 2012 Rio+20 United Nations Conference on Sustainable Development. Therefore the green transformation theme is particularly meaningful for the AGM this year. Internationally, there is considerable discussion and rising levels of commitment to implementation regarding new concepts such as green growth, green economy, low carbon economy, circular economy, and green technology. Green transformation has become a favored approach for post-financial crisis economic recovery.

The world over the coming two decades will be characterized by an enormous growth of population, increasing living standards, a growing global middle class and a high level of urbanization. The consequences will be resource and pollution constrained patterns of development, a situation already existing in many places. Competition for resources and green solutions will be inevitable. There is a global Green Race underway—a green competition between countries to become leading suppliers of resource efficient, low polluting solutions, products and services. The “12th Five-Year Plan” is the starting point for positioning China well in this race. Transforming the domestic economy and building demand for green solutions will create the competencies and scale for greener exports.

The evolution to a future resource-efficient, low-polluting world will be very dynamic.

Traditional business models for different industry sectors will be challenged. The future will belong to those who understand this dynamism and can develop new offerings of products, systems and services that are Green in the broad sense of the word. It is very important, therefore, that Chinese businesses adhere to international models of Corporate Social Responsibility (CSR) and other approaches that emphasize concern for environment and social concerns. These approaches can be good for profitability as well, even though there are costs to implement them. China will have to consider how best to stimulate businesses to prepare for this new world. The effort should include Chinese domestic and FDI enterprises, and Chinese businesses operating abroad, including ODI. All need to be brought eventually to an equal and high standard of action for environment and development, and be backstopped by a green financial sector. Much more attention will have to be given to green market supply chains.

China has a choice at this very important junction: embrace the inevitable Green Race and position itself as a global leader and supplier of resource-efficient, low-polluting solutions, or, try to maintain the old role as the supplier of low cost products to a growing world population. While China's choice may seem obvious, even already made in the case of some technologies such as solar and wind energy, the Green Race is still at an early stage. There are no inherent reasons why China could not chart a Green Transformation course that will support future well-being and wealth creation. The future of China's positioning is mainly in the hands of its leaders and people—not in the hands of external forces.

In fact, China's "going green" fits well with the domestic drive toward an environmentally-friendly society and the new scientific development outlook. Green transformation reflects the dynamism of innovation and reform. It should be regarded as an approach to development that emphasizes vigor, balance and sustainability. The ultimate goal of this form of development is to achieve a new balance in the relationship of environment and resources, social inclusiveness and harmony, while enhancing China's overall status and competitiveness regionally and globally. Green transformation will depend upon a better level of transparency and openness in decisions, and on careful attention to appropriate roles for government and market forces. Government needs to provide a clear regulatory framework to guide the operation of the market, and then to allow the market to operate freely within that framework.

As China intensifies its efforts to change the current development mode, and gains deeper understanding of the process and new needs, green transformation is now understood to be central to the direction and core content of this change. The experience gained during the “11th Five-Year Plan”, and through the inclusion of environmental objectives within the 2008 post-financial crisis stimulus package, has set in place a good basis for future efforts. China’s national will and existing experience now must be further drawn upon to create a comprehensive and coordinated approach that can accelerate the pace of change towards sustainable development; and be more efficient and effective in green transformation of economic development.

Participation by China’s citizens in green transformation is essential. Certainly as wealth is created there will be further stimulation of domestic consumption, and it is essential that the patterns of consumption are sustainable in terms of energy, pollution control, environmental impacts and maintenance of ecological services, plus many other aspects related to health, well-being and quality of life. It is essential therefore that a new level of transparency and openness be achieved so that citizens in both cities and the countryside gain a full understanding of the roles they can play as they participate in decision-making and implementation of environment and development matters. Transparency can be thought of as a driver of change, as an incentive, and as an enforcement mechanism. Not only is it important in China’s domestic green transformation, but also in the greening of China’s international brand with respect to exports and also the long-term success of China’s investments abroad.

CCICED members are pleased to see that environment and development considerations have been given considerable attention within the new “12th Five-Year Plan”. However it is important to emphasize that environmental transformation and economic transformation need to become much better aligned since they are interconnected in terms of impacts. This alignment becomes a central theme for green transformation. China urgently needs a comprehensive and practical implementation blueprint for green transformation that includes a development strategy, concrete approach and supporting policies.

CCICED members believe that China’s green transformation could have significant implications globally. Global environment and development progress has fallen short of people’s expectations, including the quite limited achievements so far of the Millennium Development Goals, climate change action and ecological protection in many parts of the world. It is therefore important to identify new directions for sustainable development, explore a new path and make new breakthroughs. Rio+20 offers one opportunity for China’s contributions and role to be highlighted, and hopefully its role in global environmental improvement strengthened. China should be giving the world a clear and unambiguous picture of its intentions concerning green transformation.

Council members deeply feel that China faces complicated environment and economy problems and unprecedented challenges as it implements green transformation. “Speed first” practices, as shown in a number of serious accidents and scandals, seriously harm human health and the environment, threaten people’s lives, impair social stability and development results, and affect public opinion about governance. These incidents have revealed deep-rooted problems of unbalanced, uncoordinated and unsustainable development—as China’s leaders have expressed. The shortcomings of social ethics and cultural values are reflected in problems with across-the-board impacts. Indeed, green transformation of development pattern is not only a matter of policy, institutional reform and technological innovation, but also one of social ethics and values.

CCICED members have noted that China’s commitment to all-round transformation of development pattern and a green development road was once again demonstrated during the recently concluded 6th Plenary Session of the 17th Party Congress, as well as in the Opinions on Strengthening Key Environmental Protection Work just issued by the State Council. The Opinions document stressed that “reform and innovation shall be the new driving force for exploring the new path of environmental protection featuring low cost, good returns, low emission and sustainability”. The Session and the Opinions are an important demonstration of China’s continued national will to strengthen environmental protection. Cultural development should also be part of the green transformation efforts. Promoting an environmental culture and ecological civilization in this process will help to build environmental ethics in China. To be fully successful, this effort must be linked to strategy for sustainable livelihoods, and new, more environmentally friendly strategies for economic growth.

There are less than 10 years left for achieving the goal of an all-round well-off society in China, and less than 40 years for achieving a fully mature stage of modernization. For the navigators of this huge ship with the largest population in the world, the journey ahead is filled with challenges. During this journey, China has to strike a proper balance between economic growth and environmental protection, transform environmental targets into genuine and lasting progress on sustainability, propel enterprises to shoulder more environmental and social responsibilities, and assess and guide its own green transition process within a global context. If China is successful in making substantive environment and development breakthroughs during the “12th Five-Year Plan”, a solid foundation will be laid for China’s sustainable future. Otherwise the process of green transformation will encounter even greater difficulties—or worse still, may even see existing gains reversed.

CCICED established three task forces linked to the green transformation theme: Research on the Development Mechanism and Policy Innovation of China’s Green Economy;

Low Carbon Industrialization Strategy in China; and Trade, Investment and Environment, focusing on FDI entering China and ODI on the part of China. The Council also carried out special policy studies on greening China's supply chains, and on mercury management in China. The goal for all of these studies is to contribute to the roadmap for transformative green development in China.

Based upon the research results of these studies and discussions during the AGM, CCICED proposes five policy recommendations to the Government of China.

1.1 Recommendation 1: Rebuild Social Values, Adjust Government Roles, and Cultivate Human Resources to Reinforce and Serve an Unswerving National will on Green Transformation of Development Mode

Green transformation of China's development pattern requires significant shifts in social values and behavior. Considering the historical experience of developed countries and today's economic realities in China, it will be a long, complex and challenging process for China to fully realize such transformation. There is a need to understand root causes, systematically adjust the approaches of the old development mode, and guide both the economic and environmental transformations. The shift requires consideration of some basic ideas and values, such as social, cultural and environmental ethics, the role of government in economic and social development, institutional changes and mechanisms of administration.

1.1.1 Establish a long-term and unswerving national will on the green transformation of development mode

Although under the severe challenges of the current international economic slowdown, financial market instability, debt crisis, and slow growth, the Government of China should not weaken environmental controls, or lower environmental targets and standards to yield to the economic pressures. It is crucial for the national government to step up its guidance and supervision of local governments, especially those which may be inclined to ignore green transformation in favor of strong economic growth. Reversals of this sort may be common. Therefore green transformation will require unswerving national commitment and determination.

1.1.2 Incorporate the concept of Ecological Civilization into overall social and cultural development, and reward sound social values and environmental ethics

Greater efforts should be made to promote ecological civilization and environmental culture, abide by rules of ecology and of social development, and, as appropriate, draw upon traditional Chinese values and ethics. Environmental values need to become part of an overall ethical system. Such a system will help provide strong moral and spiritual support to the green transformation of China’s economic development pattern.

1.1.3 Reform government functions, strengthen its management of public goods and social service functions for green development

China’s economic system has been progressing, but the government has been relatively slow in adjusting itself to societal needs in a market-based economy. What’s more, the global financial crisis to some extent has provided more room for governmental interventions in the economy. During the post crisis period, it is a pressing concern for the Chinese economy to shift from overdependence on policy incentives towards a more spontaneous growth pattern. The boundaries of government’s role should be identified more clearly, and its public service role strengthened.

First, government should not displace the market, and clear distinction needs to be established between the respective roles of governments and enterprises. Market mechanisms should help to optimize the allocation of financial resources and government should help enterprises to play a main role in the green transformation of economic development mode. Government should refrain from taking market resources, setting up unnecessary entrance barriers, forcing new investment activities on behalf of enterprises unless necessary for protection of human health and environment, and using administrative measures to influence market order and prices. Second, government should play a major role in environmental protection, energy conservation, social safety, and fair competition. Third, government should reduce its long-term dependence on administrative measures and reform natural resource pricing and introduce environmental pricing to provide a favorable market condition for those enterprises that invest in green economy and reduce the advantage of those which pollute the environment and squander natural resources.

In addition, government needs to improve its transparency in disclosing matters related to public affairs and in decision-making processes. It is also important for government to build up regionally appropriate emergency response and early warning systems and to strengthen preparedness of the whole society. These measures will help China embark on the road of green development.

1.1.4 Build a better performance evaluation system and mechanisms that strengthen accountability of government officials for green transformation of development mode

It is not enough only to strengthen the understanding of the policy makers on green transformation matters. A better performance evaluation and indicator system with a balance of punitive and incentive measures for assessment of government officials is needed. The performance evaluation system from the central down to the local levels therefore should undergo comprehensive reform. The system should focus not only on achieving economic growth targets, but also on the manner, pattern and quality of development. This requires assessment of the relationship between economic growth and social progress, with better indicators for the quality of economic growth, environmental protection, resource efficiency and green employment. In cases where economic growth is so rapid that environment is not being properly protected, there should be a negative assessment of performance. Monitoring, reporting and verification (MRV) for domestic environmental regulation is still not adequate enough, especially at regional and local levels. An evaluation and indicator system for green economy development should be established, backstopped by an improved system of national accounts modified to consider environmental statistics. Green GDP is a fundamental reform of the national economic accounting system for which the central government should continuously support relevant research and expedite its application.

1.1.5 Recognize and strengthen the critical role of enterprises in green transformation, and encourage self-motivated action

Recognizing the importance of civil society in green transformation the government should implement environmental information disclosure practices, environmental auditing and reward mechanisms as part of the effort to implement Corporate Social Responsibility (CSR) and enhance transparency towards environmental improvement efforts. Government should provide a favorable regulatory framework to facilitate enterprises' green transformation and encourage enterprises' active participation in international cooperation, through which enterprises' CSR, green image and sustainable competiveness can be enhanced.

1.1.6 Establish a human resources development system that supports green development

Knowledgeable and motivated people are the most important factor, and a basic prerequisite for green transformation of the development pattern. A wide range of scientific outlook and green-minded talents should be incorporated into the priorities of national middle- to long-term plans for China's human resources development. Such talents are needed to strengthen institutions and to raise the standards of human resources development for meeting green development. The need extends across all economic and social sectors so that a sufficient and high-caliber talent pool for green transformation can be fostered. Strong green leadership is needed in all fields, including: entrepreneurs with a good understanding of green economy and a well-developed sense of environmental and social responsibility, innovative technological experts that can serve green development, farmer leaders that help promote green transformation in rural areas, and technicians and social workers directly involved in relevant on-the-ground work concerning green development.

1.2 Recommendation 2: Establish China's Green Economy System and Advance Green Transformation of the Existing Economic Development Mode

During the financial crisis, in order to address the multiple challenges in economic, social and environmental fields, the international community put forward the concept of green economy. According to definitions by UNEP and other international organizations, green economy should promote human well-being and improve social justice, minimize environmental risks and resource scarcity, and feature "low-carbon, resource conservation and social inclusiveness". Green economy is not a synonym of sustainable development, but rather a pillar that supports it. Green economy should align existing activities in all sectors with environmental needs while addressing human well-being and sustainable livelihoods; it should minimize environmental damage of human activities, fully recognize ecosystem services and their value, and foster new green economic growth engines through innovation and improved planning and management.

The experience of China shows that the core of green economy is to harmonize the relationship between economic growth and environmental protection; the relationship needs to be balanced, coordinated and mutually supportive.

Green economy is an economic development model that integrates such core concepts as high resource efficiency, low pollution, low carbon, and balanced social development, plus the many opportunities associated with innovation. For this reason, green economy should become the most vibrant, promising and inclusive model of economic development. Green economic development is the core driver and important pathway through which green transformation can be achieved. Both at present and over the long run, the benefits of green transformation of industries can be anticipated to exceed their cost, and to achieve extensive, long-lasting economic, social and environmental benefits.

1.2.1 Set strategic targets and create an overall framework for green economy in China

The goals of green economy are to encourage harmonious development between environment and economy; to reduce the environmental and resource constraints imposed upon social and economic development; and, as well, to enhance social welfare and prosperity sharing. A preliminary green economic system that includes green manufacturing, green consumption, green trade and investment could be well-established in China within the next 10—15 years.

The overall framework for this green economic system should give full play to the role of environmental protection in optimizing economic growth. The framework should highlight two main strategies, transformation and innovation, and six main sectors. The strategy of transformation is two-fold: economic development mode and governance structure need to be transformed. Innovation emphasizes institutional, structural, and technological shifts. The six sectors include: emerging new strategic industries, green transformation of industry, agriculture and the service sector, low-carbon and ecological restoration, green consumption pattern, and a more balanced approach to regional development.

1.2.2 Implement "customized" and balanced green development strategies in different regions of the country

Since the regions of China vary in phase and model of development, this regional disparity means that there is no general shortcut to a sustainable development path, and therefore a single set of standards should not be applied to all regions. To give full play to the characteristics and potentials of each region in developing its green economy, it is first necessary to have a good understanding of the context of green economy within a region—as well as the particular challenges and opportunities, the region's capacity to coordinate national and local policies, and a sense of optimal integration of regulations with market mechanisms.

(1) Based on each region's comparative advantages and key characteristics, promote specific regional green development and prevent pollution migration and unsustainable resource and environmental uses. Prevent the transfer of outdated technology, equipment and pollution from developed to backward regions, and ensure full environmental consideration of new projects. Recipient regions should strictly implement "Three Simultaneities" (i.e., the environmental facilities shall be designed, constructed and put to use simultaneously with the main body of a project), and should follow environmental

impact assessment processes. A record-keeping system for production capacity transfer of heavily polluting enterprises and on-site dismantling mechanism of obsolete and phased-out equipment is needed. Follow-up inspection of polluting enterprises should be strengthened to prevent pollution transfer.

"Customized" green development strategies for different regions should be formulated to take advantage of their respective potentials. For the eastern region, the development of industrial clustering, research and innovation, environmental and financial services should be encouraged. The mid-western region, considering its advantages in infrastructure and human resources, should become a new manufacturing centre, as industry relocates from the eastern region. For the western region, which boasts a large workforce, vast land and rich natural resources, the development of sustainable mining, equipment manufacturing and new energy is appropriate, but needs to take into account significant but often fragile ecological systems and functions.

(2) Stick to green and balanced development between urban and surrounding rural areas; promote green, efficient and centralized urbanization in line with regional development needs. Clustered urbanization should be promoted and current uneven development of middle and small cities should be changed so as to maximize the benefit/cost ratio of urbanization, including environmental benefits and costs. Investment in green public infrastructure should be encouraged in a fashion that promotes city clustering. This does not mean a move towards more mega-cities as a solution to sustainable urbanization. Land allocation should be given to those projects with the highest added-value and ecological service capacity and with land resource value taken into account.

(3) Promote the green transformation of resource-depleting cities by establishing a new mechanism to subsidize their green transformation, and by providing direct and sufficient compensation for resources exploitation. Much of the emphasis should be on conservation planning and practices—for land, water and other natural resources and ecosystem services. With new and necessary subsidies from the central government, local governments should devote more of their limited resources to the protection and restoration of the ecological environment, and should strengthen social security mechanisms and regulatory support for enterprises. Government should rely more on the market for resources allocation and mainly provide policy stewardship.

1.2.3 Prioritize strategic emerging industry sectors and focus on the greening of all three traditional industries to promote green economy

There is a need to simultaneously support the development of strategic emerging industries and to undertake the green transformation and upgrading of the three traditional industries. This will help accelerate the shift of China's industrial structure from being very capital-intensive and heavy industry-dependent towards becoming more labor-intensive and knowledge-oriented.

(1) Adopt a coordinated and integrated approach to push forward green transformation of conventional industries. Green transformation of conventional industries requires multiple solutions for multiple challenges. More attention needs to be paid to policy coordination and co-benefits, such as emissions reduction and energy conservation, multi-pollutant management, and waste disposal via utilization in cement production. Coal-based pollution and emissions should be reduced as much as possible, particularly by developing a clean, stable, safe and diversified energy structure. The exit mechanism for heavily polluting enterprises needs to be improved. Compliant enterprises should be encouraged to take the initiative of green transformation and spontaneously phase out outdated and polluting equipment and technology. Relevant special funds should be set in place, such as a central incentive fund for phasing out backward, low productivity enterprises; a special subsidy for smaller enterprises that must be shut down; and possibly, a special fund to assist with major pollutants reduction. Financial support should be provided to dirty enterprises that take action to meet relevant environmental standards. Technological upgrading can be encouraged by preferential tax, land and credit policies. For non-compliant, to-be-phased-out dirty enterprises, punitive measures should be imposed. Such measures might include higher power and water prices, suspension of new loans or withdrawal of already granted loans.

There should be further strengthening of mandatory measures of energy saving and pollution reduction, improvement of laws and regulations concerning energy technology and standards, and new combinations of pollution treatment and resource efficiency measures to realize synergies between energy saving and pollution reduction. In addition, there should be more R&D investment to promote and guide the use of surplus energy in the cement, iron & steel, power and non-ferrous metals sectors. Preferential policies could be introduced for the treatment and disposal of industrial waste, hazardous waste, solid waste and urban sludge. Cement kilns designed to treat industrial and urban waste should be encouraged. These actions should be supported by updated policy for resource recycling. The government should issue as soon as possible the Pollution Prevention Standard for Solid Waste Treatment and the Pollution Prevention Standard on Construction Materials Production from Recycled Solid Waste. Related policies and standards need to be promulgated to promote the green transformation of the transportation sector.

(2) Promote green restructuring in the agricultural sector and link this action to food and agro-products security and to rural sustainability. Agricultural land and water use planning should be improved overall, with zones for green agriculture and its leading agro-products should be clearly delineated. The nature of such products should be based on robust, well-trusted certification processes. Monitoring work needs to be carried out for soil pollution, and training should be provided for farmers. There is an urgent need to strengthen non-point pollution prevention and treatment and to promote comprehensive environmental improvement programs, including waste treatment in rural areas. It is recommended that more nutrients be captured for farmlands to improve soil conditions and that there be active promotion of specialized and non-government services to support green farming.

The government should cancel its subsidies for chemical fertilizer production and guide their rational production and use. At the same time, large-scale production of organic fertilizers should be supported, and increased subsidies for substitution of chemical fertilizers by organic ones where feasible. The surge in animal husbandry deserves particular attention. Some segments of the market require consolidation into holdings of a size where proper waste treatment can take place. Current subsidy patterns require examination to determine how they may be improved or removed in order to create sustainable animal husbandry, including aquaculture. Biomass waste from agricultural crops is not being well enough utilized and more effort is needed to turn a greater portion of the waste into new products such as second generation biofuels. It is also recommended that forest management and other land and water uses be developed as ecological enterprises for services such as carbon sinks.

(3) Develop green service sectors and improve green employment opportunities. China should accelerate the development of green financing, green logistics and the environmental service sector. These “productive service sectors” can help drive the development of both manufacturing and service sectors. Capacity building on green skills of these “productive service sectors” should be promoted. In addition, China should strengthen regulation and guidance on the greening of traditional service sector activities, promote the reallocation of capital and investment and create more jobs in the service sector. For this purpose, the financial authorities should invest more in developing a vibrant and innovative service sector and help further improve the competitiveness and innovativeness of small and medium sized enterprises. The development of green agriculture, green industry and modern service sector

will help to create more jobs, and the special role of women in promoting green economy should be given full play. China should introduce policies that promote equal participation and benefit sharing by women and men, and the role of women's organizations should be strengthened as part of the green transformation.

(4) Promote sustainable consumption and champion green economic development. Sustainable consumption is a driving force for green economy. As people's income increases in China, the end link of sustainable consumption will be a key factor for the success of green transition. It is also an important and useful approach to advocate that good quality of life does not require the consumption of large amounts of commodities. The establishment of a new sustainable consumption pattern entails lifestyle changes and a social attitude of sustainability. In this process, the government needs to be the first to take action. Green government procurement can be a good reference point for safe, rational and frugal consumption. At the social level, a product life cycle approach that conserves resources and reduces pollution should be established. Such a system will help foster green consumption behavior across the whole society. At the corporate level, green supply chains need to be introduced widely. Market mechanisms such as sustainability certification should be utilized to promote sustainable production and consumption.

1.2.4 Establish the legal, regulatory and policy system for green economy development

Elements of a legal system for green economy are already in place, including the Law on Promotion of Circular Economy, and some of the legislation related to energy conservation. However, much more needs to be done before a satisfactory regulatory system reflecting a proper balance between use of economic incentives and command and control legislation is in place. Furthermore, success of such a system will depend upon factors such as enforcement, and optimization of the use of economic incentives.

There is a weak legal framework for environmental taxation, and reforms related to pricing and other aspects of market based environmental management and regulation. The same is true for the use of subsidies and other economic incentives meant to shift behavior in land and water use. This matter will become more important during the further development of pollution reduction, energy and climate change, resource pricing, eco-compensation and new programs for environmental restoration. Greater attention is required on the reform of pricing policies and on the removal of some energy subsidies that currently are bolstering unsustainable practices.

(1) Establish a supportive legal framework for green economic development. Many changes in the legal system are needed to better promote the development of green economy,

and to help harmonize environmental laws, regulations and institutional arrangements with other elements of the legal systems, including civil and commercial law, administrative law, economic law, social law, litigation law and criminal law, to strengthen overall legal protection of environmental resources.

The revision of the Environmental Protection Law provides a good opportunity to strengthen the responsibility of the government, with an emphasis on drafting relevant laws that clarify responsibilities concerning the regulation of environment matters at each level of the government. The civil liability of environmental damage should be strengthened, and research should be carried out on drafting laws regarding compensation for environmental pollution and damage, in order to better protect public environmental rights and interests, especially with regard to health, safety and a clean environment.

The environmental liability of enterprises also requires better legal definition. As long as it is cheaper to damage the environment than to pay for its maintenance, or to receive only minor fines in case of violations of laws and regulations, then enterprises are unlikely to conform. Furthermore, strict environmental liability will require much more in the way of guarantees for environmental restoration and higher payments to cover health or other damages to people and communities.

The government should move faster in developing and revising relevant laws and regulations that help promote carbon reduction, such as in the fields of energy generation and transfer, energy efficiency, resource saving and consumption. Climate change related laws need to be listed on the legislation agenda, the Energy Law should be developed and promulgated as soon as possible and amendments should be made to the Coal Law, Electricity Law, Energy Saving Law and Renewable Energy Law, etc., in order to further encourage the development and consumption of clean and low-carbon energy. China should make revisions to a number of laws regarding natural resource use, including the Agricultural Law, Forest Law, Grassland Law, Land Management Law, integrated water management, and various aspects related to sustainable use of the oceans.

All these laws will require administrative regulations and rules to help maintain and sometimes increase the productivity of land, water and sea, as well as the carbon sink function of agro-forest ecosystems. In addition, there is a need to revise protection and development plans for forest, farmland and grassland, to more strictly control cultivation in ecologically fragile regions and habitats important for biodiversity protection, and to forbid destruction of natural forest, grassland and farmland, and critical aquatic and marine habitats under any excuse.

The newly emerging industries in fields such as biotechnology and information technology present additional challenges since some of their environmental impacts and benefits will require regulatory frameworks and possibly enabling legislation.

Obviously the task of fully developing the legal basis of green economy and green development will require years of effort and will need considerable attention to avoid duplication and excessive overlap of regulations. Therefore priorities for immediate-, medium- and longer-term legal reform should be set. China should strengthen enforcement of those laws and regulations relevant to green economy that are already in place.

(2) Establish a comprehensive evaluation system of government policies. Rather than relying mainly on stand-alone decisions, there should be strengthened coordination among related activities, sometimes requiring cumulative impact assessments, and greater use of assessments in the context of integrated regional development, river basin management, regional transportation strategies, etc. A comprehensive evaluation system should be set up for major policies or projects concerning energy efficiency and pollution reduction. When the government develops and implements major policies, projects, or makes major direct investments, the whole process from decision making to implementation should be checked for anticipated and actual results, bearing in mind the overall goal of promoting green economy.

(3) Implement green fiscal reform, including environmental taxes such as a carbon tax, and financial policies designed to improve market-based approaches and establish emissions trading platforms. The leading role of the government should be strengthened in fiscal, taxation, financial and pricing policies. The key need for fiscal and taxation policy reform is to provide an incentive framework that encourages green investment, green trade and green production. This reform will become a major driving force for accelerating green transformation. In the short and medium term there should be a steady increase in fiscal support for green economic initiatives, with a comprehensive set of policies for designated funds, subsidies, rewards, discount charges and guarantees. The government budget should be leveraged to maximize its benefit and establish a joint investment mechanism between the central and local governments. A tax system to promote green development should include accelerating resource tax reform, adjusting consumption tax in light of energy and environmental policies, and introducing environmental tax (carbon tax included). The consumer tax should be adjusted to include high energy-consuming, high emission products. It is also recommended to increase the tax on petroleum and other high energy-consuming products and to provide tax breaks for those certified energy-saving products.

Financial policies can also be improved by introducing relevant credit policy and financial instruments to encourage investment and innovation in energy and environmental areas. Reform of the resource pricing system should fully reflect resource scarcity and environmental costs. Pricing reforms of key resources and products, such as water, electricity, coal, oil and natural gas should be deepened. The existing cross-subsidization policies should be reformed to protect socially vulnerable groups and to provide direct subsidy to these groups using national funds. Market-based instruments should be fully explored and introduced in emission reduction and energy conservation. Markets and exchanges for emissions trading, including both carbon dioxide and conventional pollutants, should be established to facilitate its implementation, with pilots being carried out as early as possible.

1.2.5 Promote green innovation including the establishment of a “green innovation” strategy mainly based on fundamental research, technological R&D, and human resources development

Green innovation strategy should bridge the connection between fundamental research and commercialization. Green innovation should also be achieved through institutional reform and by use of new environmental policy instruments, such as standards, green procurement and innovation reward systems. Green innovation should be more open to international cooperation and provide support for technology transfer for small and medium-sized enterprises, and for public-private partnerships through the creation of an international green innovation and investment platform.

1.2.6 Enhance international cooperation on green economy

Green economy in the context of sustainable development and poverty eradication is one of the two major themes of the Rio+20 Summit in 2012. It is beneficial for China to carry out international cooperation on green economy. This can be done within China and abroad by engaging in green improvements related to economic globalization; by drawing upon advanced ideas and experience of the international community on green economy; by capacity building, and, in cooperation with partner countries, by promoting exchanges and transfer of know-how, information and technology. However, it should be considered that the varied development stages of different countries should be taken into account; and that green economy should not become the source of new “green trade barriers”. China should introduce trade policies that encourage the development of green economy. A challenge for China is to consolidate its cooperation with international partners and push forward international collaboration on sustainable development, including its cooperation with both developed and developing countries, and global transfer and application of green technologies. To encourage commercial entities and enterprises to participate in green economic cooperation, China should establish cooperation platforms and promote green technology transfer and applications.

1.3 Recommendation 3: Build a Low Carbon Industrial System that Champions and Supports Green Transformation of Economic Development Mode

Historical experience, lessons from the financial crisis, and new development trends argue that manufacturing will continuously serve as the foundation for a balanced and sustainable economy. Low carbon industrialization is the prerequisite of a sustainable manufacturing business. According to some preliminary estimates, heavy industry will play an instrumental role in China's ambition to achieve carbon intensity targets in the next 10 years or even longer. Specifically, improvement of energy efficiency of heavy industries, optimization of the energy portfolio and sectoral restructuring can account for more than 90% of expected carbon reduction targets, whereas the seven new strategic industries will play an indispensable role in both the enhancement of economic competiveness and delivery of emission reduction targets.

1.3.1 Map out a development plan for low carbon industrialization in China with carbon intensity targets set for main heavy industrial sectors

There is a need to establish a low carbon industrialization plan, to coordinate this plan with other plans, and to develop a comprehensive development strategy for low carbon industrialization. China has already set a mandatory target to "reduce CO_2 emission per GDP by 40% to 45% by 2020 on the basis of 2005 level". Sectoral carbon reduction targets should be set up for heavy and chemical industries like power, iron and steel, chemicals, construction materials and non-ferrous metals, to take full advantage of the autonomy and motivation of respective sectors in setting up sector-based policies and develop R&D capacity.

1.3.2 Increase support for emerging strategic industries, the driving force for low carbon transformation

The development of strategic emerging industries is a driving force for green and low carbon industrial transformation. The government should further lower the access hurdles and create a more favorable business environment for strategic emerging industries. The development plans for the seven main strategic emerging industries should be drafted, issued and implemented as soon as possible. A special fund supporting the development of strategic emerging industries should be established. In the emerging industry parks, the central and local governments should provide support to the infrastructure construction, certain key projects, R&D, public service platform and innovation capacity building. Tax and financial tools should be adopted to accelerate commercialization of strategic emerging industries. The government could also consider the joint-stock approach, set up capital and equity investment funds, and encourage more investment in innovative but early-to-middle-stage companies of strategic emerging industries. Moreover, the government should develop relevant policies to encourage private and foreign investment in these industries.

In areas and sectors where pilot initiatives are being carried out, priority needs to be given to ensuring that prices for electricity, energy, and products are allowed to fully reflect the impact of trading or green taxes. It’s also important that they are underpinned by carefully regulated data systems, and in relation to the development plan for low-carbon industrialization. Particular attention is needed to be given to coordination of sectoral initiatives with cross-sectoral policies and programs. This will ensure synergies, and avoid duplication or offsetting effects.

1.3.3 Promote technological innovation and application to support low carbon transformation

More support should be given to low carbon research and its weight in the total R&D budget should be increased. In line with the development trend towards low carbon industries, there should be greater effort to make technological breakthroughs in the fields of carbon capture and sequestration, alternative energy and other technologies, 3R (reduce, reuse and recycle), energy and biological technology, new materials, ecological restoration, and multi-pollutant control technologies. China should set up a world-class national energy lab and support basic and generic research, with open access to enterprises, universities and other research institutions. It is important to develop a new innovation system where enterprises play a leading role. The governmental funds for science and technology should increase their support to enterprises so as to attract more investment from all sectors. More efforts should be made to protect related IPRs. A cross-sector technological union should be formed to promote industrial integration and innovation. Meanwhile, international cooperation should be strengthened on low carbon technological innovation, making good use of international resources and positioning China to take advantage of international innovation related to low carbon technology.

1.3.4 Improve the regulatory and voluntary standard system for low carbon production and products

First, amend energy efficiency standards of buildings, of transportation equipment, major industrial equipment, and main energy consuming items like household appliances and lighting products. Second, improve energy-efficient label management and accreditation; expand the scope of mandatory energy labeling; explore how to introduce "carbon footprint labels" in a phased manner, carry out low carbon product accreditation, and guide consumption behavior to become "lower carbon". Third, strictly implement energy efficiency standards and raise access of energy intensive sectors; carry out carbon-reduction assessment for new and expansion/rehabilitation industrial projects and energy efficiency evaluation for new public buildings and commercial housing upon completion. For those projects and buildings that do not meet mandatory standards, project completion approval should be suspended so as to control emissions from the source. Establish energy efficiency monitoring and verification processes and certification policies. Fourth, enhance monitoring, indicator and evaluation systems of energy saving and pollution reduction, strengthen accountability of energy saving targets, and improve incentive-disincentive mechanisms.

1.4 Recommendation 4: Develop a Green Trade and Investment System, Establish Green Supply Chains, and Champion a Goal-oriented Green Transformative Strategy for China's Trade and Investment

Investment and trade have been the driving force behind China's economic development, as well as many environmental concerns. In an increasingly globalized world, investment and trade have a profound impact on sustainable development and green transformation of China and the world. China needs to be more prudent with the current and potential environmental impacts from investment and trade activities. Green transformative change of investment and trade requires rules that are applicable across all types of enterprises, whether under FDI, China's domestic investment, or ODI involving Chinese firms operating abroad. Green investment should provide guidance, often with the participation of the banks and other institutions in the financial sector. Green trade will be a driver with both push and pull aspects, and sometimes environmental aspects of trade will be driven strongly by factors outside of China as well as domestic sustainable consumption concerns. Thus China will have to pay considerably more attention to green supply chains and green government procurement.

1.4.1 Promote an environment-friendly strategy for improving foreign direct investment (FDI) in ways that better serve green transformation in China

China's foreign investment policy should be adjusted and improved to encourage more FDI in strategic fields, such as high-tech, environmental protection and other strategic emerging industries. China should implement the "Decision on Accelerating the Development of Strategic Emerging Industries" promulgated by the State Council in October 2010 to attract more FDI in middle and western regions and inland cities in an orderly and sustainable manner. The current Catalogue of Industrial Guidance for Foreign Investment should be updated to encourage green investment in China. By drawing upon the advanced experiences of FDI source countries, especially those with high environmental standards, the FDI legal framework of China could be further amended and improved.

1.4.2 Promote sustainable outbound direct investment (ODI) and share the fruits of green development

China should make good use of the China-Africa Summit, China-ASEAN Summit and other mechanisms to carry out policy dialogue and cooperation on sustainable investment, and strengthen sustainability and security of Chinese investment in foreign countries. A complete evaluation and supervision system should be set up so that the government can keep an eye on the operations of enterprises that invest overseas, including both state-owned and Chinese private enterprises of all sizes and types. China should promote capacity building for sustainable investment and strengthen mutual trust between Chinese investors and the public and private institutions, civil organizations and the people in recipient countries.

A new Guideline on Corporate Social Responsibility (CSR) should be introduced to make the Chinese CSR standards consistent with internationally recognized ones. Chinese and foreign companies should report their performance openly and transparently using approaches such as the UN Global Compact Communication on Progress, or the Global Reporting Initiative reporting guidelines.

China should also create, together with the host country, Sustainable Development Funding financial instruments to mitigate the impact of China's natural resource procurement activities, particularly when they result in the depletion of non-renewable mineral, oil and gas, natural forest, and other biological resources, either domestically or abroad. There are a number of such funds in the world, some of which have served to offer alternative development options to the populations affected by these extractive activities.

Others have created a savings account instrument to be used by future generations, when these resources will have been depleted. Such funds must be structured jointly between the host state, its local community, and the investor with strong stakeholder participation. They can be capitalized through payment of royalties levied on the resources that are being explored and should be managed by third-party professionals as independent trust accounts, which must be accountable to the public and other related stakeholders, not just to the host government.

A number of successful examples may be useful models, such as the Norwegian Investment Fund for Developing Countries (Norfund) or the Alaska Permanent Fund Corporation (APFC). In most cases, these funds help improve the image of the investor as they are managed in full transparency and are subject to the interests of the community. Generally, revenues and dividends should be used to: diversify the economy of communities exposed to resource depletion; finance poverty reduction; and provide housing and education, improved medical services, promote environmental protection and green transformation, and other aspects of human and social development.

1.4.3 Address the negative perceptions sometimes associated with China's ODI and trading activities abroad

There are many possible reasons for such perceptions abroad, including some rooted in substance and others in a variety of motivations. While some of this negative image and perception can be countered by better information and communication campaigns, true success will require carefully integrated strategies on the part of government working with Chinese enterprises. It will be necessary to involve also governmental agencies as well as China's embassies, educational institutions, business associations, and non-governmental organizations. China can learn from precedents set by other countries that faced negative image problems and prejudices with concerted and long term, well planned, well funded proactive initiatives that addressed the perception issues and corrected the image problems. The good news of China's green transformation needs to be transmitted and disseminated in a global information effort, preferably managed and carried out by an independent, "honest broker" type of institution with high and impeccable credibility.

1.4.4 Promote sustainable development of green trade and investment through greater participation in international rules setting

China should expand import of sustainably produced products, cut tariffs to encourage import of energy intensive products while reducing domestic production of such products so as to support industrial upgrading. The government should provide guidance and incentives to stimulate export of products with low energy consumption and environmental damage so that the country's export mix can be greener. Export tax rebate on dirty products (energy intensive, heavily polluting and resource guzzling) should be abolished, and an additional export tax should be imposed on such products. These policies should be consistent and not affected by economic and trade fluctuations to ensure effective implementation.

China should play a more active role in the setting of green rules for international, regional and bilateral trade and investment and in this way to help realize green transformation of itself and the world at large. China should promote the implementation at home and abroad of international environmental agreements that China has signed, and work to include environmental and social clauses in bilateral and regional investment and trade agreements currently under negotiation. China should also encourage enterprises and research institutes to carry out studies on international best practices and their dissemination, and promote "south-south-north" cooperation under current international frameworks.

1.4.5 Set up and improve green supply chains in China and support green transformation of the whole production system by promoting green consumption and fostering green market

The government can play an enabling role in the development and management of green supply chains. Green government procurement action should be strengthened and made more prominent especially at local levels via the Government Procurement Law. A government procurement platform should be created, quotas for green procurement should be introduced and general guidelines on green government procurement should be developed based on proper green certification of products. An environmental information network of the products procured by the government should be developed and publicized. Green procurement should take place at all levels of government and in public institutions such as universities and hospitals.

China should develop a Regulation on Green Supply Chain Management and Sector Evaluation Standards of Green Supply Chain, and develop an accreditation system for green supply chains based in part on existing environmental accreditation processes. Meanwhile, "promotion centers" of green supply chain should be established to strengthen collaboration among industries, the government, NGOs and other external groups. These promotion centers could be first created in areas with, a good economic basis such as Tianjin Binhai New Area, Yangtze River Delta Region and Pearl River Delta Region, and then expanded into other areas.

The above measures will help establish a green supply chain management system led by the government, implemented by enterprises, evaluated by the market and judged by the public. This system can further support the development of sustainable production and consumption.

1.5 Recommendation 5: Develop a Strategy and National Action Plan for Managing Mercury Use in China in order to Reduce Impacts on Public Health and on the Environment

As industrialization accelerates in China, pollution from mercury and other heavy metals has caused serious social, environmental and public health problems. The Chinese government is placing great importance on this issue and promulgated the "12th Five-Year Plan" on Comprehensive Prevention and Treatment of Heavy Metals Pollution. China should take prompt action, remove obstacles and ensure implementation of the plan to achieve its goals and greatly reduce risks to human health. In particular, it is necessary to pay high attention to mercury pollution.

Mercury is not only an issue of on-going concern to the international community, but is also one of importance to China. It is released into the atmosphere during coal burning, non-ferrous metal smelting and cement manufacturing. It is used in large quantities as a catalyst in the production of polyvinyl chloride (PVC), creating demands for the mining of mercury and risks of environmental releases. It is a component in compact and regular fluorescent light bulbs and in some types of batteries. It is still widely used in dentistry and medical instruments such as thermometers. China remains the world's largest mercury producer, consumer, and emitter, and the country's total mercury use is more than 50% of global demand. China is one of only two nations still mining mercury.

The Government of China should develop a strategy and national action plan for mercury management in China, and make this plan compatible with the national plan on heavy metal pollution. The strategy and action plan is important to strengthen technical guidance, risk control, environmental supervision and reductions of pollution by mercury related industries. It is estimated that stringent but feasible emission targets could result in very significant reductions of emissions from coal burning industrial boilers and power plants, non-ferrous metal smelting and cement production. Priority should be assigned to achieving mercury-free PVC production processes. Recycling of mercury from industrial sources and mercury-added products should be strengthened to create a closed-loop system that would eliminate the need for the mining of mercury.

1.5.1 Develop a national strategy and action plan on mercury management

The national strategy and action plan on mercury management should aim to reduce health and environmental damage by mercury and cut China's contribution to global mercury emissions. The strategy and action plan should be in line with the "12th Five-Year Plan" on Comprehensive Prevention and Treatment of Heavy Metals Pollution (2011—2015), and identify short and long term mercury reduction targets for the period of 2011—2015 and beyond. Effective measures should be taken to reduce and prevent negative impacts of mercury on human health and the environment. A mandatory, facility-based and publicly accessible inventory of mercury releases and transfers should be developed to support decision making by the government, the relevant industries and communities. The strategy and action plan should be integrated into the strategies of other sectors, help improve environmental performance of mercury related industries and communities, promote clean production and realize green transformation.

1.5.2 Strengthen technical support, risk control, environmental supervision and pollution reduction of mercury related industries

China should strengthen its legal and regulatory system for mercury management, strengthen its capacity for the enforcement of relevant laws, and carry out priority-based management of mercury with effective implementation across the country. Market-based instruments should be used as important supplements to mandatory measures and targets to reduce releases and uses of mercury and to improve the management of mercury-containing waste. Scientific and technological needs should be identified to help the government make informed decisions on mercury risk control. China should promote structural adjustment of mercury related industries and communities by developing strategies with the relevant sectors to ensure that the restructuring harmonizes with market demand, urban and rural layout, regional characteristics and other essential factors. More weight should be given to a structural approach to reducing pollution (i.e., through industrial restructuring) while continuing projects to reduce and manage pollution (i.e., reducing pollution through specific treatment projects and improved management).

In order to reduce mercury emissions, mercury use should be forbidden or severely restricted in the relevant industries such as chemicals (including the production of PVC plastic), lighting, battery, medical care and pharmaceuticals. Clean production techniques and technology should be promoted and pilot programs launched to explore the best feasible technologies and environmental management practices. Where appropriate, mercury pollution prevention and treatment technologies from abroad should be introduced and commercialized within China. There is a need to support research and development of low-mercury and mercury-free alternative products and processes, gradually reaching the goal of low-mercury and mercury-free industries and realize mercury control at the source.

Measures that should be taken to protect Chinese citizens from possible exposure to mercury include: strengthening of occupational health and safety procedures for workers; rigorous management of contaminated sites, hazardous wastes and mine tailings; enhanced monitoring for mercury in selected foods; and the provision of appropriate information to the general public and to populations that may be at risk.

Chapter 2 Green Transformation of China's Economic Development Mode

2.1 Introduction

Over the past five years CCICED has examined how China could make progress towards becoming an Environmentally Friendly Society. This theme is based on China's goal oriented towards resource efficiency, pollution control and prevention, ecological protection, and better quality of life. During this fourth phase, the Council's work has covered many aspects of transformative change in China's environment and development during this period and in earlier phases. Highlights of this work and its impacts are available in a special Overview Report prepared for the 20th Anniversary of CCICED.[1] The "11th Five-Year Plan" (2006—2010) has led China into a new era of thinking and action about environment with important positive results as noted in Box 2-1.

The 2011 CCICED AGM is taking place during the first year of China's "12th Five-Year Plan" (2011—2015). The "12th Five-Year Plan" reflects the greatest commitment so far to environment and development on the part of the Government of China. It is appropriate therefore for the Council to consider how far China still has to travel on its path towards becoming an environmentally friendly society—and the challenges and opportunities to be addressed during the coming years.

1 CCICED 2011. CCICED at 20: Activities, Impacts and Future Opportunities. CCICED, Beijing. 69 pp.

Box 2-1 Examples of China's progress during the "11th Five-Year Plan" towards becoming an environmentally friendly society

① Reduction in some major pollutants (SO_x , COD) with mandatory FYP targets achieved
② Energy intensity reduced significantly, mainly via energy conservation measures
③ Unprecedented level of investment in: installation of pollution control equipment for power plants; changes in heavy industry production processes, e.g., steel; installation of water and sewage; solid waste management facilities
④ Implementation of circular economy
⑤ Implementation of forest, wetland and other ecological programs, including eco-compensation mechanisms
⑥ Incorporation of environmental safeguards within sectors such as transportation, agriculture, chemical industries, and mining
⑦ Improved enforcement, environmental impact assessment of projects and plans, public information sharing, and response to concerns
⑧ Incorporation of environmental considerations into building design, public transportation networks, and other aspects of urbanization
⑨ Inclusion of environmental considerations as an advanced element of large events (2008 Beijing Olympics, 2010 Shanghai Expo)
⑩ Inclusion of environment in the 2008 financial stimulus package
⑪ Major investment in sustainable development and environmental technology development via S&T innovation, including renewable energy sources (wind and solar power, battery technology, electric vehicles, etc.)
⑫ Introduction of new cross-cutting concepts: low carbon economy, green economy

Certainly this journey will be influenced by China's transformative economic policies that are placing greater emphasis on structural changes in the country's industrial base, on stimulating domestic consumption, and on China's going out approach to secure new markets and stable resources and other supplies to meet its needs. The future also will be shaped by international views on environment and development, globalization trends in trade and investment, and the re-balancing of global interests.

Unfortunately the global economy is still wracked by turbulence and uncertainty, with financial system reform still incomplete and economic growth faltering in many industrialized nations. China and other emerging economies are not sheltered from these perturbations, even if their immediate outlooks are more positive. Although global discussions on topics such as climate change and trade are still clouded with uncertainty of satisfactory outcome, environmental matters are still prominent on the global agenda. Internationally, green growth, green economy and green development are themes intended to place environmental considerations into the mainstream of economic recovery and development.[2]

In this last year of Phase 4 CCICED is examining the relationship between environment and economic development in some depth. It is quite clear that this topic continues to be central to the new path of environmental protection for China, and for the relations China will have in tomorrow's world. The on-going struggle to reconcile rapid economic growth with environmental needs has not been completely successful by any means. Now there are game changers that could improve the situation, for example China's ability to draw upon its major investments for S&T innovations, and the eventual leveling in heavy industry and conventional infrastructure. Also, the commitment to low carbon development and green economy initiatives should bear early fruit. On the other side, rising material demands, and the emergence of new environmental problems (e.g., ground level ozone, pollution from intensive animal husbandry, climate change impacts on water supply) are making the goal of environmentally friendly society more difficult to achieve.

In recent months the situation facing China's environment has been described as "very grave" by the Ministry of Environmental Protection.[3] Both the CPC and the NPC have called for accelerated environmental action during the implementation of the "12th Five-Year Plan". Clearly what is needed is an even longer time frame—certainly to 2020 and perhaps quite a bit longer—to achieve a fully satisfactory level of environmental progress. China's GDP likely will have far exceeded the four times increase from 2000 level originally adopted as the economic growth target to 2020. The achievement of a moderately well-off condition for China's population is a key 2020 goal. It seems logical that the goal of China becoming an environmentally friendly society should follow the same time frame. But it is less than a decade away. Realistically, therefore now is the time to have a plan of action for green transformation of China's economic development mode that covers the 12th and 13th "Five-Year Plans", but also consider a medium-term outlook to 2030.

This Issues Paper[4], the tenth produced since 2002, reviews why China's considerable efforts to solve China's environmental problems will require additional attention to changes in the country's overall economic development strategy—and how this transformation can

2 In June 2012, at Rio+20 green economy will be a central topic for the world's nations to consider. Rio+20 is the global meeting in Brazil being organized by the United Nations to determine progress on sustainable development since the 1992 Earth Summit.

3 Most recently, the scale of the environmental challenge has been documented in the Ministry of Environmental Protection China 2010 State of the Environment Report as well as in other in-depth analyses such as the China Academy of Engineering-MEP China Environment Macro Strategy Research multi-volume report produced as input to the "12th Five-Year Plan" preparations.

4 This report is written by the CCICED International Chief Advisor, Dr. Arthur Hanson, and the CCICED Chinese Chief Advisor, Professor Shen Guofang, with inputs from the Chief Advisors Group and others.

be addressed. The central need to understand how new ideas of green growth and green economy can be deployed to improve environmental protection and move China towards becoming a more environmentally friendly society. The Issues Paper draws upon the results from the three task forces and two special policy studies reporting to CCICED at this AGM.[5]

2.2 Transforming China's Economic Development Mode

China's overall development reform tasks are still immense. Zhang Ping, Chairman of the NDRC, made the following statement at a recent international gathering in Beijing concerning sustainable development[6]:

"There are still 150 million poverty-stricken population in China, poverty eradication while promoting development is formidable. Meanwhile the issue of unbalanced, uncoordinated and unsustainable development remains urgent: resource and environmental constraints for economic growth are tightened, the relation between investment and consumption is imbalanced, technological innovation is under-boosted, industrial structure remains irrational, unemployment and structural inconsistency need to be handled and social conflicts increase significantly."

China's leaders have signaled clearly enough that the country's economy will need to undergo major restructuring, certainly during the "12th Five-Year Plan" but also likely to continue well beyond that. In the debate at the National Peoples Congress before the "12th Five-Year Plan" was adopted in March 2011 the shift in economic development mode was described as needing to move from "unbalanced, uncoordinated and unsustainable development" towards a "green, competitive and inclusive economy." This will mean a shift from the existing emphasis on investment in heavy industry to a more balanced situation emphasizing seven emerging industries and a larger service sector. Measures will be taken to encourage movement of some enterprises to locations away from the richer coastal provinces to China's interior and western region. Efforts to foster domestic consumption and

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5 The Task Force on the Development Mechanism and Policy Innovation of China's Green Economy provides an important overview based on international thinking and China's situation. This work is complemented by the Task Force on Low Carbon Industrial Strategy for China which examines shifts needed for today's major industrial sectors and the potential contributions of seven emerging industries. The Task Force on Investment, Trade and Environment examines the environmental challenges and opportunities related to China's growing Outward Direct Investment (ODI) and environmental aspects of Foreign Direct Investment (FDI) inside China. A Special Policy Study on Green Market Supply Chains will report on this specific aspect of trade. And a Special Policy Study on Mercury Management in China will present its findings.

6 Zhang Ping. 8 September 2011. Speech at the High-Level Symposium on the UN Conference on Sustainable Development.

markets will quicken. Chinese economic and financial activity beyond its borders will be expanded through the going out strategy, including more ODI. In addition, regional development, countryside development, and urbanization efforts will be improved, with an emphasis on “putting people first”. Both the domestic and international shifts offer new opportunities to create global and Chinese wealth, and possibly accelerate economic development and growth.

Efforts for transformative change in China’s economic growth have been ongoing since the “9th Five-Year Plan” started in 1996. Now, however, the transformation in economic growth is considered as an urgent and massive effort. At the same time, the rate of economic growth is proposed to be lowered somewhat to an average of 7% per year during the “12th Five-Year Plan”. By comparison, for the “11th Five-Year Plan”, GDP growth rates of 7.5% per year were proposed. The actual growth rate averaged about 11% per year over this time span. In some provinces the economic growth levels have been even higher. The size of China’s economy in 2010 was more than 2 ½ times its size in 2005. Nearing the end of 2011, the first year of the “12th Five-Year Plan”, GDP growth is projected to be about 9%, and some provinces expect to see figures well above this. China is seen by many in the international community to be an essential player in avoiding a double dip recession in the global economy. Thus there is continuing pressure both internally and externally for a continuation of high growth rates.

CCICED has indicated since 2006 that it believes China has entered a transformative stage in its environment and development, and the evidence for this has become stronger with each passing year. A critical test came in 2008—2010 with the on-going global financial crisis. If anything, this event led to stronger action on environment and development issues. Certainly within China the transformative effort on environmental matters was not weakened. The implication is that both economy and environment are concurrently undergoing transformative governance reform and re-shaping. The question is whether the transformative change of each can be made interactive and mutually supportive of the other.

Concerning environmental objectives, China’s “12th Five-Year Plan” brings with it an unprecedented level of tested management skills, organization, money and the fruits of the past decade’s innovation investment in emerging technologies. These are indeed benefits of past economic growth. The environmental mandatory targets now include additional pollutants, nitrogen and ammonia, and greenhouse gases (see Box 2-2). There is attention being given to additional concerns such as heavy metals and soil pollution, and, overall, there is attention to improved quality of life and to addressing the rising income gap between rural and urban inhabitants.

Box 2-2 "12th Five-Year Plan" and some longer-term environmental goals in China

"By 2015, the energy consumption per unit GDP will be reduced by 16%, the carbon intensity by 17%, the chemical oxygen demand and sulphur dioxide emission by 8% respectively, the ammonia and nitrogen oxides by 10% each, and the water consumption per unit industrial added value by 30%. The non-fossil energy share of total primary energy consumption will reach 11.4%, and the forest stock will increase by 600 million cubic meters."

"By 2020, we will try to reduce carbon intensity by 40% to 45% over the 2005 level, make the proportion of non-fossil energy in primary energy consumption reach 15% or so, and raise the forest area by 40 million ha and forest stock by 1.3 billion m^3."

—Zhang Ping, NDRC Chairman, in speech to the UN Rio+20 Symposium, Beijing, 8 September, 2011

Meeting the environment, energy and carbon intensity goals should help to meet economic transformation goals such as those for heavy industry. The environmental goals also will play an important role in quality of life improvements, which in turn will translate into new opportunities for economic and social development. Economic growth should make the task of finding financing environmental improvements easier, and it is generally presumed that higher income levels increase demand for better environmental conditions, even though with increased consumption levels environmental impacts also may increase. These examples demonstrate that environment-economy relationships can pull in both positive and negative directions. In the next section recent international and Chinese perspectives on Green Transformation are examined to understand their characteristics and applicable to changes in China's economic development mode.

2.3 Green Transformation

2.3.1 International views on green growth and green economy

Internationally, there is a strong, recent push likely to be influential for the future of both environmental protection and sustainable development. This push is described variously as Green Growth (OECD, G20, numerous countries), Green Economy (UNEP, EU, China, Rio+20, various countries) and Green Development. The concept is to mainstream environmental objectives into economic and development decision making at a level far beyond what has been so far achieved. The impetus for these new approaches is coming from many directions, and is considered as an important element of global economic recovery. Much of the effort on green growth emerged as means of linking economic recovery paths to more environmentally friendly approaches that also could move countries on a track towards addressing environment and energy relationships and climate change. There is debate about how effective either approach will be in creating new jobs. With worry about global recession and job creation needs for most countries this is an important concern for both richer and poorer countries. Green growth and green economy concepts drawn from various international sources are examined below, with key similarities and differences noted.

2.3.1.1 Green growth

Through studies undertaken by OECD based upon the inputs and experience of member countries, a picture of green growth has emerged that fleshes out ideas first discussed in the G20. As well, UN ESCAP has devoted considerable effort to defining green growth as it might be applied in the Asia Pacific Region. Green growth gained traction through economic stimulus spending in 2008—2010. There were no firm guidelines or level of funding in this emergency situation. However, green growth proved to be attractive to political leaders in the G8 and G20 while trying to rebuild an economic order that would not simply recreate the existing economy with its flaws of unsustainable use of natural resources and, too often, with serious ecological and social impacts. The on-going and serious nature of the global financial crisis has dampened some of the initial enthusiasm for green growth. The initial attention particularly was focused to a large extent on climate change mitigation strategies and other energy and environment relationships. Now green growth is seen through a wider lens with a clearer view, for example of the role of ecological services in poverty reduction.

Green growth means fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To do this, it must catalyze investment and innovation which will underpin sustained growth and give rise to new economic opportunities.

—OECD 2011

The OECD has promoted green growth with its members and others since 2008 and has prepared a number of studies[7] at the request of ministers. Matters requiring policy attention are noted in Box 2-3. OECD is cooperating with other organizations and individual countries to define the nature of national strategies for green growth. However not many countries actually have such strategies, even though many have environmental initiatives designed to provide economic benefits.

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7 OECD, 2011. Towards Green Growth. Green Growth Strategy Synthesis Report; and OECD, 2011. Tools for Delivering on Green Growth.

The UN Economic and Social Commission for Asia and the Pacific has promoted the Greening of Economic Growth in this populous region for the last decade. ESCAP believes this region could be the most significant regional beneficiary of green growth initiatives. The need is great due to the huge population, the shift in production and wealth to Asia, and the large number of very poor people in both the large cities and the countryside. The themes examined through ESCAP's publications[8] and initiatives are:

(1) Sustainable consumption and production

(2) Greening business and markets

(3) Sustainable infrastructure and cities

(4) Green tax and budget reform

(5) Investment in natural capital

(6) Eco-efficiency

(7) Sustainable livelihoods

ESCAP emphasizes inclusion, livelihoods and other social aspects of green growth: A policy that emphasizes sustainable economic progress to foster low carbon, socially inclusive development.

Box 2-3 OECD green growth policy needs
① Economy and environment should be on convergent pathways, contributing to well-being measured in new ways
② Transformational change is required to break unsustainable trend lines
③ Structural adjustments are required
④ Factors to be considered: sectoral reallocation, labour and skills adjustment, regional/spatial dimension, multi-level governance, distributional aspects, competitiveness and green protectionism
⑤ Pro-poor green growth strategy is needed for developing countries
⑥ Key mechanisms for integrating green growth into economic policy need to be backed-up by enabling government action
⑦ A "Policy Package" approach linking various types of instruments including price and non-price approaches will be more successful than either approach on its own
⑧ Policies for fostering green innovation are needed
⑨ Greening household behavior is important for sustainable consumption
⑩ Leveraging public and private sector finance/investment is an essential tool
⑪ Better measurement of actual progress is needed in order to assess impact and to alter course when necessary.

8 UN ESCAP. 2008. Greening Growth in Asia and the Pacific. www.greengrowth.org.

2.3.1.2 Green economy

There are various definitions of green economy and the topic is inextricably bound to the idea of sustainable development, although generally considered to be supporting the latter term rather than synonymous with it. Although there have been various efforts to bring forward the concept of green economy as an alternative to mainstream economic development, including consideration of "green GDP", such ideas have not caught on. The debates now taking place on the role and value of green economy are of a different nature. Whether at a national, regional or a global level, they are being promoted as feasible and politically viable paths that would become the new approach to economic development. Thus they are very important in the thoughts about Green Transformation of economic development mode.

2.3.1.3 UNEP green economy

UNEP has been the flag-bearer for green economy[9]. Its definition of green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities, with characteristics of being "low carbon, resource efficient, socially inclusive". Key concepts are noted in Box 2-4. A useful identification of important sectors for a green economy has been provided by the Australian Bureau of Statistics (see Box 2-5).

Box 2-4 Key concepts in the UNEP green economy approach
① Green economy is central to poverty alleviation
② Must address "myth" that there is "inescapable trade-off between environmental sustainability and economic progress"
③ Shift from an "era of capital misallocation" during the 1990s and early 21st Century
④ Many new jobs can be created
⑤ 2% of GDP is the total investment level needed for 10 key sectors (see Box 2-5)
⑥ Twin challenge for rich countries is to reduce per capita ecological footprint without impairing quality of life; poorer countries challenge is to improve level of services and material well-being without drastically increasing ecological footprint
⑦ Enabling conditions must be addressed, including domestic fiscal measures and policy reform, international collaboration via trade, aid, market infrastructure, capacity-building
⑧ Key hypothesis is that green economy should produce higher GDP and GDP per capita by comparison to Business as Usual.

9 UNEP. 2011. Towards a Green Economy. Pathways to Sustainable Development and Poverty Eradication; ESCAP, ADB AND UNEP, 2010. Green Growth, Resources and Resilience. Environmental Sustainability in Asia and the Pacific.

Box 2-5 Ten important sectors for a green economy (Source: UNEP, as noted in Australian Bureau of Statistics Sept. 2011. Measuring the Green Economy)
Agriculture – sustainable agriculture and food system practices including supply chains and market infrastructure. *Buildings and cities*– new green buildings and retrofitting existing buildings; in cities – resource efficiency through proximity of urban functions, modal shifts in transportation and increased efficiency in provision of infrastructure, utilities and energy. *Energy* – renewable sources. *Fisheries* – rebuilding depleted stocks and better management practices. *Forests* – new types of forest related employment such as forest carbon projects. *Manufacturing* – gains from investing in improved resource efficiency and reduced GHG emissions. *Tourism* – investments in sustainable tourism. *Transport* – green transport solutions including public transport. *Waste* – decoupling waste production from economic growth – reducing waste and turning waste into a resource – reuse, recycling. *Water* – policy regimes that facilitate conservation and rapid adaption to changing supply conditions.

Rio+20 UN Conference on Sustainable Development Major Theme: "A Green Economy in the Context of Sustainable Development and Poverty Eradication".[10]

When nations come together in Brazil in June 2012 to plot a renewed course for sustainable development, one of the key themes for decisions will be a new economic growth paradigm that is friendly to the earth's ecosystems and can also contribute to poverty alleviation. But there is also the worry "that the new concept could be used to reinforce protectionist trends, enhance conditionalities associated with international financial cooperation, and unleash new forces that would reinforce international inequalities." There are differentiated implications for developed and developing countries that are being explored through a series of meetings in various parts of the world, including in China. Many of the concerns so far identified are related to trade risks, existing subsidies, and the need for access to funds and green technologies, especially in poorer nations; and the need for new sustainable consumption patterns in richer nations.

The Rio+20 dialogue likely will explore in considerable detail the relationship of green economy and green development. Structural transformations are important in this perspective. Structural change may be driven by investment strategy, technology policies, infrastructure choices, and production/service shifts in primary, secondary and tertiary sectors. These will be linked to institutional change as well. Green development can still be a strategy that "puts people first" but not at the expense of environmental sustainability.

10 Report by a Panel of Experts to 2nd Preparatory Committee Meeting for Rio+20. 2011. Transition to a Green Economy: Benefits Challenges and Risks from a Sustainable Development Perspective. 91 pp. UNEP, United Nations Dept. of Economic and Social Affairs, UNCTAD. 2011.

"We know that a green economy is not an alternative to sustainable development"

—Sha Zukang, Secretary General of Rio+20

The Rio+20 dialogue also is oriented to a "global green economy". This focus brings out three important considerations: the principle of "common but differentiated responsibility", the realization that "one size fits all" thinking and action is unlikely to be successful, and the role of partnership and international agreements (economic, environment, and others). Equity in access to emerging green economic opportunities, green global markets, trade green protectionism and financial transfers are key concerns.

Translated into specific topics, the debate about green economy in the preparations for Rio+20 is centred on topics such as the following:

(1) Green jobs and social inclusion

(2) Energy access, efficiency and sustainability

(3) Food security and sustainable agriculture

(4) Sound water management

(5) Sustainable cities

(6) Management of the ocean

(7) Improved resilience and disaster preparedness

(8) Cross-cutting priorities (e.g., climate change, means for implementation)

These topics have long been discussed in the context of sustainable development. Green economy is a way of further bringing environment into the mainstream of a restructuring global economy. In this sense it is particularly significant for the emerging economies such as the BRIC nations that are reshaping both supply and demand for the 21st Century.

It is likely that the greatest attention and shaping of green economy at Rio+20 will be for meeting needs of developing countries. As noted by China's Foreign Minister Yang Jiechi at the recent UN preparatory meeting held in China[11]:

"Particular attention should be paid to meet the concerns of developing countries…Poverty eradication should serve as an important indicator in formulating and applying green economic policies, and active help should be given to developing countries in tackling the risks and challenges in their transition to green economy. In particular, such concerns of developing countries as assistance with environmental strings attached and 'green barriers' should not happen."

11 Speech by Yang Jiechi, Foreign Minister of the PRC at the High-Level Preparatory Symposium of the Rio+20 UN Conference on Sustainable Development, 8 September 2011, Beijing.

The admonitions of Martin Khor of the South Centre at this meeting bear repeating[12]: "The 'value-added' to the green economy as contrasted to sustainable development should be identified. Care has to be taken to ensure that the 'green economy' term and concept is also understood to include the social, equity and development dimensions, including the need for international provision of finance and technology and accompanying global economic reforms." This is a tall order that likely cannot be met without very active participation of emerging economies such as India, China, and Brazil. These major countries have the experience and available funds that can open channels for green investment, trade and technology flow with other developing countries.

Other National Green Economy Examples

Although interest, debate and action on green economy is occurring in parts of the industrial world, it is not always focused in the form of national strategy. In the EU "Europe 2020 Strategy" there are three interlocked strategies including green growth:

(1) Smart growth – developing an economy based on knowledge and innovation as key to competitiveness

(2) Sustainable growth – resource efficient, low carbon and competitive economy

(3) Inclusive growth – fostering high-employment economy delivering social and territorial cohesion.

There has been considerable analytical work on Green Economy over a long stretch of time at both EU and European country levels, including the landmark documents on Blueprint for a Green Economy[13] published in the 1980s.

A recent assessment[14] conducted by the Netherlands Environmental Assessment Agency and the Stockholm Resilience Centre notes the need for a long-term vision (to 2050) backed by scenarios and models that can be used to identify strategic decision junctions in the coming 5 to 10 years. The 2050 vision focuses on three main themes: "producing food for a global population of nine billion while minimizing biodiversity loss; mitigating climate change while enhancing energy security for the EU; and practical and workable solutions for an EU transport system that is low carbon". Three strategic approaches are highlighted: how to address interim solutions (e.g., to current energy supply constraints) without foreclosing longer-term options; how to address diversity as a strategy element in all key themes (e.g., avoiding uniformity in landscapes), and influencing strategies for "balanced consumption"

12 Martin Khor. July 2011. Risks and Uses of the Green Economy Concept in the Context of Sustainable Development, Poverty and Equity. South Centre. Research paper No. 40. 43 pp.

13 David Pearce, Anil Markandya and Edward B. Barbier. 1989. Blueprint for a Green Economy. Earthscan, London. 192 pp.

14 Netherlands Environmental Assessment Agency and Stockholm Resilience Centre. October 2009. Getting into the Right Lane for 2050. A Primer for EU Debate. 104 pp.

for the longer term.

In Australia much of the discussion on green economy has been related to low carbon economy including the desirability of carbon tax. There is no national green economy strategy, but there are a number of national initiatives that would be consistent with such a strategy. There is a need for further development and refinement of appropriate measures for a green economy within the Australian national system of accounts.[15]

The North American drive towards green economy is similarly diffuse, with no overall strategy in either Canada or the USA. Much of the effort in these two countries is taking place at subnational levels (states and provinces, cities). There is analytical work underway, often undertaken by non-governmental organizations. Within specific sectors, there are many initiatives, for example in natural resources, renewable energy and transportation. Mexico will cooperate with UNEP through a newly created Mexican Center for Sustainable Development. This will become a centre of excellence for the Latin American and Caribbean region on issues related to low-carbon growth, clean technology transfer and green economy. In addition UNEP will work with Mexico on the creation of a long-term national green economy.

Japan has pursued some elements of green economy quite aggressively in the past, notably energy efficiency and pollution prevention. In the aftermath of the 2008 global financial crisis, Japan's economic stimulus package contained funding for environmental improvement. Since then[16] considerable attention has been given to assembling a fairly comprehensive approach to economic restructuring, citizen involvement (especially on sustainable consumption), and efforts directed at technology innovations for immediate and longer term applications in industry, transportation, etc. Japan envisions an effort that is regional in scope, with efforts to improve environmental conditions in various parts of Asia. An example is the China-Japan Green Expo held in Beijing this past June. Japan's business interests are well represented in the effort to promote green economy both in Japan and overseas.

2.3.1.4 Conclusions on "going green" international experience

This survey of ideas either being proposed or implemented reveals some consistency but also many differences in approach. In the industrial economies there is a tendency to

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15 Andrew Cadogan-Cowper and Tony Johnson. 2011. Measuring the Green Economy. Australian Bureau of Statistics.

16 See Takashi Yano. IGES presentation on Japan's New Green Economy Framework and Practices. December 2010. Tripartite Green Economic Policy Seminar, Beijing. http://enviroscope.iges.or.jp/modules/envirolib/upload/3066/attach/yano_iges_temm_green_economy_rev.pdf.

avoid comprehensive strategies. Partly this is the consequence of existing investments during earlier years in industrial eco-efficiency, etc. However, the absence of integrated strategies for green transportation, especially in North America, and the relative failure to deal with sustainable consumption in the richer countries is disturbing. In many poor nations there is an obvious need for ensuring access to funding and appropriate technologies and to capacity development. In addition, there is general concern for linking green growth and green economy to better arrangements for investment and trade. And, in general, there is interest in Low Carbon Economy, even if the topic may be defined in quite different ways for rich nations, emerging economies and poorer countries. There are local, national, regional and global aspects to green economy, and the links among these levels need to be considered. This is true for matters that relate to financial transfer systems, employment, and impacts of international agreements and other arrangements related to going green.

The knowledge required for properly planning for green economy and green growth, the monitoring of environment and quality of life through new indicators and changes to systems of national accounts, and the access to information by citizens are indicated to be still inadequate, probably in most countries. A very current example of this is the sudden appearance of shale oil and gas exploitation throughout the world, often with inadequate environmental assessment and other safeguards. This development may have a significant impact on the investment in renewable energy and on the integrity of ecosystems and ecological services. Yet it is taking place with a great deal of rapidity and enthusiasm even as countries try to develop green growth strategies.

A question that stands out is: why not Green Development rather than Green Growth or Green Economy? It is a bit puzzling, but it is a term that has not really caught on internationally. China, however, uses both Green Economy and Green Development, with the latter term being a very significant theme of the "12th Five-Year Plan". The most common interpretation appears to be green economy contributing towards sustainable development.

There is, of course, the hope that green economy/growth will lead to new, permanent jobs and sustainable livelihoods. This is important for both poorer and richer nations. The views on whether there will be net employment gains depends on particular circumstances—and probably on a whole chain of events rather than on any single initiative. For example in fisheries, if the stocks are depleted or pollution and habitat destruction occurs, there will be no jobs. Indeed, it may be necessary to reduce the number of fishers in order to create sustainable fisheries with good value added. Thus ecological restoration and other action on removing subsidies may be required for years before there truly are good opportunities for new jobs. In the case of innovative technology development such as for advanced renewable energy, there may be years of work ahead to prove economic viability and develop markets.

The role of government as enabler of green economy seems clear. Also, that a degree of boldness is required in order to break away from business as usual. This will prove difficult for some countries badly affected by recession or other disruptions. Governments also need to decide how to build partnerships, foster green investment and trade arrangements, and then encourage private sector action. This message comes across in the detailed literature on green economy.

A matter of concern is the danger that some key regions will be left behind as new technologies mature, or that investment may be concentrated in a small number of large countries, or that lack of political interest or other factors may cause some countries or even regions to falter in the quest for green growth and green economy. Basically, the challenges must be met not only at a national level but also regionally and globally. In other words, green growth and economy is an issue of globalization as well as a national concern. The outcome of the Rio+20 meeting will therefore be significant.

Whether green growth or green economy are robust enough concepts to move countries and the global economy to greener paths and a satisfactory economy-environment relationship will only become clear years from now. There should be little question, however, that these ideas even in their current form should be of great value to countries like China that are in a position to undertake transformative changes to both environment and economy as they seek sustainable development.

2.3.2 Views about a green economy for China

Senior leaders have indicated the central nature of green economy in China's future. At the 2011 Boao Forum[17], President Hu Jintao indicated the issue of green economy is something that should be addressed by Asian countries generally, and he also indicated China's directions in the immediate future:

[In Asia] "we need to transform the development pattern and promote all-round development. We should transform the economic development pattern in keeping with global trends, restructure our economies, build capacity for scientific and technological innovation, and develop the green economy…In the next five years, China will make great efforts to build a resource-conserving and environment-friendly society. We will further

17 Hu Jintao, Opening Speech at the Boao Forum, 15 April 2011.

implement the basic state policy of resource conservation and environment protection, raise energy efficiency, cut the intensity of greenhouse gas emissions, develop a circular economy, promote wider application of low-carbon technologies, and actively respond to climate change. By doing so, we hope to balance economic and social development with population, resources and the environment, and embark on a path of sustainable development."

President Hu, in a 2010 to APEC leaders has noted the broader link needed between environment and overall economic policies[18]:

"*We should emphasize sustainable growth, which includes not only resource and environmental sustainability but also sustainability of fiscal, monetary, trade and industrial policies and the reduction of macroeconomic volatility and risks.*"

The significance of making these macroeconomic linkages is to provide for coordinated economic development, social development and environmental protection, and therefore move to "actively address the climate challenge, energetically develop the green economy and foster new sources of economic growth."

Premier Wen Jiabao in a speech to The Royal Society in London in June 2011[19] placed major emphasis on the role of S&T to achieve green economy and development goals.

"Tomorrow's China will be an economically advanced country with its people enjoying prosperity…We will stick to scientific development, work hard to shift the model of economic development and achieve green, low-carbon and sustainable development…Science and technology hold the key to China's economic prosperity and sustainable development…R&D funding as a percentage of China's GDP will rise to 2.2 percent from the current 1.75 percent. At the same time, we will accelerate the development of strategic emerging industries, with priority given to energy conservation, environmental protection, new generation of information technology, biotechnology, advanced equipment manufacturing, new energy, new materials and new energy powered automobile. These efforts will boost our development at present, and provide strong support for our development in the long run."

China is outpacing some other major industrialized nations in the level of its clean technology[20] R&D investments. According to The Guardian[21], in 2010 China invested USD 34 billion; by comparison the USA invested USD 18 billion. However, this large investment must be turned into commercialized ventures that can be implemented on a large scale. China's leaders have noted in recent meetings with leaders from other countries such as

18 http://www.china.org.cn/business/hu_g20_apec/2010-11/14/content_21339851.htm.

19 http://news.xinhuanet.com/english2010/china/2011-06/28/c_13952856.htm.

20 An account of the trends in China's green technology is provided in the China Greentech Report 2011. http://news.xinhuanet.com/english2010/china/2011-06/28/c_13952856.htm.

21 http://www.guardian.co.uk/world/2011/feb/04/china-green-growth-boom-industry.

Japan, the USA and the UK, that China wishes for their cooperation "to jointly pursue sustainable development and contribute to world economic recovery and the fight against climate change."[22] This point underscores China's understanding that no nation can be an island in tackling this set of issues. Green economy has to be a shared burden but also lead to sharing of present and future economic opportunities.

An important component of green economy will need to be China's role with developing countries, through trade, development cooperation and China's outward direct investment (ODI). In recent discussions, this subject has been raised, for example with South Africa's President in September 2011.[23]

"[Premier] Wen said China welcomes South African exports to China, and will encourage Chinese companies and financial institutes to participate in South Africa's infrastructure construction on transportation, energy and communication, and support the two sides to expand cooperation in new energy and renewable energy, manufacturing, green economy and agriculture."

The comprehensive nature of environment-economy transformative change is being captured by China's senior leaders in their speeches, and the "12th Five-Year Plan". However, it needs to be translated into specific operational policies that will affect many industrial sectors, all regions of the country, and China's international outreach.

In CCICED's 2011 reports and recommendations many of these more detailed operational policy concerns are addressed from various perspectives including green economy needs and opportunities within specific sectors; low carbon industrialization strategy; trade and investment with attention given to further greening of both FDI and China's ODI in developing countries; greening of market supply chains in order to achieve at least some sustainable consumption goals, a strategy for how China might manage and reduce its mercury use and release into the environment while balancing the need to ensure economic damage is contained; and an examination of what would be required for China to build an improved outlook on its environment and development future. These topics will not be considered in detail in this Issues Paper. However it is useful to draw upon the Green Economy Task Force report to provide an overview of its findings and recommendations since they do indicate actions China can take on the path for a green economy (see Box 2-6 for the Task Force definition of green economy).

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22 Premier Wen speaking to Deputy Prime Minister Nick Clegg in London. China Daily 27 June 2011. http://www.chinadaily.com.cn/china/2011-06/27/content_12784592.htm.

23 http://www.gov.cn/english/2011-09/29/content_1960085.htm.

CCICED task force on green economy[24]

The "China Advantage" should come into play during the transformation to a Green Economy. This is a set of factors that will almost certainly permit China to move more swiftly than most other countries: strong political commitment, the huge fiscal capacity to support green investments, market size (including both domestic and export opportunities), reasonable labour costs, S&T investment and innovation-oriented manufacturing capacity, and China's emerging ambition as a "green innovation hub". The advantages will permit China to seek its own green development pathway.

Box 2-6 Definition of green economy used by CCICED green economy task force
"An economic development model that regards environmental protection and sustainable resource utilization as essential conditions for sustainable growth. This new model gives priority to the health and well-being of citizens, minimizes harm of human activities to the environment, and adequately recognizes and values both natural and human ecosystems for their ability to supply services. It seeks to seize new green growth opportunities, through a combination of continuous innovation and efficient governance."

The basic conditions required for a successful green transformation include:

(1) Leadership and strategic planning by the government to provide the political foundation for a green transformation and leapfrogging

(2) The right "positioning" and appropriate regulating and enabling role played by the government in the transitions required for a green economy

(3) A well-functioning market as a driver for innovation and sustainability especially on the part of enterprises and the financial sector.

The CCICED Green Economy Task Force has proposed ten key recommendations which would encourage development mechanism and policy innovation at national, regional and sectoral levels, and create key enabling conditions:

(1) Strengthen the functions of the government in public service provision as well as market supervision and management

(2) Establish a mechanism for ensuring and evaluating policy coherence and impact for promoting green economic development

(3) Carry out a comprehensive greening of the fiscal policy and tax system

24 This section is abstracted from the CCICED 2011Task Force Report: Development Mechanism and Policy Innovation of China's Green Economy.

(4) Avoid unsustainable relocation of backward technologies and production facilities and achieve a coordinated green regional economy

(5) Adopt a more concentrated approach to China's green urbanization

(6) Develop and strengthen an integrated approach to green the traditional industrial sector

(7) Promote green agricultural development in the modernization process

(8) Fully leverage the role of the service sector as a catalyst for green transformation

(9) Make green transformation a more inclusive and empowering process

(10) Make green innovation a catalyst for China's modernization and leapfrogging.

Given the sheer size of the Chinese economy as well as the large diversity in regional conditions within China, there is no "one-size fits all" pathway to a green transformation. Instead, China's future green development will need to rely on a differentiated and regional approach based on regional conditions and characteristics. Also, sectoral needs vary greatly as seen in the results of examining agriculture, several industrial sectors and the service sector. Within sectors there are different needs for large enterprises by comparison to SMEs. When considering green transformation as an empowering process, it is possible to reach poorer people, take into account gender-based interests, and, in general to take into account those who are marginalized through transformative change.

2.3.3 Conclusions about green transformation – China and globally

China is well equipped to ramp up its efforts to improve its environment and economy relationship. This will need to be done broadly in the context of green economy rather than in the narrower context of green growth. The reason is that China is still in the process of building a mature economy that will include a much larger service sector, expanded domestic consumption, considerable infrastructure investment, and much larger overseas investment. The focus on benefits related to employment, competitiveness, equity, efficiency and value-added aspects related to green transformation should be across-the board, not limited to environmental protection, energy and environment or a few other categories. Nevertheless, it is important to take into account green growth approaches such as those being considered within OECD countries, since China's high growth rates must still be turned into growth that is more environmentally friendly.

Over the past years there have been periods where economic growth has clearly outpaced the capacity for environmental improvement. Thus even with decline in the intensity of pollution and energy use per unit of GDP, the total amount of some key pollutants is still very large and increasing. The recently released 2010 China State of the Environment Report paints a grim picture of the extent of acid rain (half of China's cities affected), soil pollution, and very low water quality in some major rivers and many other concerns. That the environmental situation might get worse if economic growth continues to outpace the estimated growth rates is of course a possibility, especially given the efforts to stimulate domestic consumption. In fact the 2010 China Ecological Footprint Report suggests that China is now consuming at a level well beyond its ecological capacity.[25]

The work by UNEP on green economy, now being followed up in the preparations for Rio+20 is significant for all countries of the world. There are entry points for nations at all levels of economic development including very poor countries and very rich ones. It is the emerging economies, including China, which may enjoy the best gains in the short and medium term, since they have economic momentum and the opportunity to invest in new ways of doing business, and without the drag of declining infrastructure and old economies. Perhaps the greatest challenges will be for some of the richer countries that are still wedded to levels of high consumption and practices that are clearly unsustainable but politically often difficult to change.

The need for international cooperation on green growth and green economy should be obvious. If countries simply export their environmental problems to other parts of the world, then no one wins in the longer term. On a more positive note, a careful agenda for cooperation on ways to accelerate the pace of change towards widespread use of better environment and sustainable development technologies could benefit all countries and the global environment. China, other emerging economies, and a number of OECD nations are well placed to gain new economic opportunities in the process. Investment and trade arrangements can help or hinder the progress of green economy globally and regionally, depending on whether they are implemented with green implications considered. Similarly with institutional arrangements for environment and development, which are still weak at the global level. Finally, as will be discussed below, there are numerous opportunities not being fully implemented, such as new global treaty arrangements (e.g., for mercury management), greening of market supply chains and other business practices that will have important implications for green transformation of global and national economies.

2.4 Green Transformation of China's Economic Development Mode – Five Challenges and Five Opportunities

A roadmap for green transformation in China will inevitably show many roads, suggesting more than one route to get to important destinations. The three task force reports

25 CCICED and WWF. 2010. China's Ecological Footprint.

being discussed this year provide a good amount of information and roadmaps for specific topics such as low carbon industrialization strategy. The important starting point is that all evidence suggests that it is feasible to mainstream environment into economic development decisions in China—with the expectation that the outcome will be beneficial to the economy and the environment, both near-term and longer-term. As China's leaders have pointed out, this is the desired direction for the future.

Even the accelerated level of activity proposed for the "12th Five-Year Plan" will not be enough to complete the task of green transformation, of course. The efforts are likely to be much more complex in the coming five years by comparison to past periods, and this situation will certainly be even more the case in the 13th and successive FYPs, likely till at least 2030. But even as the challenges become more difficult over time, so also will the economic and other opportunities become greater. China can work towards selectively and carefully addressing environment and development by mastering new technologies, progressively managing the shift to high performing types of enterprises, building outstanding cities, securing ecosystem and human health, creating internationally-recognized "branding" of its products, services and ODI as environmentally friendly, and by maintaining a moderate level of per capita material consumption. Success in each of these areas will be essential for green transformation of China's economic development mode.

Fortunately this transformative effort is already underway within China and to some extent in its international economic relationships. The key point now is how to define policies and actions now that will address immediate needs for green transformative change and set the stage for those changes that will be required in the medium and longer term. The issues briefly described below include five challenges and five opportunities.

2.4.1 Five challenges

2.4.1.1 Shifting the nature of the Chinese economic growth and environment relationship between 2012 and 2020

It seems reasonable to conclude that within China the pattern of underestimating actual growth rates—by comparison to those estimated within the Five-Year Plan—may well continue, starting with 2011 results. However, the difference between actual and projected growth will be smaller over the next several years by comparison to earlier plans, especially if the global economy continues to face difficulties. Likely, significant progress will be made on transformative change to the economy. Both of these conclusions are important from an environment and development view. If the actual GDP growth rate remains below say 8.5%

per year, and if there is industrial restructuring on the scale envisioned in the plan, then there should be a reasonable opportunity to see very significant progress in environmental protection. If there is high economic growth overshoot, the pressures on environment will be extreme no matter what environmental measures are taken. This is the first point to keep in mind.

The second point to consider is how environment is being mainstreamed into economic decision making within China. It is clearly articulated and well understood what the transformative change is likely to be for the economy. But, as CCICED has indicated since 2006, China has now entered a period of transformative change on environment and development as well. There are numerous examples of this new intersection of environment and economy. For example:

(1) The presumption that an important driver of industrial restructuring will be energy efficiency and emissions reduction.

(2) The shift being discussed towards building a proper environmental tax system that could help to introduce additional market based regulatory approaches, possibly including a carbon tax.

(3) The move towards eco-compensation as a means to protect valuable, but often under-priced ecological services. This example brings in additional considerations such as regional economic development and means to reduce income disparities and reduce poverty.

It is necessary to understand how to optimize the benefits from these joint environmental and economic transformative changes.

Third, China is in the fortunate position of being able to improve significantly the environment and economy relationship. It is actually an advantage conferred by the past periods of high economic growth. The more rapid than expected achievement of economic targets is creating considerable demand for environmental quality, and also generating the funds required to invest in such improvements. Since China still must develop so much of its infrastructure, cities and production facilities it has the opportunity to do so sustainably—featuring resource and energy efficiency, pollution prevention, and good environmental design. These points are well understood, but operational policies to carry out these transformative efforts are urgently needed, for the 12th and the 13th "Five-Year Plan" Period to 2020.

2.4.1.2 Turning environmental target achievements into sustainable development outcomes

It does not necessarily follow that achieving environmental targets such as those set for pollution control will translate directly into outcomes of environmental improvement. This is particularly true if the targets are focused on intensity reduction rather than total reduction of emissions, and also when economic growth rates are high so that improvements are masked by new forms, or levels, of environmental degradation. Additionally, there are significant monitoring and reporting issues, scientific unknowns about the nature of some problems (examples include the still emerging situation of soil pollution and the problems of water quality in coastal ocean areas), and cumulative impact matters that are significant at regional levels.

This challenge may be further compounded if environmental impacts are re-directed from one part of China, or to another, or exported abroad, for example by meeting targets through purchase of commodities or other materials for use in China from countries where environmental considerations are not given adequate attention. Another problem is substitution of new environmental problems for old ones, for example, by changing production processes to ones that introduce new types of wastes. And, there is the need to consider equity concerns, for example, by reducing risk of disasters and health hazards in the process of relocating industrial processes, mining, etc.

These are classic planning problems that can really only be resolved by taking an integrated approach to environment and economy decision making. The use of functional zoning can help, although care is required to ensure that greening of the economy in selected areas does not create zones of low environmental quality or loss of ecological services elsewhere. Adaptive planning and improved central government-local government coordination are critically important requirements.

Better environmental monitoring, improvement in the compatibility of data sets, and building high credibility with the public through regular release of reliable, high quality environmental information including toxic substance inventories, environmental assessments, etc., are important means to improve understanding of what is actually being accomplished in terms of improved environmental outcomes. At the same time it is a means of capacity development for government officials, communities and the private sector—the "helping hands" to raise the level of environmental achievements.

2.4.1.3 Promoting green business, CSR and financial sector shifts

There are dramatic differences in the capacity of Chinese enterprises to participate in a green economy. The spectrum covers those likely to have a global impact through new technologies, products and services, to the many SMEs that have a difficult time complying with almost any level of environmental regulation. "Winners" and "losers" is hardly the best description, although it might be applied. More appropriate is the recognition that some of the best innovations in the future will continue to come through nurturing of start-up enterprises. Also, that transferring obsolete industrial infrastructure to new locations is not a good idea either for green business, or for business period. Increasingly, the renovated, large SOEs in China present great opportunity for greening of supply chains, which often involve substantial numbers of smaller firms. However such efforts are still relatively far behind what has happened on the part of international firms attracted to China as foreign investors.

Along with the direct participation of enterprises engaged in resource extraction, manufacturing, retail sales, and various service sectors, there is a need to involve the financial sector more substantively in green transformation of the economy. The financial and stock markets should certainly be part of this, as is now the case in some other parts of the world. These shifts could come about quite rapidly, especially if there is continued reform of this sector as proposed after the 2008 global financial meltdown. This is perhaps the most overlooked aspect of the green shift needed in China and throughout the world. Even at the most basic level, for example, on the role of future financial stimulus packages for sustainable development, should these be required in the coming years, there is limited understanding of what would be optimal.

Corporate social responsibility implies an acceptance of voluntary action on the part of businesses and their associations. Such action may include environmental certification, actions intended to introduce cost-effective changes in product design and manufacturing that also reduce environmental effects, greening of supply chains, and adoption of best practices. CSR also requires good governance on the part of businesses, dialogue and other interaction with communities where the enterprises are active, and reliable information sharing. These and other CSR criteria are not being met well enough within China at present. And, in spite of numerous laws and regulations applied by government, there is still not a complete enough, or even appropriate enough regulatory framework, either for businesses entering China through FDI, or domestic enterprises. Thus, a major part of China's transformative effort on environment and economy still needs to focus on development of a green market-based regulatory system. A lot of experience is available from elsewhere in the world. Much of this comes via international non-governmental organizations that often now work in partnership with corporations.

2.4.1.4 Optimizing transformative change outcomes in the "12th Five-Year Plan"

The "11th Five-Year Plan" was a great success in many ways, including some related to the environment. It set the stage to create additional transformative changes in the period to

2015. As indicated in various places within this Issues Paper, one of the most demanding tasks will be to align transformative changes of both economy and environment. It would be tempting to conclude that it would great if both economic and environmental targets could be exceeded. But the reality is that it is quality rather than quantity that is critical, hence the emphasis placed by leaders such as Premier Wen Jiabao on "putting people first", quality of life, and "good, fast, harmonious and stable development".

Minister Zhou Shengxian translates these ideas for action in the "12th Five-Year Plan" as requirements for "small in cost, good in benefits, low in emission and sustainable in development"[26] These are in reality very demanding criteria, especially when taken together. Even though there are additional indicators incorporated into this new FYP, they are still oriented towards individual components rather than this bigger picture of the environment-economy relationship. Perhaps there is an underestimate of what might actually be accomplished over these coming four years since there should be many co-benefits from carefully aligning environmental, economic and social changes.

As Minister Zhou noted in April 2011, "The overall degradation trend of eco environment basically has not been reversed…Translating the 'target driven mechanism' of environmental protection into industrial restructuring and economic transformation will better facilitate the whole society [to] follow the development path with high productivity, well-off life and good ecology."

Some of the ways to ensure rapid and sound green economy and development include: ensuring that regional green economies emerge more or less simultaneously in all parts of China, including those that are likely to be recipients of industries formerly the mainstay of east coast Chinese regions; rapid scaling up of green initiatives especially in key sectors such as energy, agriculture, and urbanization; rigorously seeking co-benefits from pollution prevention, low carbon economy initiatives, and circular economy; greening the "Blue Economy" of ocean and coastal areas; linking poverty eradication, achievement of the MDGs in China, biodiversity conservation and environmental protection; further clustering of green initiatives to maximize synergies and promote rapid commercialization and implementation of innovation efforts.

The "12th Five-Year Plan" places considerable emphasis on the identification of new

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26 "Small in cost" - harmony between environmental protection and economic development and supporting greater scale economic activities with minimum resource & environment cost. "Good in benefits" - overall plan for environmental protection and socio-economic development and seeking for the best environmental, economic and social benefits. "Low in emission" - combination of pollution prevention and environment governance and minimizing the adverse environmental impacts of economic & social activities. "Sustainable in development" - combination of environmental protection with long-term development. http://english.mep.gov.cn/Ministers/Speeches/201104/t20110415_209261.htm.

jobs for Chinese youth and also for those who may move from existing livelihoods either in the countryside or the cities. The claims of green economy are for considerable growth in such opportunities, especially in UNEP's international efforts. The OECD has been cautious on the subject. However, without a doubt employment opportunities will be an important component of green economy in China. Therefore this topic must be monitored carefully in Chinese efforts to align its environment and economy. It is also important to be realistic on this point during the "12th Five-Year Plan". Perhaps the full employment potential will only be realized in later periods as global demand shifts, sunrise industries mature, and the take-off in service sector employment soars to its full potential.

2.4.1.5 Linking Chinese and international efforts

China now faces dual expectations from the international community that, with its large role in trade and world economy and its rising place in global environmental affairs, the country's support will be sought at this time of global economic crisis and environmental crisis. The extent of these suggested commitments and their nature vary greatly, based on who is making the proposals. But clearly there will be challenges to address. These relate to the difficulty of addressing climate change, new environmental initiatives such as the proposed global treaty on mercury, the on-going struggles with world trade negotiations, and the next steps to be taken globally concerning green economy and sustainable development, especially action that may be negotiated at Rio+20.

Each of these topics and others has their own channels for dialogue, negotiation and action, and therefore they will not be discussed in any depth here. But there are some general points that should be considered. First, on green economy, when China's recent initiatives are compared to those being suggested by OECD and by UNEP, it is quite clear that China is already well engaged. In fact, China is probably better engaged in terms of action than most other countries whether from the developed or developing categories. Secondly, even though Chinese greenhouse gas emissions and energy use continue to rise, there is also progress on reducing intensity per unit GDP. And on trade matters, China continues to rise in prominence, and therefore has a considerable range of interests to consider.

The challenges are how to develop stronger partnerships and other international cooperation to improve China's green transformation and economy while simultaneously ensuring that competitiveness, external image, and contributions globally are maintained or, hopefully, improved. These two big challenges are interactive, of course, but often the linkages are not particularly clear, including how to optimize the relationships. An example is climate change, energy and trade.

Five matters of considerable interest and concern—out of many that could be highlighted—are:

(1) Role of China as a source of development assistance and transfer of successful environment and development experience to countries in Africa, Asia and elsewhere

(2) Border tariffs and other trade matters such as green subsidies associated with environment and climate change

(3) Partnerships with China on science and technology for sustainable development issues such as carbon sequestration, new generation automobiles and other vehicles, and on advanced forms of energy generation

(4) Reduction in transboundary and intercontinental pollution transfers

(5) Global greenhouse gas reductions based on mutually acceptable arrangements that have not yet been resolved.

The significant price tags that accompany these matters certainly have held back progress in the past, and sometimes even more so during the global financial crisis. In some ways this is advantageous to China at the present time. It is possible to engage in partnerships under good terms. The substantial investments China is making within other developing countries require consideration of environmental costs but in addition, there is a strong interest in trade, capacity building, etc. The contributions China makes overall will be substantial. The key is to ensure there is superior value for both China and developing countries' sustainable development. And, in its relationships with many countries, including OECD countries and other emerging economies, China will need to maintain its competitive advantages as environmental matters become more important on trade and investment.

2.4.2 Five opportunities

2.4.2.1 Creating integrated sustainability policies for better environmental, economic and social conditions

There is recognition that sustainable development still is a long way from achieving its potential in part because most initiatives have failed to address environmental, social and economic issues in an integrated fashion. This is true in China as well as other countries and globally. Many opportunities have been lost, whether the subject is optimizing water resource use, poverty elimination, urban design, biodiversity conservation, or many other sustainable development topics. The hope now that countries have more experience with each of these three fundamental themes is that in the years ahead more attention can be paid to integrated approaches. There is enough experience in China to believe that it should be possible to achieve better results if integrated planning and management for sustainable development is implemented.

The key need is to build on the strong policy concepts identified in the past decade, including scientific development and innovation, harmonious society, MDGs, ecological compensation, pollution pays, market pricing, circular economy, low carbon economy, and now also, green economy and development. These concepts need to be backstopped with operational policies, often tailored to specific sectors or regional circumstances. Other operational considerations include monitoring and adaptive management measures that more accurately address progress and course corrections during implementation.

Also required is a more coordinated approach among various agencies and levels of government, and across sectors. An example is the work on mercury management in China carried out for this CCICED meeting. There is a strong desire to address ways to reduce mercury entering the environment, and also to prevent it becoming a human health hazard. Like other heavy metals, it can persist in the environment, and be introduced into ecosystems and food chains in a variety of ways. Because it is a byproduct of coal burning in power plants, and in certain industrial processes that are currently on the increase as well as in some products such as energy efficient compact fluorescent lights, there are numerous economic impacts associated with its removal from existing activities. Also, significant issues arise from its use. Therefore it is only by an integrated strategy with considerable attention to operational policies that progress will be made.

Another prominent set of examples where integrated planning and management are required is for river basin management, and coastal zone management. Both topics have been studied in the past through CCICED task forces. Now the issues are becoming urgent as issues such as non-point agricultural use, expanding urbanization, oil spills, chemical manufacturing facilities and other stresses on the waters of China increase. The models for planning and management have been identified, but are not working well enough due, in part, to the lack of integrated sustainable development implementation policies.

Such policies generally will not be confined to command and control interventions. They will include integrated regional planning, better functional zoning, enabling measures for market based management systems, and with opportunities for more voluntary action by enterprises, and with participatory initiatives at the community level.

2.4.2.2 Low carbon industrialization strategy for China: revamping the existing and enabling the new

The extraordinary interest in low carbon economy throughout China and the announced national target of a 40% to 45% reduction from 2005 levels in carbon per unit of GDP by 2020 offers new greenhouse gas intensity reduction opportunities in a number of sectors. However, it is also clear from the recently completed analyses of CCICED and the Government of China that meeting the target will depend very much upon industrialization strategy. Exploration of Low Carbon Industrialization Strategy by the CCICED Task Force reveals that a highly focused effort based on carbon reductions in seven existing heavy industries plus commitment to seven emerging pillar industries will be the most important contributors by far. The CCICED task force calculated that about 70% of the total change in intensity required by 2020 could be from two factors: 42% from energy efficiency and 29% from structural change in the energy industry. Beyond the implications for environmental improvement, there are other benefits including protection of some jobs in the existing industries, plus new employment from the emerging sectors such as biotechnology, new energy industries, information technology and advanced materials. Other benefits include enhanced energy security and a shift towards innovation-led development and away from the current model of investment-driven development.

Hopefully low carbon development in China, especially the industrialization transformation, will become a success story beyond all expectations. It should serve as a prime example of the desired dual transformations of environment and economy. It will open any number of new possibilities for strengthening green economy and green development.

2.4.2.3 Achieving sustainable consumption in China

This is somewhat of a wild card. Can Chinese consumption actually be made sustainable as income levels rise, especially among the rising number of middle class people with fast-growing levels of disposable income? Elsewhere in the world it has rarely worked out that people form a conserver society as they grow wealthier. Will China be different, and if so, in what ways, and how can sustainable consumption behavior be fostered and enforced? How can this issue be dealt with—at the same time as plans are made to stimulate domestic consumption, a goal of the "12th Five-Year Plan"? As CCICED's work with WWF China has revealed, there is rising ecological demand by China not only on its own resources but also on those from other parts of the world. The rising demand for animal protein in the diet leading to pollution from livestock feed lots, luxury demand for live reef fishes unsustainably caught from reefs in Southeast Asia and transferred to restaurants in China's urban centres, and the environmental costs of private autos in China's larger cities are examples of the problems created by rising domestic consumption.

China's consumption patterns are, of course, strongly linked to urban life styles. Yet relative to most western societies, most Chinese urban and rural residents currently live a conserver lifestyle, with smaller living areas and resource saving habits, but the situation is changing, sometimes quite rapidly.

There also are indications of demand for products that are produced in an environmentally friendly way, and with consideration of contaminants. Organic foods that are free of pesticides or other contaminants is a prime example. However the market systems including widespread use of reliable certification has not occurred. Greening of supply chains is an important matter for China's domestic consumers as well as its international trade. In fact over time, it may be even more important to domestic markets. Developing good domestic certification systems that some have described as Green Chinese Consensus (rather than relying strictly on international certification criteria) may be useful for Chinese consumers.

New Chinese sustainable consumption patterns will require behavioral and life style shifts, and the creation of service industries that cater to providing necessary information both to consumers and marketing information useful to producers. Also required are various enabling policies on the part of government, plus considerable changes on the part of many enterprises. However there are many examples that this is starting to happen.

While it may seem incongruous to simultaneously promote both a conserver society (such as xiaokang society) and a consumer society, this is the reality. Therefore, there is a need to also work very hard to decouple consumption from high energy and material use, and to internalize environmental externalities. Quality of life rather than quantity of goods is also a way to promote both environmental conservation and transition to a service economy.

2.4.2.4 Making China's "going out" ODI strategy environmentally friendly

Will China's environmental impacts on the rest of the world lessen or increase as a result of efforts to bring about improvements in its own environment and economy relationship? With China's "going out" strategy now well established, Chinese businesses are expanding trade relationships that often involve either long-term contracts for commodities production, and Chinese ODI, turn-key operations or joint ventures on many types of projects, sometimes drawing heavily on Chinese engineering prowess, for example in large dam construction and mining. Just as other Asian countries such as Japan and Korea expanded their activities abroad during the 1970s and 1980s, and before then, multinationals from Europe and North America. Certainly Chinese businesses are still operated at a level that is still quite limited over what is expected even a few years from now.

However there is ample evidence that China’s “brand” is not well established, and the news sometimes is not good. In these relatively early days of “going out” there have rebuffs of Chinese firms when attempting to purchase companies, or trying to establish operations in some resource sectors. There are reports, sometimes factual, sometimes not, of activities by Chinese businesses operating in Africa or Asia that suggest little regard for environmental factors or other problems. It is a very important time to create a consistent positive image as a country dedicated to good quality of ODI, and with a sensitivity to local communities and local environments. There are good examples where this is occurring but it has to be made the norm.

There is a simple to enunciate but perhaps difficult to apply “golden rule”: ensure Chinese enterprises meet the same level of environmental performance whether they are operating within China or outside. And the same rules should apply to ODI by Chinese firms as to international firms entering China via FDI. Since over time there will be tightening of environmental standards and rules for businesses within China, then there would be constant improvement abroad as well. Of course, if there are special requirements in particular countries (e.g., regarding protection of primary forests in Indonesia) then these rules would also have to be respected. Another important mechanism is for Chinese firms to join international efforts such as the Round Table on Sustainable Palm Oil. Over a period of years all the products imported into China from producer countries could be certified as sustainably produced, similarly for soy and some fisheries, forest or other products.

China’s opportunities if it comes to be regarded abroad as an environmentally friendly investor, partner, producer, or employer, are that it will have greater access and security of supply for needed resources and products, and also will open new opportunities for trade. In addition, it will be in a position to assist in an effective fashion with development opportunities for countries with which it hopes to have long-term relations, for example in Africa, Latin America and Southeast Asia. Through these relationships issues of global environmental significance such as reduction of desertification, improved water management, aquaculture development, and introduction of renewable energy technology can be addressed through Chinese experience. These examples are ways that green transformation by China can be directed at global, regional and national improvement of economic modes.

2.4.2.5 Green economy medium and long term plan (15 Years - 2015 to 2030)

Any sense that the issues of green transformation can be completed any time soon should be set aside. While it is vitally important to start immediately in the "12th Five-Year Plan", many of the key opportunities will enter over longer time frames, when the green framework in China and in the world is more robust, new sustainable technologies have matured, and there is experience and partnerships capable of accelerating the pace of change. Just as China set out its economic and development aspirations in short, medium and longer term plans, there is a need to do so also for green economy and development. The longer term may have to be out as far as 2050 for at least some aspects such as climate change. However, what is of greatest concern in terms of both setting out new objectives and building useful scenarios, is the need for a medium and long term plan extending for 15 years, from the end of the "12th Five-Year Plan".

The advantage of having such a plan is that it could be used to get at some of the more difficult issues such as how best to deploy the products of sustainability technologies that are now being worked on. And the scope for implementing integrated management and other elements of green transformation requiring institutional innovation and strengthening. It would include some of the very expensive shifts that are required in order to clean up rivers and lakes, and legacy problems such as those associated with soil pollution. Of special significance are actions that will have to take place if climate change, biodiversity conservation and some other environment and development concerns are to be properly and fully mainstreamed into economic decision making.

The implications for placing China into a much stronger competitive position within the new green economy envisioned for the world, and in its relationships with other emerging economies are considerable. Well before this time frame is over, China is likely to be the biggest economy in the world and much more balanced in its foreign trade and domestic consumption situation. It will be at a different stage of development, much less focused on infrastructure and some other aspects such as heavy industry. Quality of life and quality of the domestic and global environment will be an even bigger concern than today. It will require a green framework for action that will have many more components than today. And, hopefully, China will be regarded as a country that is viewed as environmentally friendly, with the opportunity to share with others interested in a pathway leading towards becoming an Ecological Civilization.

2.5 Conclusion

Over the past five years the many positive Chinese accomplishments concerning environment and development governance have included: providing strong guidance from senior levels of the government, accompanied by better public dialogue on performance; adapting to changing circumstances, especially with the inclusion of environmental criteria and initiatives in the financial stimulus package in late 2008; improving laws, regulations, and broadening deployment of planning tools such as environmental impact assessment; expanding use of market-based economic instruments; strengthening the environmental management and administrative system; increasing funding for environment and development issues; expanding public input and access to information; making enterprises and the financial sector active participants in environmental protection; using events such as the Beijing Olympics and the Shanghai World Expo as vehicles for introducing innovative environmental action; and engaging very substantively in global environmental dialogue. Yet this very substantial effort has not directly translated into adequate progress on environmental protection outcomes.

It is therefore an inescapable conclusion that green economy and green development are necessary for environment and economy to become mutually supportive in China's future. This must also happen elsewhere, and China's experience will be highly relevant, leading to new opportunities for green trade and investment. China has signaled its interest in further international cooperation and partnership on both green growth and green economy. Green economy can become the catalyst for other social and economic benefits, as is likely with lower carbon industrialization, deployment of sustainable development technologies, and actions such as creating green supply chains.

Despite many uncertainties concerning the strength of the global economy, China's well-considered "12^{th} Five-Year Plan" should offer the opportunity to foster transformative changes related to both economic development and environmental improvement. To achieve full benefits, attention is required not only to meeting individual targets but also to developing integrated approaches that link economic, social and environmental outcomes. Also, with the point that green economy is not a "one size fits all" approach, consideration is needed for specific sectoral strategies and a focus on those situations that foster emerging solutions which may take some years to express their full value.

The enabling conditions for a better relationship between environment, the economy and development are still lagging, perhaps less so in China than in many other nations. But even with the proposed level of investment in the environment (almost half a trillion USD over the period of the "12th Five-Year Plan") the environmental challenges for this very large country will be far from fully met. It is therefore important to consider medium to longer-term challenges and opportunities, with the period between 2015 and 2030 perhaps being the most appropriate.

China is at the stage of its development where it is well placed to have a greater positive influence throughout the world. If an environmentally friendly "brand" can be reliably built it will be to China's advantage, but also will be beneficial for many other countries, especially those developing countries with which it is building long-term relationships.

Green economy therefore must focus on becoming green development, for that is the greatest need for environmental protection in the world. In the coming years, China will be able to contribute its substantial knowledge and experience to many others. Ecological civilization within China and at a global level may then be within closer reach.

Chapter 3 Development Mechanism and Policy Innovation of China's Green Economy

3.1 Introduction: the Taskforce and the Report[1]

Following the industrial and information revolutions, the "green revolution" is another vital catalyst that could transform the global economy. The concept of "green economy" was first proposed in 1989 by the British environmental economist David Pearce in his report "*Blueprint for a Green Economy*" – which shed an illuminating light on the central role that environment should play in business, economic and public policy decision making.

The financial crisis in 2008 has accelerated the disillusion with the conventional "black" economic development model that has relied heavily on resource depletion and utilisation of fossil fuels, leading to serious environmental pollution and ecological crisis. As the same time, the crisis also spurred a new wave of change and search for new growth and development opportunities. Consequently, green economy is now seen as a new vehicle for creating economic, social and environmental benefits. The UNEP (United Nations Environment Programme) launched the "Green Development Initiative" together with a "Global Green New Deal" to mobilise and re-focus the global economy towards investments in clean technologies and "natural" infrastructure. At the G20 London Summit in 2009, the overarching agenda of an "inclusive, green and sustainable recovery" was endorsed by the world leaders. The Organisation for Economic Cooperation and Development (OECD) launched its work on the "Green Growth Strategy" in 2010, which aimed to provide both a generic conceptual framework and practical policy tools to create new green growth opportunities. The common theme across these international initiatives is the integration of global environmental challenges into everyday economic decision-making, ranging from the

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1 This Policy Report is based on the background material and research results from the Green Economy Taskforce sub-topic research teams. The drafting team for this Report consists of the following members: Yang Chaofei, Lars-Erik Liljelund, Nannan Lundin, Yuan Qingdan, Yan E, Shen Xiaoyue, Cao Dong, Lai Xiaodong, Zhao Xuetao, Jia Lei, Lou Zhaohui and Xiao Cuicui.

macroeconomics to investment and science, technology and innovation. Great emphasis is given to the role of green investment, consumption and innovation, which are deemed the key drivers for a green and sustainable recovery, poverty reduction and long-term growth. From an international business perspective, a global green race, which is driven by an opportunity narrative (rather than simply a compliance issue), has become the driver of a global green economy. Countries will compete and collaborate to become the leading producers and exporters of resource efficient and environmental friendly technologies and solutions. This requires governments to work together with the business sector. The green growth agenda are to transform domestic markets and build strong domestic demand, as well as to increase the share of the global market for green products and services. (The World Business Council for Sustainable Development, WBCSD, 2010).

With a continuous and rapid growth of above 9% since the open-door and reform policy was launched in early 1980s, China surpassed Japan and Germany to become the world's second largest economy and the largest exporter in 2010. However, in the midst of industrialisation and urbanisation, China's growth model still suffers from the problem of high resource utilisation, high energy intensity, high emission, poor coordination, low recycling and low efficiency. While "business as usual" and the Western over-consumption lifestyle will not be an option for China, there are no off-the-shelf solutions for the green transformation, given the scale and the complexity of the challenges China faces. China needs economic development, but it also needs to decouple economic development from the increased use of energy and resources as well as from profound ecological and environmental damage. Consequently, China needs to seek its own path towards a green transformation and the "Chinese dream" will need to be a green dream.

As the largest emerging economy as well as an emerging "rebalancing" power, China's transformation towards a green economy will also have far-reaching implications for the global economy. It will fundamentally change the characteristics of China's economy: from the world's workshop to the world's consumer market; from "made in China" to "innovated in China"; and from the recipient of inward investment to the supplier of outward investment. It will also help to preserve resource security, to enable the scale-up of global green technologies and to create new sources for green growth globally.

The policy message from China's the "12th Five-Year Plan" (2011—2015) adopted at the National People's Congress (NPC) in March 2011 was resolute and unambiguous: China needs to accelerate the transformation of its mode of economic development, moving from an unbalanced, uncoordinated and unsustainable development towards a green, competitive and inclusive economy. In fact, "economic transformation" is *not* a new policy agenda for

China and the transformation of its economic mode does *not* need to start from scratch. In 1996 when the “9th Five-Year Plan” was adopted, the key message was that “China’s economic policy should give clear emphasis to the transformation of economic growth mode”. In 2003, the Chinese government introduced the “Scientific Concept of Development”. Strategic guidelines were subsequently issued to promote a people-centred scientific development based on a holistic, balanced and sustainable development concept. The concept of and strategies for developing a “ecological civilisation” were introduced in 2007 to further integrate and accelerate the process of building a resource- and energy-saving and environmental friendly industrial structure, growth and consumption mode.

Evidently, China has already embarked on the pathway towards a green development since the past decade. The ongoing process of building a resource-saving and environmental-friendly society as well as the development of the circular economy and low-carbon economy has already laid down promising groundwork. The real issues now are how to accelerate and deepen China’s green transformation and how to further improve cost effectiveness and governance efficiency, given the scale and the complexity of the challenges that China faces. In other words, it is time for China to start treating the cause and not just the symptom. At the same time, it is imperative for China to seize the new green growth opportunities for modernisation and leapfrogging that the green transformation will bring.

In order to increase the speed, scale and depth of its green transformation under the “12th Five-Year Plan” and beyond, China needs innovative mechanisms and effective policy mix, taking into account China-specific conditions as well as making use of international experiences and best practices. The objectives of the Task Force for “Development Mechanisms and Policy Innovation of China’s Green Economy” are therefore:

(1) To clarify conceptual issues related to China’s green economy;

(2) To outline the enabling conditions, with a particular focus on China-specific challenges and opportunities;

(3) To put forward an overall strategic framework for developing China’s green economy;

(4) To address key tasks of green transformation at both the regional and sectoral levels;

(5) To provide concrete policy recommendations that are of strategic importance and viable for quick implementation.

In this report, green economy is seen as the “integrator” and “synchroniser” of new development mechanisms and policy initiatives to address multiple economic, environmental and social challenges. The analysis will therefore go beyond the scope of environment to produce a coherent policy framework. The report will focus mainly on the development mechanisms and policy tools/mixes. Some of the equally important issues in China's green transformation, such as low-carbon industrialisation and international trade, investment and environment, will not be investigated and addressed in great detail, but will be covered by general discussions based on the results from the previous and/or parallel ongoing CCICED Task Forces.

3.2 China's Green Economy – Concept and Background

3.2.1 Concept and key principles

Drawing on the latest work by the UNEP and the OECD as well as taking into account China-specific characteristics, a green economy is defined by this Task Force as[2]:

An economic development model that regards environmental protection and sustainable resource utilisation as essential conditions for sustainable growth. This new model gives priority to the health and well-being of citizens, minimizes harm of human activities to the environment, adequately recognises and values both natural and human ecosystems for their ability to supply services. It seeks to seize new green growth opportunities, through a combination of continuous innovation and efficient governance.

A green economy covers all stages of economic activities (e.g. material extraction, production, distribution, utilisation and end-of-life management) and needs to be an integrated and coordinated development at the national, regional, sectoral and enterprise levels.

It is important to note the underlying notions of people-centred green development as well as an enlarged perception of national wealth. The total national wealth, which is the ultimate yardstick of a green development, embraces not only the wealth of the current but also future generations. Its emphasis is not only attached to physical wealth, but also to human, institutional and natural resources.[3] In a Chinese context, this broadened conceptualization of national wealth is of great importance as China moves from a low- to middle-income economy, and when millions of Chinese consumers start to pursue a more affluent and consumption-driven lifestyle. A green mind-set should value the richness of invisible assets, such as green values that emphasise a harmonious relationship between

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2 For a detailed overview of green economy concept, see UNEP March 2010. *Towards a Green Economy – Pathways to sustainable development and poverty eradication*, and OECD May 2011. *Towards Green Growth*.

3 For more detailed discussions, see K Hamilton et al., *Where is the wealth of nations? Measuring capital for the 21st century.* World Bank, 2006.

nature and the society, as well as a sustainable and healthy lifestyle that goes beyond the narrow focus of material wealth.

To make the first moves towards the "beyond-GDP" mentality, some leading Chinese scholars have advocated a broadened scope of economic development goals, which emphasises economic well-being, living conditions and happiness as the cornerstones of a harmonious society (see Figure 3-1).[4]

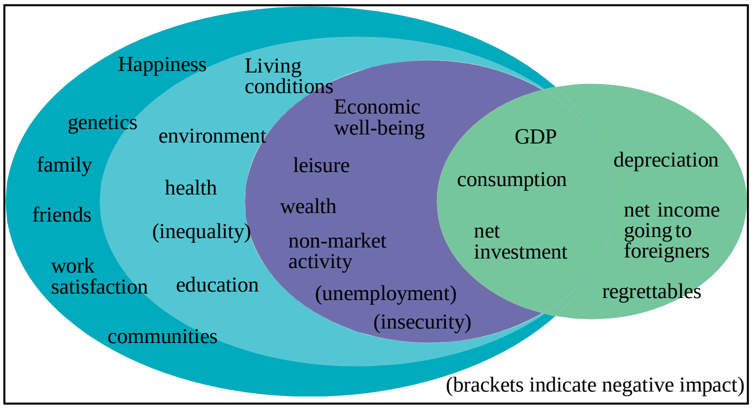

Figure 3-1 What GDP does and does not measure

Source: "Measure of well-being", Deutsche Bank Research 2006.

The transformational and holistic view of national wealth and social values calls for institutional and policy innovations. The following key principles will guide China's green economic development, which espouse a progressive view on the relationship between the economy and the environment, and a refined understanding of economic and social progress within the China-specific context. More specifically:

(1) The essence of a green economy is a balanced and mutually supportive and reinforcing relationship between economic development and environment, rather than one of trade-offs and conflicting interests.

(2) The speed, efficiency, quality and equity of economic development are given more equal priorities to reflect a more sustainable and harmonious relationship within the human society and between the nature and the human society for the present and future generations.

(3) Given the uneven stages of development across the Chinese economy, China has to simultaneously deal with pressures faced by developing and industrialised economies. Green economy for China is not only about catching-up, cleaning-up and avoiding "lock-in", but

4 See e.g. China Dialogue (Beijing), 24 February 2011. *China must measure happiness.* http://www.chinadialogue.net/article/show/single/en/4130--China-must-measure-happiness-.

also about seeking its own green development path and taking advantage of the unique opportunity of leapfrogging and green growth.

(4) Given the size of China's population and continuously increasing income level, demand-side management and the green transformation of consumption and distribution will also become more important, at the same time as China seeks a new pathway of green and low-carbon industrialisation and production. Excessive lifestyle in Western society and over-consumption should not, and cannot, be repeated in China's future development in the face of environmental and ecological constraints.

(5) Given the sheer size of the Chinese economy, there is no "one-size fits all" green economy model for China. It requires a differentiated, coordinated and regionalised approach, taking into account region-specific constraints and opportunities.

3.2.2 China's green economy – an inevitable strategic choice

The rapid industrialisation, urbanisation, and modernisation of the agriculture sector have increased both the scale and the complexity of the challenges faced by China. At the same time, the growth model characterised by high resource utilisation, high energy intensity, high emission, low recycling and low efficiency has created serious resource bottlenecks and resulted in comprehensive environmental and ecological impacts.

In 2010, China's energy consumption was about 3.2 billion tons of standard coal equivalent (tce), which was an increase of 5.9% from 2009.[5] At the same time, the level of energy consumption per capita in China, driven by the effect of increased living standard and urbanisation, has also increased quickly in recent years from 0.87 tons of standard oil equivalent (toe) in 2000 to an estimated 1.60 toe in 2009.[6] According to the International Energy Agency (IEA, 2010), China will add 500 GW of new coal-fired electricity generation capacity between now and 2020. To meet the surge in energy demand, China has become a large net importer of both coal and crude oil, which raises serious concerns for China's energy security. For instance, China's thermal coal net imports amounted to around 100 million tonnes in 2010, making China one of the largest coal net importers. The speed, at which China's coal import has reached an "alarming level", with imports accounting for 52% of the total consumption, adds to the urgency of the situation. According to a report by

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5 Source: National Bureau of Statistics of China (Beijing). 28 February 2011. *Statistical Communiqué of the People's Republic of China on the 2010 National Economic and Social Development* (In Chinese). http://www.stats.gov.cn/tjgb/ndtjgb/qgndtjgb/t20110228_402705692.htm.

6 For more details, see International Energy Agency (IEA, Paris), November 2010.*World Energy Outlook 2010*.

the Chinese Academy of Sciences (CAS, 2009)[7], 64.5% of China's oil consumption is likely to be met by imports in 2020.

The need for strengthened measures to protect the natural environment – air, water and soil – is also acute and comprehensive, such as:[8]

(1) High emissions of sulphur dioxide (SO_2) and nitrogen oxide (NO_x);

(2) Ambient air quality in many Chinese cities is bad and has significant negative health impact;

(3) China's rivers and freshwater lakes are seriously polluted and the depletion of groundwater is also a growing concern;

(4) Land loss caused by industrial expansion and desertification as well as the loss of farmland productivity caused by the pollution of heavy metals, pesticides and fertiliser threaten both food security and biodiversity;

(5) Frequent occurrence of environmental accidents and mass protests threaten both environmental and social security.

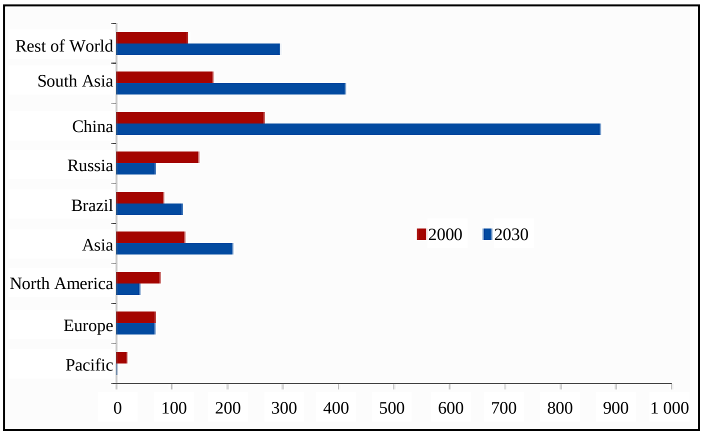

Figure 3-2 Premature deaths from PM_{10} exposure (per million inhabitants)

Source: "Towards Green Growth", OECD, 2011.

It is becoming increasingly evident that China has paid a high price for the economic growth. According to the most recent estimates by the Chinese Academy for Environmental

7 For more details, see CAS 2009. *China sustainable development strategy report 2009-China's approach towards a low carbon future*, Beijing, May 2009.

8 See Vennemo et al., *Environmental Pollution in China: Status and Trends.* Review of Environmental Economics and Policy, June, 2009.

Planning (2010), China's economic growth was inflicting more than RMB 1.3 trillion worth of damages on the environment (equivalent to 3.9% of China's GDP in 2008), in the forms of pollution spills, deteriorating soil, and vanishing wetlands. The costs of pollution spills and other environmental damage have risen by more than 74% in the five years running up to 2008; the estimated costs could be even higher if other forms of environmental degradation, such as loss of biodiversity, desertification and soil degradation through over-intensive farming, were also taken into account.[9]

Furthermore, as a consequence of the rapid economic development, large and fundamental social changes have also been taking place. These include urbanisation, migration and increased income inequality, which can be observed both across different regions, within urban areas as well as in the gender gaps. Parallel with the economic concerns, the rationale for the Chinese government to address environmental issues is these social changes in the Chinese society, which have a disproportionately adverse impact on the most vulnerable groups.

A political awareness and consensus has thus emerged that China can no longer afford a continuous "black" economic growth in the face of these serious resource bottlenecks. Environmental issues and social concerns are no longer merely the negative "side-effects" of China's economic growth. China now finds itself in a loop, in which resource bottlenecks, environmental degradation and social discrepancy are causing serious economic problems and preventing a continuous and sustainable economic growth. A green transformation of the Chinese economy is therefore an inevitable strategic choice that aims to curb resource utilisation and ecological degradation, and at the same time improve economic efficiency as well as social inclusion and stability.

3.2.3 China at a crossroad: an entwined process of economic and environmental transformation

During the "12th Five-Year Plan" period and in the medium term, structural and systemic solutions and institutional improvement will be crucial for China's future economic stability, sustainability and competitiveness. The following four aspects show how the economic and environmental transformations are linked in a mutually supportive and reinforcing way. However, there are also both strengths and weaknesses in this entwined process.

(1) The institutional effect: The most important observation from the growth analysis of

9 See e.g. The Guardian (London). 28 December 2010. *China counts £130bn cost of economic growth.* http://www.guardian.co.uk/world/2010/dec/28/china-130-bn-economic-growth.

the Chinese economy is that economic efficiency gains are typically related to better functioning market economy dynamics, in particular the growth of the private sector, the urbanisation process as well as market-oriented reforms in product markets.[10] In the field of environmental protection, institutional, policy and capacity development have also undoubtedly improved in the past three decades. However, direct government intervention in the market, particularly through subsidies and other forms of price distortions in resources-related inputs market, has led to inefficient resource utilisation and an irrational industrial structure. Furthermore, while there is no shortage of standards and regulations, there is an urgent need to improve the quality (e.g. a science-based approach to environmental impact and outcome), the viability (e.g. ability and potential for compliance by enterprises at different development stages) and the linkage with technology and innovation (i.e. the availability of best technological solutions and the potential for stimulating more efficient solutions) of environmental enforcement. Finally, on top of the various administrative and regulatory measures on polluters and regulators, the intrinsic incentive structure for both compliance and monitoring needs to be adjusted and improved.

(2) The scale versus efficiency effect: After three decades of economic growth with an annual GDP growth above 9%, the annual GDP growth target in the "12th Five-Year Plan" period has been set at 7%, which is lower than previous FYPs. According to various estimates and forecasts, China's actual GDP growth rates in the coming decade will probably be again higher than the official targets. However, a slower growth rate (compared to the historical trajectory) will likely be a permanent trend for China's future economic development. This anticipated lower GDP growth in the short and medium term can be considered a direct measure to deal with resource, environmental and ecological constraints, which should have direct effects on energy saving and emissions reduction. Nevertheless, the challenge in terms of improvement of resource efficiency and emission reduction in a slower growth pace is still enormous. For instance, according to the estimates made by the Chinese Academy of Sciences (CAS, 2009), if the environmental quality is to be maintained at a level similar to that in 2000, resource efficiency would need to increase by a factor of 4—5 and the environmental footprint per unit GDP to decrease by 75% in 2020, when the GDP target for 2020 is expected to quadruple compared to the level of 2000.

(3) The structural effect: The structural transformation of the Chinese economy can be

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10 See F. Gang, *China towards 2020: Growth performance and sustainability,* National Economic Research Institute (NERI) 2007 and OECD 2010.

observed from two different aspects: ① Sectoral upgrading with a focus on both intra-sectoral modernisation and "decarbonisation" in the industrial sector, and the expansion and modernisation of the service sector. ② The shift of the main driver of economic growth from an investment- and export-driven growth towards a more domestic consumption-driven growth. Both types of structural transformation will have the potential to reduce the environmental impact and enhance the efficiency of resource utilisation and allocation, while at the same time address domestic and international economic imbalances. While consumption-driven growth is considered the most important structural change, the question remains whether the efficiency effect will be sufficiently strong to balance out/offset the increase in demand for resources as a result of the income and the scale effects. Therefore, a strengthened demand-side management will be needed to accompany a "cap" on resource use.

(4) The technology effect: Efficiency-driven instead of input-driven economic development requires investments in physical and human resources for technological and innovation capacity building. It will not only help to create solutions to prevent and manage environmental consequences, but also speed up and scale up the innovation and industrialisation processes. In particular, in many low-carbon green innovation fields, the technology and innovation gaps between China and the advanced industrialised economies are relatively narrow, as both are currently at the starting point of the green race. The downside, however, is the substantial uncertainties related to both technological choices (in terms of the possibilities of technological breakthroughs, production and service models) and the feasibility of the scaling-up and commercialisation of new technologies in the Chinese market. Hence, a "green rush", without taking into account the technological and market risks and environmental impact seriously, will not contribute to the development of the infrastructure and innovation environment, but waste financial and land resources.

3.3 Structural Transformations and Green Initiatives – International Experience

3.3.1 Structural transformation – policy insights in OECD countries

Since World War II, major industrialised and advanced economies have experienced a continuous and gradual process of structural change, based on country-specific endowments as well as various national and international socioeconomic circumstances. The driving forces behind these structural changes included a combination of the follows: resource constraints (e.g. oil crisis and raw material shortage), technology revolution (e.g. information and communication technology), and last but not least, globalisation in terms of trade, investment and to an increasing extent, mobility of human resources.

There is currently no ready-made "policy package" and/or governance guideline to achieve a green economy. However, some general and common lessons from previous major structural reforms and policy processes that have contributed to change (and those which failed to do so) are both relevant and important for the current and future policy-making to promote the green economy (OECD, 2011):

Policy insight 1: Transparency as well as effective communication to explain the benefits of reform and structural adjustments are key to mobilising public support.

Policy insight 2: Relevance and responsiveness between policy orientation and corporate behaviour are necessary conditions for structural changes. From a business viewpoint, the following government support is of particular importance for involving the business sector in the green transformation:

(1) Clear and long-term market signals, notably price signals to both producers and consumers in energy- and resource-related fields, such as energy efficiency;

(2) Financial market that addresses: ① risk, ② rate of return and ③ size of market;

(3) Public-private partnership, especially for technology development and diffusion.

Policy insight 3: Institutional capacity and governance structure for cross-government and cross-societal coordination are key success factors. In designing and implementing green growth strategies, governments need to find satisfactory compromises not only among conflicting objectives of different strands of society, but also within the government itself. Green growth strategies cannot be implemented through a single type of policy. Instead, getting the right policy mix requires strategic coordination among ministries that may not be used to working together.

Policy insight 4: Being fiscally neutral is NOT enough to address distributional concerns associated with structural adjustment and changes. To manage the distributional consequences, targeted compensatory measures are needed to compensate the adversely affected and/or the most vulnerable groups (e.g. in the forms of targeted/ direct cash transfer and/or (green) tax shifts).

Policy insight 5: The issue of economic and sectoral "competitiveness", as well as the impacts on economic efficiency and environment, as a result of economic transformation need to be addressed using an evidence-based approach. This is to prevent unfounded "competitiveness concerns" thwarting the reform effort.

3.3.2 New green initiatives and their key elements

At both the inter-governmental and national level, a broad range of new green initiatives have been launched in the aftermath of the financial crisis in 2008—2009. Their objectives are to achieve sustainable economic recovery in the short run and to create new competitiveness and new jobs from a long-term strategic perspective.

The UNEP has launched the Green Economy Initiative and Global Green New Deal, where green investments have been identified as the key to economic recovery and creating green jobs while reducing environmental pressure. Supported by and combined with policy and institutional reforms, green investments will lay the foundation for a green economy of the 21st century. In 2009, out of the USD4.5 trillion fiscal stimulus packages announced by G20 countries in response to the financial and economic crisis, at least 15 percent was allocated to what was broadly categorized by HSBC as the "green" sectors. In China, out of the USD586 billion stimulus package, USD200 billion was categorized as green stimulus.[11] More importantly, beyond the short-term responses to the financial and economic crisis, UNEP's Green Economy Initiative also encouraged the integration of green investments into the medium and long-term economic planning and development strategies. According to the UNEP's estimate, investing 1—2 percent of the global Gross Domestic Product per year from 2010 till 2050 in greening ten environmentally and socially significant sectors would be highly competitive vis-à-vis investing the same amount in a business-as-usual scenario in terms of outputs and jobs, on top of environmental gains.[12]

At a general level, the OECD green growth strategy addresses the most fundamental policy elements in a green transformation, which includes:[13]

(1) The integration of the natural asset base into everyday market and policy decision making;

(2) Environmentally-motivated and growth-oriented fiscal/tax reforms to align economic and environmental policy objectives;

(3) Both technological and non-technological changes and innovations are instrumental in driving green growth.

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11 See e.g. HSBC Global Research (London), 31 March 2009. *More Green Money on the Table.* http://www.endseurope.com/docs/90401c.pdf.

12 For more details, see UNEP March 2010. *Towards a Green Economy –Pathways to sustainable development and poverty eradication*.

13 For more details, see OECD May 2011. *Towards Green Growth*.

Box 3-1 Green growth initiatives in OECD countries
① Green Investment Bank (UK, 2010): It will be launched in 2012 with an initial capital injection of GBP 3 billion of public money to provide funding for low-carbon projects.
② Tomorrow's Agriculture (Denmark, 2009): High-level environment, nature and climate protection with modern and competitive agriculture and food industries.
③ National Green Growth Plans 2009—2013 (Korea, 2009): A comprehensive policy framework for green growth and a designated spending of 2% of annual GDP on green growth programmes and projects.
④ Green Innovation (Japan): to create JPY 50 trillion environment-related market and 1.4 million new environment-related jobs.
⑤ Green Growth Advisory Group (New Zealand): Ministers of Finance, Economic Development and Environment jointly established a high-level private sector advisory group for green growth policy consultation.
Source: "Towards green growth- A summary for policy makers", OECD, 2011.

In the context of the global green business agenda, Chinese companies are playing an increasingly active role. Some Chinese companies, in particular those in the traditional "black" and "brown" sectors, already embarked on the process of upgrading and transforming their business practices. Through further interaction and collaboration with the international business community, Chinese companies can share best practices and knowledge as well as create common platforms for the global low-carbon and green transformation.

Box 3-2 Chinese companies' participation in cement sustainability initiative (CSI)

The Cement Sustainability Initiative (CSI) is a global effort by 23 major cement producers with operation in more than 100 countries, including 5 Chinese companies: China Resources Cement Holdings Limited (CRC), China National Buildings Material Group Corporation (CNBM), Sinoma, Tianrui Group and Yatai Group. The companies' participating in the CSI have all signed the CSI Charter, with the following commitments for climate protection:

① Use the tools set out in the CO_2 protocol to define baseline emissions and make them public;
② Develop a climate change mitigation strategy and publish targets and progress;
③ Report annually on CO_2 emissions in line with the protocol;
④ Participate in the Getting the Numbers Right (GNR) global cement CO_2 and energy information database;
⑤ Contribute agreed datasets to the GNR database.

CSI is an important international business platform for Chinese companies as it offers opportunities to learn from internationally and commonly applied methodologies and approaches as well as to bring China-specific experience into the debate. With the support from international groups participating in the CSI, joint workshops and training sessions are organized in China to develop the knowledge and know-how about sustainable production practices. For instance, CRC and Lafarge held training on health and safety - an issue becoming increasingly important for Chinese companies. Joint workshop on co-processing and alternative fuels in cement kilns was also organized and hosted by Holcim and Chinese cement companies.

Source: The Cement Sustainability Initiative (CSI),WBCSD, 2011.

3.3.3 Policy relevance and lessons for China

For China, green transformation is about learning from mistakes of the unsustainable development model as well as searching for a new development model that both internalises and creates economic, social and environmental benefits. Consequently, the important policy lessons for China from international experiences in structural transformation can be summarised as the follows:

(1) The role of the market in allocating resources is essential for the most efficient utilisation of resources; at the same time, the government also plays a crucial role in creating the favourable market conditions. Green transformation needs to be based on a "dual driving force"– neither the government nor the market force alone, can drive the green transformation;

(2) Green industry transformation and upgrading is the key pillar of a green economy. A green industry policy should be formulated in accordance to the macro-economic environment in order to promote the greening of industrial structure. In particular, economic policy instruments (e.g. financial support and tax incentives) should be fully utilised to promote (and accelerate) industrial structural adjustment;

(3) Science, technology and innovation are the most important driver for inter- and intra-sectoral green transformation and upgrading;

(4) The shift of backward production capacities and industries to less developed or developing countries through outward foreign direct investment and international trade has been an integral component of the structural transformation in advanced industrialised economies. It is imperative that China does not repeat the mistakes of industrialised countries where the "greening" of economy relied largely on the outsourcing of "brown" and polluting industries to less developed countries.

3.4 Enabling Conditions: China-Specific Challenges and Opportunities

3.4.1 Basic conditions for green transformation and development

Drawing on both China's success and failure in the ongoing transformation process as well as international experiences, some basic conditions, i.e. the necessary policy and market conditions required for a successful transformation in the near future, are identified as follows:

(1) Leadership and strategic planning by the government as the political foundation for a green transformation and leapfrogging:

1) A “beyond-GDP” mentality, not only at the national but also the regional and local level policy-making and governance;

2) Make structural transformation and institutional innovations new drivers for green development;

3) Mainstreaming green development into an integrated policy-making framework, in the fields of macroeconomic, regional, industrial, environmental and innovation policies;

4) Manage the transitional and adjustment costs of greening the economy, including employment and social consequences, with a particular focus on the most vulnerable groups and in the traditional “black” and “brown” sectors.

(2) The right positioning of the government and the appropriate role played by the government in the green transformation:

1) Avoid direct intervention in economic development and business activities; instead, focus should be on strengthening the responsibility of the government in providing public services;

2) Avoid excessive intervention (in pricing, resource allocation and competition) that impedes green transformation; instead, priority should be given to setting an appropriate regulatory framework, sending out clear price signals and establishing an effective incentive structure;

3) Avoid replacing the role of the business sector in investment and innovation; instead, focus should be given to creating and supporting an enterprise-centred green transformation process. Private-public partnerships should be established to promote technology innovation, development and diffusion –a concerted effort is needed when price signals and market forces alone are not enough.

(3) A well-functioning market as a driver for innovation and sustainability:

1) Enterprises are the main drivers and implementers in the enterprise-centred green innovation system and transformation process. In particular, the development of innovation-based SMEs should be emphasised and encouraged as a key driver for an enhanced innovation capacity and a new market dynamics in China’s green economy;

2) “Right” pricing mechanisms for resources and environmental assets need to be established, to reflect both the scarcity and the polluter pays principle. Innovative market mechanisms, such as emission trading and eco-compensation schemes should be introduced, based on well-defined environmental and natural resources-related property rights, such as exploration rights, mining rights and various emission rights/permits;

3) The development of financial sector to both raise the efficiency and quality of capital-input by leveraging green investment from the private sector and stimulating

efficiency improvement through better financing models/mechanisms for green innovation and entrepreneurship;

4) Combine supply-side with demand-side management to maximise the efficiency and benefits of green production and consumption. Consumers should be encouraged to shift towards and benefit from a greener lifestyle and consumption pattern.

3.4.2 Key challenges and barriers faced by China in the green transformation

Despite the progress made so far, China will inevitably face daunting challenges in the transformation towards a green economy. These challenges and barriers are associated with a complex mix of factors, such as the rapid economic growth, the structural characteristics, institutional and regulatory barriers as well as external pressure resulting from globalisation.

3.4.2.1 Institutional barriers and "green governance paradox"

The "dislocated" and "excessive" role of the government in the market, is still an important source of structural imbalance, market distortion and inefficiency, which will need to be adjusted and corrected. Typical examples are the capital market distortion that led to the persistent overinvestment problem and the rapid development of capital-intensive industries in China; and factor price distortion in the form of various energy price subsidies. As many leading energy policy analysts pointed out, energy price subsidies are inefficient use of public financial resources and also send out the wrong price signals. As a result, they not only act as disincentives to energy saving and efficiency efforts, but also make little sense in terms of adjusting income distribution.[14] On the other hand, the government's role in market supervision needs to be strengthened, particularly in relation to the control of natural resource exploration, pollution and emission and food safety, where current government supervision is inadequate or even completely absent.

To overcome the GDP obsession and to prevent a "green rush" especially at the regional and the local levels, the "green governance paradox" needs to be addressed (see Figure 3-3).[15]

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14 Source: Zhou Dadi "How can the energy price reform be carried out in China?", World Energy and Finance Net (WEFN),5 September, 2008. http://www.wefweb.com/news/200895/0809291137_0.shtml.

15 For more detailed discussions, see ANUE E Press (eds.) China: *The next twenty years of reform and development.* Canberra, Australia, 2010, pp53-72. http://epress.anu.edu.au/china_20_citation.html.

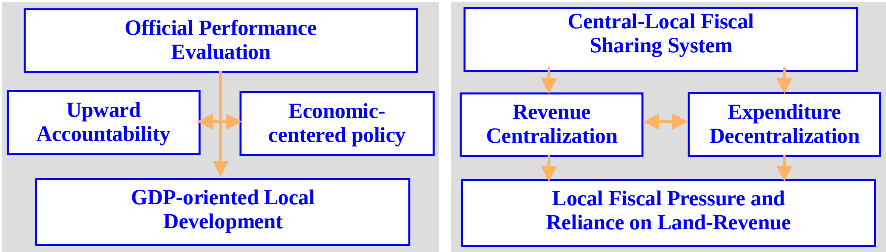

Figure 3-3 The green governance paradox

Source: Qi Ye, "Institutional building for low-carbon cities: balancing development and environment", 2008 AWI Climate Change Workshop, Beijing, 27-29 April, 2008.

The current fiscal revenue sharing arrangement between the central and local government creates strong incentives for regional governments to seek higher GDP growth. It also led to insufficient expenditure on social and public spending at the local level, in particular in less developed regions. On the other hand, it caused local governments to blindly expand local production and investments in order to increase their revenues through a range of local taxes, such as development, contract, and land occupation taxes. This is partly the reason why many of the recently documented environmental disasters and land acquisition abuse cases involved businesses and investments directly affiliated to local governments. Therefore, the "incentive and fiscal asymmetry" problems as well as the vicious cycle of unsustainable development, poor environmental and social performance in less developed regions need to be addressed urgently.

3.4.2.2 Weakness in legislation, regulation as well as coordination and enforcement

To facilitate China's green transformation, an integrated legislative framework and governance structure should evolve to enhance implementation and coordination across government entities and between different levels of government, as well as between the government and the populace. For instance, large-scale technology development and diffusion and green investments in infrastructure and public services cannot possibly be driven and managed by stand-alone agencies. Instead, it requires a specific policy mix, a rare degree of coordination among ministries and an exceptional level of openness and creativity in private-public partnership. However, the following key weaknesses in legislative and regulatory policy tools need to be addressed to enhance enforcement and coordination.

(1) Legislation and regulation: ① There are already a considerable number of laws and regulations related to the development of a green economy. However, they are currently

relatively fragmented and an integrated legislative framework for the green economy is lacking; ② Many of the laws and regulations lack operative values and can hardly provide support for promoting green economy in practice; ③ Due to the problems of local protectionism and various conflicts of interests, weak coordination and implementation will hamper China's green transformation.

(2) The fiscal inputs for promoting green economy: In addition to the low level of investment in environmental protection (especially in comparison to the magnitude of the problems), the structure of environmental investments needs to be improved. Investment in urban environment infrastructure facilities, despite being the main component of environmental investments, does not necessarily have a strong linkage with the improvement in the overall environmental standard in China. On the other hand, the increase in the investment in treatment of industrial pollution has been moderate. This is not compatible with the corresponding need for such investments in the industrial sector and the need to accelerate the process of greening energy- and pollution-intensive industries. The government needs to increase its support not only through subsidies, but also stimulating industries to move away from the end-of-pipe approach towards the "reduction at source" measures, which are more environmental friendly and cost-efficient.

(3) Environmental tax system: A profound but gradual "green tax reform" needs to be a key element in China's green transformation under the "12th Five-Year Plan". Currently, China lacks a genuine "environmental tax base" that can help establish various market mechanisms for accelerating and deepening energy-saving and emissions reduction actions.

(4) Finance mechanisms: China has recently become a global leader in "green investments". This achievement, however, is largely driven by government support. This raises serious concerns about the sustainability of such development in the long run. There is a large amount of private capital available in the Chinese capital market; however, the challenge is how to channel private capital to green investments and green sectors. The key is to make green investments more attractive and profitable than the "conventional" investments, which impose large ecological footprints and environmental impacts.

3.4.2.3 Increasing influence comes with greater responsibility – international pressure

As China continues to be the engine for global economic recovery and future economic growth, both the expectations and scrutiny on China from the international community are also increasing. In other words, China's increasing influence comes with greater responsibility.

(1) “Green protectionism” – a key challenge for China in its deepened integration in the globalised economy. The transition towards a green economy requires that trade and investment are not only open, but also green and fair. How to balance between green trade and investment with “green protectionism” will be a common political and economic challenge for China and other main industrialised economies. At the same time, this should also be seen as a positive pressure on China to upgrade its technological and environmental standards and to move away from the “race to the bottom” trend. Winning the “green race” will bring China long-term economic and social benefits, and avoid the high price of environmental and ecological degradation.

(2) China’s trade and Foreign Direct Investment (FDI) structure has led to an “environment deficit”, as a result of energy- and resource-intensive processing based exports as well as FDI in heavily polluting and energy-intensive sectors.

(3) International climate change policies and actions impose pressure on China. China’s high-level energy demand and heavy reliance on fossil fuels have made it the world’s largest CO_2 emitter. Therefore, energy-saving and emissions reduction are not only important for China’s green transformation, but also for China’s international image and long-term competitiveness. Instead of having a defensive mind-set and regarding these issues as a threat to China’s continued economic growth, embarking on a transition to a green and low-carbon economy will provide the opportunity for China to engage as a constructive and active partner in dealing with these globally shared concerns.

3.4.3 Favourable conditions for and new growth opportunities in China’s green transformation

The most important favourable conditions and powerful drivers that can turn barriers into opportunities in China’s green transformation are strong political commitment, the considerable fiscal capacity to support green investments, the sheer market size and China’s emerging ambition as a “green innovation hub”.

3.4.3.1 Political commitment – the core driving force for green transformation

(1) A green strategic framework – the “12th Five-Year Plan”

“Green development” has become one of the most important strategic policy themes in the “12th Five-Year Plan”, which aims to accelerate the structural transformation of China’s growth pattern to achieve an inclusive, green and competitive economy. In terms of policy and market signals, a total of 24 guiding (non-binding) and binding targets have been outlined in the "12th Five-Year Plan". Key targets related to an inclusive, green and competitive economy are presented in Table 3-1.

Table 3-1 Selected targets in the "12th Five-Year Plan" (by 2015)

Target	Specification*	
Growth- and structure-related	① Annual average GDP growth of 7%. ② Service sector value-added to reach 47% of GDP (up by 4% points). ③ Urbanisation rate to reach 51.5% (up by 4% points).	Guiding
Energy-, climate- and environment related	① Energy consumption per unit GDP reduced by 16%. Carbon emission per unit GDP reduced by 17%. ② Non-fossil energy as a proportion of primary energy consumption to reach 11.4% (from the current 8.3%) ③ Water consumption per unit of value-added industrial output reduced by 30%. ④ SO_2 and COD emissions reduced by an additional 8% (these were reduced by 14.3% and 12.5% respectively during the "11th Five-Year Plan"). ⑤ NO_x and ammonia nitrogen emissions reduced by 10%. ⑥ Heavy metal from industry will also be regulated although no specific target is given yet. ⑦ Forest coverage to reach 21.66% of the landmass and forest stock to be increased by 600 million m^3. ⑧ Arable land to be maintained at 1.8 billion acres.	Binding
Competitiveness related	Percentage of R&D expenditure of GDP to reach 2.2% (from the current 1.8%).	Guiding
Inclusiveness related	① More than 45 million jobs to be created. ② Urban registered unemployment to fall below 5% 2015.	Guiding

Source: The Outline of the "12th Five-Year Plan" for National Economic and Social Development 2011—2015 (in Chinese). State Council, March 2011. *Base year for the targets in the "12th Five-Year Plan" period is the end of the "11th Five-Year Plan", i.e. by the end of 2010.

In terms of sector-specific targets in the "12th Five-Year Plan", the details are presented in Table 3-2.

Table 3-2 Sectoral strategies to promote green development in the “12th Five-Year Plan”

Sector	Selected key priorities
Agriculture	① Develop a “modernised” agriculture where food security is of the highest priority. Structural adjustment and improvement to achieve high output, good quality, high efficiency, ecological friendly and safe products. ② Increase the income and living standards of the agriculture population.
Industry	① Upgrade traditional manufacturing sectors in terms of technological and innovation capacity, energy efficiency and environmental performance as well as industrial structure and regional distribution, and the development of SMEs. ② Foster and develop “emerging and strategic sectors”, i.e. Energy saving and environment protection, next generation information and telecommunication technology (ICT), internet of things (物联网), Alternative energy, biotechnology, high-end and advanced equipment manufacturing, new materials and clean energy vehicles. These emerging and strategic sectors are expected to account for 8% of China’s GDP by 2015.
Service	① Accelerate the development of manufacturing related service sectors, e.g. financial service, logistics and ICT-related high-tech services. ② Accelerate the development of services in the commercial and tourism sectors. ③ Improve the policy framework for supporting service sector in the fields of energy and water pricing, taxation, and public procurement.

Source: The Outline of the “12th Five-Year Plan” for National Economic and Social Development 2011—2015 (in Chinese). State Council, March 2011.

(2) Broadened and deepened actions for energy saving and emissions reduction

In the “11th Five-Year Plan”, binding energy-saving and emissions reduction targets were included in the national economic and social development strategies for the first time. In the “12th Five-Year Plan”, China faces more arduous tasks and daunting challenges, which at the same time also present strategic opportunities for transformation.

In relation to energy-saving and emissions reduction, the guideline advocates an integrated approach to achieve China’s more ambitious environmental targets – the government provides a guiding role; enterprises act as key implementers; market-mechanisms act as effective drivers and, strong support from the society/the public through broad participation. In the recently released “*Comprehensive Energy-Saving and Emissions Reduction Work Programme for the* “12th Five-Year Plan” (State Council, 2011), a total of 50 policy measures were specified, covering 12 different policy fields.

Box 3-3 Eight key areas of energy-saving and emissions reduction in the "12th Five-Year Plan"

① Control the total volume of energy consumption. Energy-saving assessment in the approval of fixed assets investment projects should be used as a key instrument to control total energy consumption at the regional level.

② Strengthen energy management of major energy-consuming entities, especially entities with an annual energy consumption above 10,000 tonne sce, and to introduce the "Top 10,000 Energy-Saving and Low-Carbon Enterprises Programme".

③ To further strengthen industrial energy-saving and emissions reduction. Key sectors include: power generation, coal mining, steel, non-ferrous metals, petroleum, petrochemical, chemical, building material, paper and pulp, textile, printing and dyeing, and food processing.

④ Promote energy-saving in buildings. Develop and implement a Green Building Action Plan, covering all areas of decision-making – (city) planning, regulations, technology, standards and design.

⑤ Promote energy-saving and emissions reduction in the transport sector. Intensify the development of public transport in cities, carry out special low-carbon transport programmes and accelerate the elimination of outdated transport modes.

⑥ Promote energy-saving in the agricultural sector and in countryside, with a strong focus on the treatment of non-point source pollution, integrated rural environmental management and implementation of agricultural clean production programmes.

⑦ Promote commercial and residential energy-saving. Implement energy–saving and emissions reduction in the business (such as retail) and tourism sectors. Promote the use of energy efficient appliances and lighting products, and encourage the purchase of environmental friendly and energy-saving vehicles by households. Reduce the use of disposal products and excessive packaging.

⑧ Strengthen public sector energy-saving and emissions reduction. Stricter building codes should apply to new buildings and retrofitting of public office buildings for energy-saving should be accelerated.

Source: Comprehensive Energy-Saving and Emissions Reduction Work Programme for the "12th Five-Year Plan" (in Chinese), State Council, 2011.

(3) A comprehensive policy framework for green innovation capacity building

The strategic focus on and planning for the emerging and strategic industries will have profound implications for the development of China's green economy – not only for the development of new industries, but also for the modernisation of traditional industries. In this context, green innovation capacity building will be of great strategic importance, and is simultaneously driven by market, institutional and regulatory factors. China is on the way to create a well thought out "green technology and innovation strategy" (see Figure 3-4).

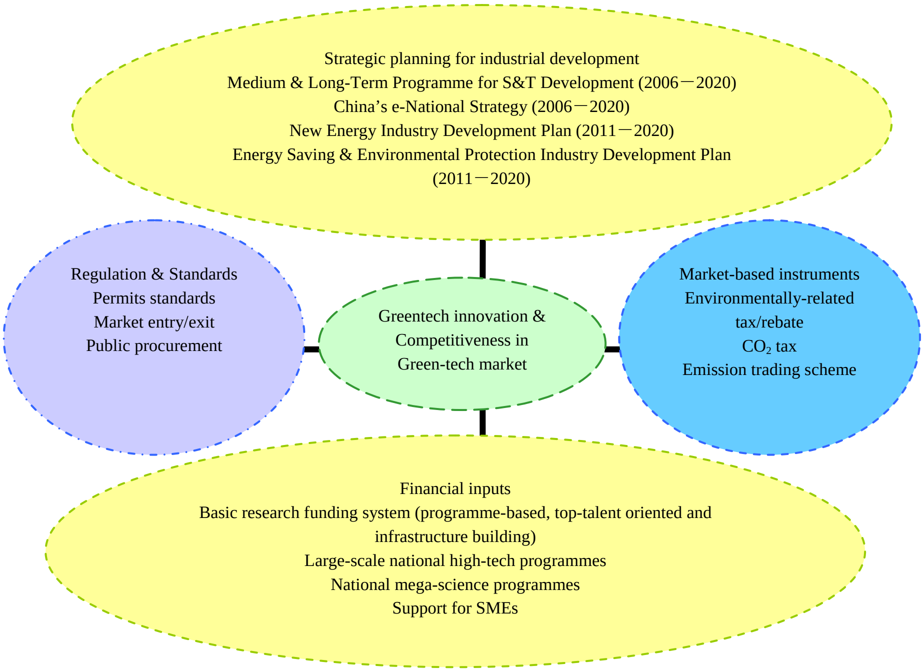

Figure 3-4　Supporting framework for China's green technology and innovation

(4) The macro environmental protection strategies

Despite progress made in the past decade, in particular in the "11th Five-Year Plan", the overall environmental situation as summarised in the Macro Strategic Study on China's Environment (Chinese Academy of Engineering and Ministry of Environmental Protection, 2010) was: "partial improvement although overall degradation is still continuing; the situation remains grave and pressure continues to increase".

Faced with the daunting challenges, the objectives of China's ongoing environmental transformation are straightforward: to close the implementation and enforcement gaps and to create a new pathway to environmental protection,which is cost-efficient, economically viable/beneficial, low-emission and sustainable. The key elements of the framework for the new environmental protection pathway include:

1) To develop a strategic environmental system that fits China's conditions
2) To set up an overall defense system for pollution prevention and control
3) To set up an effective environmental governance system
4) To improve environmental policies, regulations and standards

5) To build a full-fledged environmental management system

6) To create a system for public participation in environmental protection

Box 3-4 China's environment macro strategy

Overall objectives:

Environmental protection should focus on overall improvement of national environmental quality and integrity/stability of ecosystems, promoting coordinated development of environmental protection and socio-economic development, strengthening the capacity of sustainable development, providing people with clean water, air and safe food, ensuring a sound environment for people to live in, ensuring public health, and realising environmental quality objectives that are compatible with a strong modern socialist country.

Phased objectives (2020 —2050)

① Two "effectiveness" by 2020: Effective control of major pollutants discharge and effective safeguard of environmental security.

② Two "comprehensiveness" by 2030: Comprehensive control of total discharge of pollutants and comprehensive improvement of environmental quality.

③ Two "compatibility" by 2050: Environmental quality compatible with people's increasing living standard and with the status of a strong modern socialist society.

Source: Chinese Academy of Engineering and Ministry of Environmental Protection, 2010.

3.4.3.2 Considerable fiscal capacity to support and leverage green investments

According to official statistics, a total of 215.1 billion RMB from the central budget were allocated to energy saving and emission reduction actions and to phasing out backward production capacity under the "11th Five-Year Plan". This in turn leveraged 1.6 trillion RMB worth of investment from the private sector. The total investment in the treatment of environmental pollution increased by an annual average growth rate of 15% since 2000, and the share of environmental investment in GDP reached 1.33% by 2009. The total amount of government investment will continue to increase in the "12th Five-Year Plan" period[16].

In the field of renewable energy, China has already become an investment powerhouse. With its investments up by more than 50% and reaching $34.6 billion, China led the world in renewable energy investment for the first time in 2009. According to estimates made by the Pew Charitable Trusts, China will remain the top destination for renewable energy investment over the next decade. As China strengthens and deepens its clean energy policy in the future, it could attract as much as $620 billion by 2020, which is by far the highest

16 For more details, see State Council, 5 March 2011, *Report on the work of the government.* http://online.wsj.com/public/resources/documents/2011NPCWorkReportEng.pdf.

among G-20 member countries.[17]

Under the fiscal stimulus plan introduced in 2009, a large amount of spending was allocated for investments in energy efficient buildings, renewable energy, rail transportation and electric vehicles. This provided a strong basis for a greener infrastructure and urbanisation process as well as for scaling up and diffusing green technologies and innovations. The Chinese energy-saving and emission reduction sector is also expected to grow by 15%—20% during the "12th Five-Year Plan" period and China aspires to become the largest market for energy saving and emission reduction technologies and services.

3.4.3.3 An emerging global "green innovation hub"

In terms of international knowledge and know-how transfer, the market size, manufacturing capacity, and increasingly also the local innovation environment and infrastructure have made China an attractive destination for patent filing and know-how transfer. China thus has a unique opportunity, not only to green the Chinese economy but also to accelerate the global green transformation – from being a fast follower to a scale-up enabler and green innovation leader.

Despite the fact that China did not actually meet its R&D expenditure target, i.e. 2% of GDP, it nonetheless accounted for 12% of global R&D expenditure in 2010.[18] In recent years, considerable research efforts have gone toward environmental innovation in China and the rate of growth of patented environmental inventions has been remarkable (see Figure3-5). Furthermore, China has already become the most important recipient among emerging economies of patent applications from OECD countries in the fields of solar PV and wind power. Moreover, for multinational R&D centres, China's market size creates favourable conditions for the acceleration of R&D, small-scale testing, large-scale demonstration and real-life modelling of various green technologies. While the global dimension in China's overall national innovation system still needs to be further developed, the existing global green innovation networks in China are an important stepping-stone, leading to an accelerated pace and a broader international perspective in the green transformation and modernisation. Finally, the issue of Intellectual Property Rights (IPR) has increasingly become an important political agenda in international technology transfer and collaboration. It is now widely accepted that in order to facilitate global knowledge sourcing

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17 For more details, see The Pew Charitable Trusts. March, 2010. *Who's wining the clean energy race?* http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global_warming/G-20%20Report.pdf.

18 See e.g. Gordon Orr, *Unleashing innovation in China*, McKinsey & Company, January 2011. https://www.mckinseyquarterly.com/PDFDownload.aspx?ar=2725.

and sharing, a more inclusive and effective IPR regime, e.g. "protect-and-share" is needed to establish new multidisciplinary and private-public partnership based knowledge transfer initiatives. An increasingly globalised research environment, with strong science-industry linkage, can provide China with a pragmatic and creative platform. This will open up a window of opportunity for developing new approaches and models for innovation and technology development and diffusion that can address global challenges as well as strengthen partnership and competitiveness.

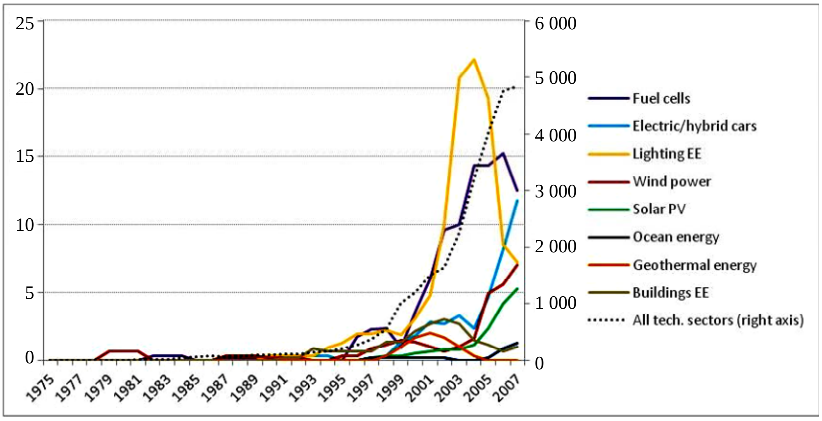

Figure 3-5 High-value patents in China climate: mitigation technologies[19]

(Counts measured in terms of "claimed priorities" worldwide)

Source: Data provided by the OECD, 2011.

3.4.4 Cost-benefit analysis of the green industry transformation

China's green development requires a significant amount of investments and extensive technological supports. As the industrial sector is currently the largest energy user and the most polluting (including GHG emissions) sector, a green industrial development will also have a considerable impact on China's socio-economic development. A quantitative cost-benefit analysis on the green transformation of China's industrial sector has been carried out (see Table 3-3). The bottom line is that, despite the short- and medium-term costs, the long-term economic, environmental and social benefits will be the most important incentive for China to pursue a green development.

19 For a detailed methodology discussion, see http://www.oecd.org/officialdocuments/publicdisplay documentpdf/?cote=ENV/EPOC/WPNEP(2009)1/FINAL&docLanguage=En.

Table 3-3 The green transformation of China's industrial sector -A cost-benefit analysis (RMB)[20]

Costs	12th FYP	13th FYP
Energy-saving & environment protection investments	5.77 trillion	6.83 trillion
Job losses in energy- and emission-intensive sectors	952 100 (head count)	2.9 million
Potential macroeconomic loss	More than 100 billion	
Compensation to adversely affected poor population	Depending on scope and strength of polices	
Benefits	**12th Five-Year Plan**	**13th Five-Year Plan**
Lower energy cost	1.43 trillion	5.47 trillion
Development of energy-saving & environmental protection industries	Total output: 6.35 trillion Increased GDP 8.08 trillion	Total output: 7.51 trillion Increased GDP 9.56 trillion
Green jobs created	10.6 million	12.5 million
Positive health effects/ avoided negative health impact	more than 1% of GDP	
Avoided technological lock-in and improved trade condition and environment	qualitative analysis	

3.5 Strategic Framework and Indicator System

3.5.1 Strategic framework –conceptual rationale and framework design

The development strategy for China's green economy involves setting development priorities, defining key tasks as well as establishing a supporting (and enabling) system (see Figure 3-6). The strategic framework follows a "three-tier structure":

3.5.1.1 Tier 1: "Objectives" level

(1) Two key strategies:

1) Transformation of the growth model and the role of the government, with an emphasis on the "labour division" and the need for partnership between the public and the private sectors;

2) Innovation in terms of technology as well as institutional governance structure and policy mix.

(2) Two key objectives: Overcoming resource and environmental constraints and improving people's livelihood.

20 The estimates are produced by the Institute of Industrial Economics, Chinese Academy pf Social Science (CASS) which is one of the research teams of the CCICED, Green Economy Taskforce.

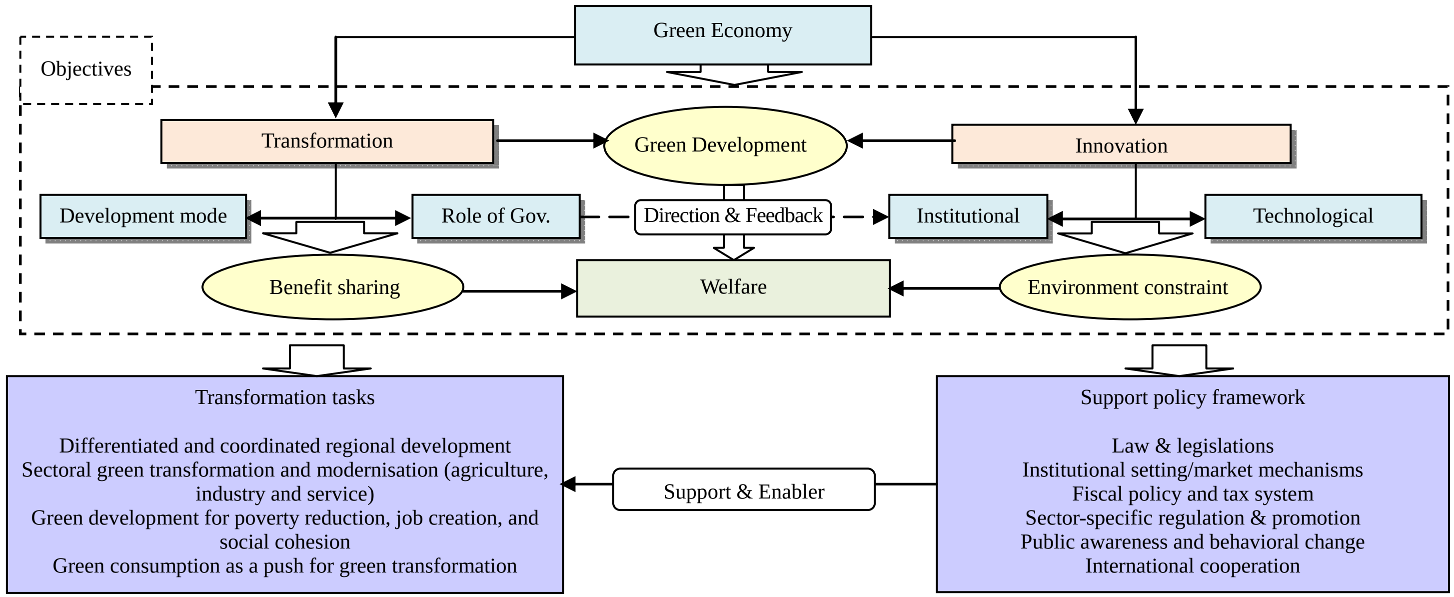

Figure 3-6 Strategic framework of China's green development

3.5.1.2 Tier 2: "key tasks" level

The key tasks cover the main strategic directions of China's green economy, such as

(1) Inter-sector structural adjustment

(2) Intra-sectoral adjustment and modernisation

(3) Coordinated regional development

(4) Domestic demand-driven economic development

(5) Social development for a harmonious society

(6) Innovation capacity development for enhanced competitiveness

3.5.1.3 Tier 3: "supporting (and enabling) system" level

The supporting system consists of the necessary institutional setting, governance structure, regulatory and policy mix that enable key tasks to be implemented and achieved, such as:

(1) Law & legislations

(2) Institutional setting/market mechanisms

(3) Fiscal policy and tax system

(4) Sector-specific regulation & promotion

(5) Public awareness and behavioural change

(6) International cooperation

3.5.2 Measuring the green transformation process – the indicator system

The new conceptualisation of green economy as well as the new strategies for developing a green economy require appropriate and adequate information and comparable data for monitoring and policy-making purposes. However, in both academic research and more practically oriented policy work, the indicator system for measuring the green transformation process is still in the early stages of "learning-by-doing" and "learning- by-debating".

The OECD green growth indicators and two domestic examples of regional and city-level sustainable development monitoring are presented. The objectives are to illustrate the key elements and policy implications of the ongoing work on green economy related indicator systems.

3.5.2.1 OECD green growth indicators

The OECD framework for monitoring progress towards green growth explores four inter-related groups of indicators, reflecting a holistic and an integrated view on the key drivers and foundation of a green growth (see Box 3-5). The work to date suggests that environmental and resource productivity has risen. However, improved environmental productivity is not necessarily accompanied by an absolute decrease in environmental pressure or the sustainable use of some natural assets.

Box 3-5 Monitoring progress towards green growth – OECD indicators

1 The environmental and resource productivity of the economy	• Carbon and energy productivity • Resource productivity: materials, nutrients, water • Multi-factor productivity
2 The natural asset base	• Renewable stocks: water, forest, fish resources • Non-renewable stocks: mineral resources • Biodiversity and ecosystems
3 The environmental dimension of quality of life	• Environmental health and risks • Environmental services and amenities
4 Economic opportunities and policy responses	• Technology and innovation • Environmental goods & services • International financial flows • Prices and transfers • Skills and training • Regulations and management approaches
Socio-economic context and characteristics of growth	• Economic growth and structure • Productivity and trade • Labour markets, education and income • Socio-demographic patterns

Source: "Towards green growth- A summary for policy makers", OECD, 2011.

3.5.2.2 Regionalised performance assessment system

Taking into account the large regional diversity and following the "main functional zones" strategy, a new differentiated and regionalised performance assessment system has been launched by the State Council (see Table 3-4). In the context of the "green governance paradox", this new performance assessment system is an encouraging step towards removing the GDP obsession and achieving effective implementation of green regional development that takes into account regional characteristics and potentials.

3.5.2.3 Urban sustainability index

As a result of rapid urbanisation, there are serious concerns about resource use efficiency and environmental quality for current and future green transformation. The Urban Sustainability Index was developed to provide a snapshot of the status of cities in terms of sustainability performance along side with economic development, using indicators that are readily available in and relevant for China (and other emerging and developing economies).

Table 3-4 Functional zones performance evaluation system

Functional Zone	Key focus areas	Key assessment indicators	Assessment indicators de-prioritised or downgraded
Optimized Development	Transformation of economic development mode	① Share of service sector, new and high-tech industry in total value-added ② Share of R&D in total output ③ Per unit output water and energy use, key emissions and CO_2 emission ④ Reduction of total volume of key emissions ⑤ Water and air quality ⑥ Absorption of migrant labour	①GDP growth ②Investment growth ③Export growth
Key Development	Industrialisation and urbanisation Integrated performance assessment, taking into account: ① Economic development ② Absorption of migrant labour ③ Quality and efficiency of economic development ④ Economic and industrial structure ⑤ Resource utilisation ⑥ Environmental protection ⑦ Public service provision to migrant labour	① GDP growth ② Employment of non-agricultural population ③ Fiscal revenue as a share of GDP ④ Per unit output water and energy use, key emissions and CO_2 emission ⑤Reduction of total volume of key emissions ⑥Water and air quality ⑦Absorption of migrant labour	①Growth rate of investment In the Western and Central regions: ②Growth rate of FDI ③Growth rate of export
Restricted Development	① Agricultural production security ② Ecological protection	① Production capacity ② Income of farmers ③ Water and air quality ④ Recovery and treatment rate of land degradation and desertification ⑤ Forestry coverage rate ⑥ Biodiversity	① GRP growth ② Investment growth ③ Industrial output ④ Local fiscal revenue ⑤ Urbanisation rate
Prohibited Development	Specific to protected areas and objectives	Zone-emission of pollutants	Revenues from tourism and other economic indicators

Source: The guideline and strategies for the implementation of main functional zones in the “12th Five-Year Plan” (in Chinese), State Council, 2011.

Box 3-6 Urban sustainable index

Categories	Definition	Indicators	Description of the indicators
Basic needs	▪ Access to safe water. living conditions, education and health services	▪ Water supply ▪ Housing ▪ Health ▪ Education	▪ Water access rate (%) ▪ Living space (sq.m per capita) ▪ Doctors per capita ▪ Student teacher ratio (primary school)
Resource efficiency	▪ Efficient use of energy. power and water. waste recycling	▪ Power ▪ Water demand ▪ Waste recycling ▪ %GDP from heavy industry	▪ Total electricity consumption (kwh per GDP) ▪ Water consumption (Liters per capita) ▪ Rate of industrial waste recycled and utilized (%) ▪ Heavy industry GDP/Total GDP (bln RMB)
Environmental cleanliness	▪ Clean air and water ▪ Waste management	▪ Air pollution ▪ Industrial pollution ▪ Waste water treatment ▪ Waste management	▪ Concentration of SO_x, NO_x, PM_{10} (mg/cu.m) ▪ Industrial SO_2 discharged per GDP (T/RMB) ▪ Wastewater treatment rate (%) ▪ Domestic waste collected &transported (10,000 T per capita)
Built environment	▪ Dense. transit-oriented. green. efficient design	▪ Urban density ▪ Mass transit usage ▪ Public green space ▪ Building efficiency	▪ Persons per square kilometer of urban area ▪ Passengers using public transit (bus, trolley) ▪ Public green space per capita (sq.m per capita) ▪ Buiding heating efficiency
Commitment to future sustainability	▪ Investment in human and physical assets	▪ Green jobs ▪ Investment on environmental protection	▪ # of environmental professionals per capita ▪ Amount of environmental sanitation funds per GDP

Source: "The Urban Sustainability Index: A new tool for measuring China's city". Columbia University, Tsinghua University and McKinsey & Company, 2010.

The sustainability performance of 112 cities that were earmarked in the "11th Five-Year Plan" as the focus of sustainable development efforts was assessed for the period 2004—2008, using the Urban Sustainability Index system. Key policy lessons from the sustainability performance assessment include:

(1) Most of the critical indicators that drive sustainability such as mass transit usage, waste water treatment and environmental investment were unaffected by the level of economic development.

(2) "Sustainable growers" are becoming more sustainable while also achieving above-average rates of economic growth. They are "all-rounders" who do well across many dimensions, not just on a small set of indicators.

(3) Sustainability initiatives require extensive coordination across various government agencies and functional units. "Top-level" priority and vision need to be combined with incentives that encourage cooperation and coordination among agencies.

(4) Best sustainability performing cities demonstrate not only execution and coordination capacity built on transparency and accountability, but also an unwavering focus on industrial restructuring, environmental-based planning, and use of efficient policy mix including both market-based mechanisms and regulatory measures.

3.6 Key Tasks for China's Green Transformation and Development

3.6.1 Green regional development – a differentiated approach

Given the sheer size of the Chinese economy as well as the large diversity in regional conditions, the planning of China's green economy transformation needs to go beyond the scope of macro-economy and national policy. Having recognised that there is no "one-size fits all" pathway to a green transformation and the structural drawbacks of the "one-rule for all" policy approach, China's future green development will need to rely on a differentiated and regional approach based on regional conditions and characteristics. For instance, under the "12th Five-Year Plan", the government will implement the "main functional zones" – where development priorities of the different regions are defined according to their level of economic development, ecological endowments as well as the need to protect and preserve these endowments. In short, a regionalised and differentiated approach will assist and encourage individual regions to achieve their self-sustaining endogenous development – through tapping the underutilised potentials in these regions, utilisation of appropriate market-based mechanisms, and collaboration across different levels of government.

3.6.1.1 An efficient and concentrated green urbanisation path[21]

In China, larger cities have packed a more powerful economic punch. Out of a total of 858 cities (official and unofficial) today, only 14 cities have populations above five million yet they account for 33 percent of China's total GDP in 2007. Clearly, the history, location, economies of scale, and preferential policies sanctioned by the central government (for example, Special Economic Zone status) have contributed to the success of China's larger and more populous cities, but that is not all. Three critical factors explain why larger cities have more advantageous conditions for economic success: their ability to attract talent, their ability to attract investment, and the city network effects that stimulate growth.

Now and over the next two decades, China's cities will need to surmount two inter-related challenges: firstly, the on-going unprecedented scale of urbanization and the resulting pressure on social change and resource constraints; and secondly, the need to meet the rising aspirations of Chinese leaders and citizens for a better quality of life. On the other

21 The contents of this section are based on the analysis and the draft by the experts from McKinsey & Company's Great China Office. For more details, see Jonathan Woetzel et al., *Preparing for China's Urban Billion*, McKinsey Global Institute, March 2009. http://www.mckinsey.com/mgi/publications/china_urban_billion/.

hand, these challenges also present great opportunities for China to leapfrog towards a new and more sustainable urbanization model that can serve as an inspiration to other developing metropolises.

China has yet to decide on what model of urbanisation is best for its future, and the issue is currently subject to intense public and political debate domestically. Although each urbanisation scenario presents a largely distinct set of opportunities and challenges, the two concentrated growth scenarios, i.e. super cities and hub and spoke could be the most optimal, which would induce higher productivity and efficiency in China's urbanisation process (see also Box 3-7):

(1) Highest per capita GDP — Evidence shows that scale effects and productivity gains tend to be larger in concentrated urbanization scenarios. Both concentrated urbanization scenarios would produce about 20% higher per capita GDP compared to the more dispersed urbanization scenarios.

(2) More efficient use of energy — energy productivity could be almost 20 percent higher in concentrated models of urbanization, as a result of more efficient industrial and service sectors, and higher energy efficiency in buildings and public transportation in large cities.

(3) Lowest rate of loss of arable land – more concentrated models of urbanization could reduce the loss of arable land to only 7 percent to 8 percent of the current total.

(4) More efficient mass-transit – concentrated urbanization scenarios would produce the necessary public-transport capacity with lower costs and increase the chances of successful execution. In the super-cities scenario, China would need to expand its current subway system by 8 times. But under distributed growth the light-rail system would have to grow by nearly 300 times.

(5) More effective control of pollution – although mega-cities in the super cities scenario would face extremely serious peak pollution problems (e.g. NO_x and water), enforcement of measures to regulate pollution is more widespread and effective in larger cities than in smaller cities.

This scale of China's urbanisation – along with a continuous rise in living standards – will generate enormous pressures on cities in terms of: ① land and spatial development, ② resource exhaustion and pollution, ③ skills and jobs, and ④ funding for provision of public services, including services for the migrant population. China must take steps now to ensure that this unprecedented transformation unfolds as smoothly as possible, while at the same time ensure that it seizes the new and green growth opportunities.

Box 3-7 An efficient and concentrated green urbanisation path

Rapid urbanization has yet to reach its peak in China. In little more than two decades, two-thirds of all Chinese – one billion people – will be living in the cities. Broadly speaking, China faces a choice between a dispersed and a more concentrated pattern of growth:

Two concentrated urbanisation scenarios:

① Super-cities: This represents a highly concentrated model of urbanisation with a small number of truly global mega-cities with populations of 20 million-plus.

② Hub and spoke: This model comprises of city clusters with one or two cities act as the "hub" while the neighbouring cities are "spokes", which are closely linked to the hub(s) through well-developed transportation connections and, more importantly, deep economic ties.

Two dispersed urbanisation scenarios:

① Distributed growth: This scenario envisions the continuation of today's urban growth pattern, but with a heightened emphasis on middle sized cities and underdeveloped regions. It implies an accelerated growth of a large number of cities with populations of 1.5 million to 5 million.

② Townisation: This model represents a deliberate boost of urbanisation at the grassroots level, with the parallel growth of many small cities with populations between 500,000 and 1.5 million.

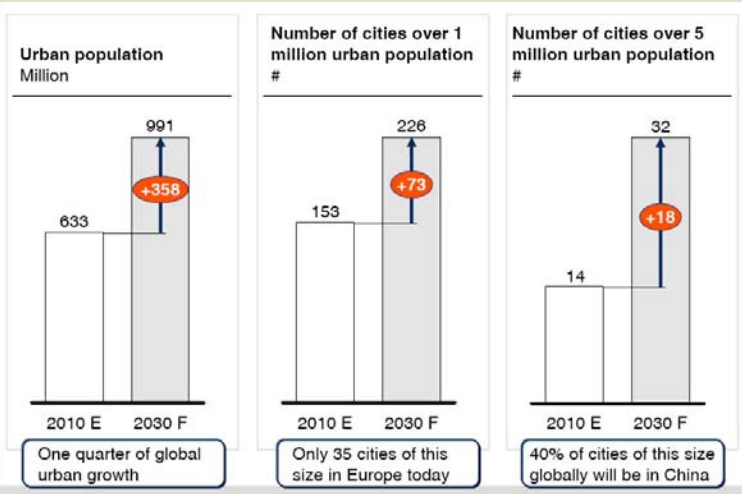

Figure 3-7 China's scale of urbanisation – in a global context

Source: "Preparing for China's Urban Billion" McKinsey Global Institute, 2009.

3.6.1.2 A sustainable industrial gradient transfer

In the midst of industrialisation and urbanisation, the industrial sector will remain the basis for China's economic growth as well as be an important source of employment for a long period of time. However, the geographical distribution/landscape of China's industrial structure and manufacturing capacity is undergoing profound shifts, which will have significant impacts on the current and future regional development. During the "11th Five-Year Plan" period, "industrial gradient transfer" from the eastern coastal region to the less-developed interior and western regions generated a second "investment wave", driven by a combination of various factors. Firstly, in recent years, the manufacturing sector in the richer regions has experienced a double-digit increase in labour costs. In addition to the cost factor, under the pressure of increasingly stringent energy and environmental protection targets and land resource constraints, the eastern coastal region is trying to limit the expansion of the "three-high" (high energy consumption, high pollution and high emissions) industries. Finally, the production shift is also part of the development and modernisation strategies of the eastern coastal region, which is facing the need to upgrade its industrial and economic structure. These factors have prompted businesses to look for new investment venues in the interior and western regions, and led to a rapid GDP growth in these regions, in particular in the heavy chemical, mining and building material sectors.

The structural shift of the "three high" industries has added complexity to the green economic development landscape in the less-developed interior and western regions. The main difficulty lies in the increasing reliance on the heavy industry, making an upward trend in energy consumption in the short term inevitable. Consequently, the gap between the pressure to save energy and reduce emissions on the one hand and rapid GDP growth on the other is becoming wider. At the same time, rapid and large-scale industrial expansion has also led to excessive investments and overcapacity building in many cases.

From an overall green development perspective, the relocation of these "three-high" industries will not solve the problem and will only exacerbate the environmental and energy problems in the western and interior regions, if it is not managed properly. As China continues to industrialise and urbanise, the "three-high" industries will most likely remain a major force of development especially in these resource-rich, but less developed regions. Consequently, the key issue for these regions is how to avoid a high-carbon and high-pollution lock-in as well as how to modernise and transform these "three-high" industries through technology innovation and breakthrough. At the same time, it is important to highlight that these regions are often rich in *both* traditional fossil fuels and renewable energy resources, and many are also in the process of modernising their industrial and agriculture sectors. Green transformation in these regions – in particular using green development to overcome the problem of resource-curse – requires creating the right incentives for the desired mode of development and to strengthen human resources and governance capacity. It is important that the up-and-coming regions do not repeat the past mistakes of the coastal region of aimless expansion of low-quality and “destructive” development.

In the process of industrial gradient transfer, coordination between the central, regional and local governments are particularly important. The ultimate objective is to achieve a coordinated regional development and to increase benefit-sharing and alleviating imbalance across regions. More specifically:

(1) Industrial gradient transfer needs to take place in a sustainable way. The key is to strengthen supervision and monitoring and to strictly enforce the related legislations and regulations. For instance, obsolete and highly polluting equipments in the eastern coastal regions must be decommissioned locally and are strictly forbidden to be transferred to less developed regions for re-use. Investment projects in the interior and western regions that do not meet the environmental standards and industrial regulations should also be strictly forbidden.

(2) The differentiated green regional development needs to be supported by fiscal transfer schemes and innovative market mechanisms. For instance, the fiscal transfer system between the national and regional governments can be adapted to facilitate the process of “differentiating” various functions and development objectives in different regions, such as developing ecological functional zones, securing food security, restructuring traditional manufacturing bases and promoting sustainable industrial gradient transfer.

(3) The development of specific green regional development strategies based on region-specific green development potentials and the need for environmental and ecological protection.

3.6.2 Green agriculture – to improve geographic and strategic planning and to safeguard food security

A green agriculture is defined as an agriculture that aims to promote food security and safety as well as ecological and resource security, relying on advanced science and technology, modern agricultural machinery and management concepts/systems. The green transformation of agriculture is a comprehensive process. Instead of solely focusing on quantity security, quality security has also become a top agenda and green agriculture will gradually become China’s leading model of a modern agriculture.

China is a large agricultural country and 60% of its population still resides in the countryside. Based on its medium and long term economic development plans, the primary sector will still account for 13% of its GDP and employ 40% of its workforce by 2020. However, China’s arable land and water resources are inadequate to support its large population: despite having 22% of the world's population, its arable and water resources only account for around 7% of the world total, representing a very low level of natural resources per capita. Beyond the resource shortage, soil quality/land productivity has also decreased because of pollution, overuse of fertilizers and pesticides and climate change.[22]

At the same time, the agricultural sector in China is currently undergoing a rapid process of industrialisation - moving from household-driven and small-scale activities to large-scale cultivation and industrial husbandry. This in turn will require a coordinated development of its industrialisation process and natural environment in order to establish mutually dependent and supportive industrial and agricultural sectors. While it is vital to seize the opportunities of efficiency gains from economies of scale and more advanced production processes, it is also important to deal with new environmental challenges. In many respects, the environmental challenges faced by the agricultural sector are increasingly similar to the challenges faced by the industrial sector. For example, while large-scale cultivation and industrial livestock farming have led to increased availability of animal and biomass wastes, inefficient organisation and the lack of large-scale utilisation technology have prevented these resources from being used as a source of renewable energy and organic fertiliser. Instead, they become a new source of waste and pollution.

Given China's limited opportunity for expanding the area under cultivation, the increase in food production in the past 30 years came largely from land use intensification based on greater irrigation, improved crop varieties and a substantial increase in the use of synthetic nitrogen fertilizer. One of the important contributing factors that have stimulated the excessive use of fertilisers is preferential policies. For a long period of time, fertiliser producers in China have been eligible for various types of subsidies, such as price rebates on electricity and gas consumption, and transport cost compensation. These subsidies lead to reduced production costs, but also spur excessive production. At the same time, the problem with fertilisers overuse is also substantial. This is due to both technology and market factors such as weak substitution between chemical fertiliser and organic fertiliser, inefficient irrigation practice, lack of agricultural insurance and low level of cultivation technology. To achieve a "win-win-win" situation – income gains for farmers, food security and reduced environmental impact – through the reduction of nitrogen fertiliser overuse, it would require better information and technical support to the farmers as well as institutional changes to correct the existing "market and policy failures".

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22 For a more detailed overview, see CAS 2009. *China sustainable development strategy report 2009-China's approach towards a low carbon future*, Beijing, May 2009.

In this context, the key tasks for the green agriculture transformation include:

(1) Rationalise industrial planning and set clear development priority. The geographical distribution of green agriculture production and nomination of key agricultural products need to be determined based on the specific characteristics of regional ecology, local production conditions and the comparative advantage of agricultural products.

(2) Strengthen the development of green agriculture bases and promote sustainable industrialisation of the agriculture sector. Technological capacity and supervision of agricultural bases should be strengthened in order to accelerate the process of innovation and modernisation, and to promote and develop leading agricultural enterprises.

(3) Strengthen non-point source pollution control and promote an integrated approach to rural/farm environment management. The current subsidy system for industrial husbandry needs to be improved in order to strengthen pollution reduction measures.

(4) Increase agricultural waste utilisation through the industrialisation of animal husbandry and farm product cultivation. Promote resource efficiency and demonstration and diffusion of environment-friendly technologies.

Finally, it is important to note that the problems of China's agriculture sector go far beyond excessive fertiliser use. The main challenges, such as post harvest crop loss, inefficient irrigation and food waste (the avoidance of which could reduce the need for increased production/pressure on land) all call for policy support and immediate actions.

3.6.3 Green transformation towards a multifaceted, innovative and open industrial sector

In the past three decades, China's industrial sector has experienced spectacular growth as a result of the continuous reform and increasing market openness. Consequently, it has made a significant contribution to China's continuous economic growth and enhanced China's international status. However, China's growth and industrialisation have relied heavily on a resource-intensive pathway, which is characterized by "high-input, high-consumption, high-pollution, low-quality, low-efficiency/profitability, and low-output". Similarly, a "pollute first, treat later" approach has been adopted when it comes to environmental protection.

The "12th Five-Year Plan" period is at a critical juncture where the green transformation of China's industrialisation faces daunting challenges and also important strategic opportunities – China is half way through its industrialization process and is in the process of upgrading its production structure and innovation capacity. On the one hand, the (continuous) expansion of its heavy industry, which resulted in resource waste, environmental degradation and structural imbalance, imposes serious constraints on China's sustainable development. China's green transformation can be built on its enhanced technological and innovation capacity as well as the achievement and deepened measures on energy-saving and emission reduction. In such a context, a green industry transformation is defined as:

"A new pathway of industrialisation that seeks to 'green' the whole industrial production process and to achieve the co-benefits of economic and environmental efficiency, guided by the principle of resource saving and environment friendliness and by the core strategy of green innovation".

Although China still faces daunting challenges in moving beyond the resource-intensive and environmentally polluting development stage, it does not mean that China is bound to repeat the conventional unsustainable industrialization pathway of developed countries. The key tasks involved in the green transformation therefore include:

(1) Promote the transformation of industrial energy consumption through improvement of the energy supply structure. The basis of a green economy transformation is to improve the efficiency in energy use and to promote the development and utilisation of renewable energy. More specifically: ① Build up a clean, stable, secure and diversified energy supply system: This should be achieved by reducing the use of fossil fuels as much as possible and by developing renewable and clean energy, such as solar, wind, biomass and nuclear power; ② Further strengthen the binding targets of energy saving and emissions reduction.

(2) Build an innovation-driven green industrial system and promote a multifaceted green structural transformation: ① Develop strategic industries, which can form the basis of a breakthrough in the green industry transformation. Further improve market entry conditions and create new business models that can develop and promote leading enterprises in these new industries; ② Explore the great potential of the "greening" of traditional "black" and "brown" sectors; ③ Develop a manufacturing-related service sector as an important "catalyst" for green industry transformation.

(3) Promote green industrial products export through the adjustment and creation of domestic and international demands. ① Encourage exporting enterprises to accelerate the process of upgrading and transformation. Exporting enterprises need to expand their production value chain, enhance the image of their brands and enlarge the scope and/or scale of their products with indigenous technologies. This will help enhance the international competitiveness of "Made in China" products. ② Continuously improve the systems of export quotas and export tax refunds. The exports of scarce resources as well as "high energy-consumption, high-pollution and high emission" products need to be strictly

controlled in order to optimise the international trade structure. ③ Apply a strategy of "import diversification": Efforts should be made to introduce advanced green technologies and core equipments.

(4) Attract foreign and domestic capital investments and participation in China's green industrial transformation. Both green technology RD&D (research, development and deployment) and the development of emerging and strategic industries require large amount of investment. In a market economy, the government should play only a guiding role and public funds should be channelled to strategic areas and core technologies, while the majority of green investments should come from private sources. Therefore, the Chinese government should provide more supporting policies to encourage the flow of private capitals into green industries. At the same time, in a globalised world, China needs to further open up its market for new green industries and service sector, and should attract foreign technology and know-how through foreign direct investment. In order to do this, China needs a more open and sophisticated green transformation-oriented investment and response system.

(5) Ensure robust implementation of the concept of green economy and the creation of a green management and social monitoring system along the whole industrial value chain. The leading/driving role of businesses and enterprises in green transformation should be emphasized and enhanced. At the same, the role of the civil society, including the general public and non-governmental organisations, should be encouraged and fully utilised, particularly in promoting the concept of green consumption and lifestyle. This will help build a more robust social monitoring system for green development and stimulate demand for green products and services. This will in turn encourage a new type of "green" production- and eco-symbiosis between enterprises, creating a complete green production management system along the whole value chain.

3.6.4 Green service sector: technology and finance services as new derivers of modernisation and growth

The role of structural adjustment, i.e. an overall structural shift from the capital-intensive and heavy industry-dependent growth to a more labour-intensive and knowledge/skill-driven economy, has been moderate under the "11th Five-Year Plan". For instance, the service sector, in terms of its share of the overall value-added in the GDP and its share in the total employment, did not meet the targets set out in the "11th Five-Year Plan". Recognising its immediate as well as long-term importance to China's economic growth, in particular in terms of job creation and improvement of life quality, the "12th Five-Year Plan" has attached a strong emphasis on the development of the service sector.

First of all, there is an urgent need to modernise the traditional service sector where the skill level and technology standards are still low, and where unsustainable practices generate serious environmental pollution and resource waste. Furthermore, there is a great potential in China's service sector because of its market size, the scope and scale of its energy and environmental challenges and its fast-growing financial market.

Some strong policy signals and policy improvements have already been introduced to stimulate the development of a modern and green service sector, with a clear focus on enhanced technology and skill contents of services delivered. For instance, under the "12th Five-Year Plan", the remit of emissions reduction is extended from SO_2 and COD to include NO_x and heavy metals; the emphasis on energy-saving is expanded from the industrial sector to the public and commercial buildings and transport sector. Furthermore, both the central and local governments will increase fiscal incentives (e.g. 2 billion RMB in 2010) for energy management and efficiency improvement.[23] A VAT reform has been proposed to make it more favourable to Energy Service Companies (ESCOs). In addition, energy-saving targets for public and commercial buildings are refined and strengthened by moving away from an intensity-based (i.e. energy consumption per unit sales) to an absolute target (i.e. energy consumption per m^2).

The role of green finance to support environmental focused activities and industries has also received more attention. Various "green credit" and "green finance" regulations and support measures were already introduced under the "11th Five-Year Plan". Policy banks, together with related ministries and government agencies, played a guiding role in supporting and encouraging commercial banks to fund environment-friendly investments and innovations. For commercial banks, green credits and green investments are increasingly seen as win-win financial products for reducing both financial and environmental risks. This development needs to be further promoted and strengthened under the "12th Five-Year Plan", where the role of enterprises, especially SMEs, is emphasised and supported.

However, as an emerging sector, technology service companies – in particular in the field of energy-saving and emissions reduction – still face various technological, institutional and market barriers. For instance, the private sector only contributed to 10%—20% of recent water infrastructure investment in China; and business models based on private-public

23 Fore more details, see e.g. The Ministry of Finance and the National Development and Reform Commission, June, 2010, "*Interim Measures on management of financial incentive funds for energy management contracting projects*" (In Chinese).

partnership, e.g. building-operation-transfer (BOT) and operation and maintenance (O&M), have produced mixed results. Unsuccessful cases were often due to barriers such as pricing issues, limited market knowledge and inadequate financing. As a result, while the number of municipal wastewater treatment plants has grown rapidly, the operational efficiency is low, often due to inefficient operational and service models. In the field of energy saving, under the "11th Five-Year Plan", energy management contract system and ESCOs have taken off although their scale is still limited. For instance, the amount of energy saved through energy management services amounted to 22.4 million tonnes of standard coal equivalent (tce) in the "11th Five-Year Plan", which accounted for only 4.5% of the total 490 million tonnes of energy saved in the same period. Financing is a principal barrier to the development of ESCOs in China – currently less than 1% of loans go to energy savings. Poor risk assessment and lack of collateral hinder banks' appetite to lend to energy service companies[24].

To overcome the barriers while at the same time explore the new growth opportunities of expanding and modernising China's service sector, the following key tasks in the green transformation have been identified:

(1) Clarify priority/key areas and accelerate the development of a modern green service system. Service sector is a key catalyst for structural adjustment and upgrading. The development of the service sector, in particular manufacturing-related services, is of strategic importance for job creation, increasing service consumption as well as for the alleviation of environmental and resources pressure. To support the green transformation of the agricultural and industrial sectors and to meet the needs of the emerging and strategic industries, the development of green finance, green logistics and the environmental protection and energy-saving service sectors need to be accelerated. By prioritising the development of a modern service, great efforts should be made to create high-quality, knowledge-based and skill-intensive jobs.

(2) Promote the "greening" of traditional service sector through improved regulations and guidance. China's traditional service sector is out-dated and disorganised, and is unable to satisfy the need of the green transformation. Better guidance and management by the government is needed to enhance the standard and quality of services delivered – specific "green transformation" programmes and standards need to be created for traditional services including commerce, catering sector and tourism.

24 For more details, see The China Greentech Initiative (Beijing), April 2011, *China Greentech report, 2011*. http://cgtr.china-greentech.com/CGTI-ChinaGreentechReport2011.pdf.

(3) Promote internationalisation of China's modern service sector through service export. As an integral part of China's international trade, service exports need to be promoted and enhanced not only to support the "going-out" strategy of China's manufacturing sector, but also to foster talents and enhance China's international competitiveness in the global technology and finance service markets.

3.6.5 Green development: poverty reduction, job creation and empowerment of women

3.6.5.1 Green development

As a result of the rapid economic growth in the past three decades, China has made significant progress in poverty alleviation and in achieving the Millennium Development Goals (MDGs). Since 1990, China has accounted for four-fifths of the global decline in the number of people living in absolute poverty. According to China's progress report for the MDGs submitted to the United Nations in 2008, China was on course to achieve all the MDGs by 2015. However, the promotion of gender equality and women empowerment on the one hand, and the reversal of environmental and resource degradation on the other by 2015 were two goals that would require additional attention and actions[25].

Despite the significant progress achieved so far, uneven regional development and increased income disparity in urban areas require continuous and enhanced actions to promote poverty reduction and social "harmony". As a result, a people-centered scientific development has become the key policy agenda to reverse the "high economic growth, slow social development" divergence. Like other emerging and developing countries, China is facing twin challenges in its green development. Higher human development, in terms of improved living standard including better access to clean water and energy as well as better health and education, needs to be achieved within the constraints of natural resources and the limits of ecosystem to avoid excessive ecological footprints (see Figure 3-8).

25 There are in total eight Millennium Development Goals: Eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases, ensure environmental sustainability and develop a global partnership for development.
For details on China's progress towards the MDGs, see http://planipolis.iiep.unesco.org/ upload/China/ China_MDG_progress_report_2008.pdf.

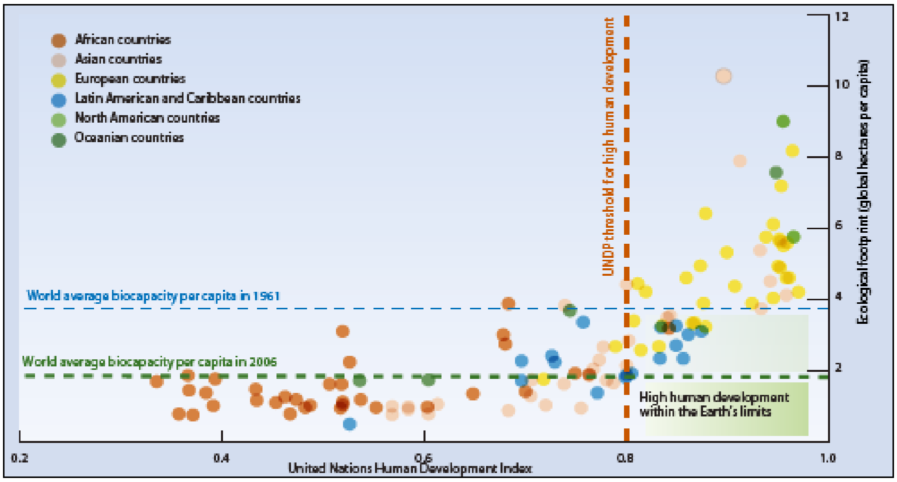

Figure 3-8 Towards a green economy: a twin challenges

Source: "Towards a Green Economy – Pathways to sustainable development and poverty eradication: A synthesis for policy makers", UNEP, 2011.

At the same time, the development dimension of the green transformation is also about various developmental "co-benefits" and new opportunities, such as cleaner energy and better health; and stronger ecosystem conservation that also generate more jobs. These co-benefits are particularly important for people living in poor and rural areas, and are crucial to achieve stronger inclusiveness.

Furthermore, poor economic conditions have led to poor public service provision in the less developed areas. The improved employment prospect and new green development opportunities will need to be accompanied by the increase in government support for public services. In China's green transformation, job creation and public service provision will likely to be the most effective vehicle for reducing poverty and stimulating social development. Therefore, the green development tasks include:

(1) Promote a job-generating green development instead of a jobless growth:

1) Promote green job creation with strong positive developmental effects in the poor and rural areas, especially in the forestry and renewable energy sectors. China is already leading the world in the implementation of ambitious reforestation and renewable energy programmes;

2) Promote labour-intensive and high-quality manufacturing jobs in the process of greening and modernising China's traditional industries and manufacturing-related service

sector;

3) Accelerate the development of new and "green" sectors, in particular the energy-saving and environmental protection sector to create both manufacturing and service jobs;

4) Enhance resource- and eco-efficiency, so that green growth, efficiency improvement and job creation are mutually reinforced and the job-generating potential of the economy as a whole is strengthened.

(2) Reduce the economic gaps and discrepancies in growth potentials between developed and less developed regions through improvement in job prospect and enhanced public service provision:

1) Attach great emphasis on an inclusive and coordinated green development and more equitable sharing of the fruits of the green development. Therefore, a more equitable provision of basic public services (including education, healthcare, public facilities and services) should be one of the ultimate objectives of the green development;

2) Attach strategic importance to people's livelihood under the green development, and implement concrete policy measures and financial support through regional policy and fiscal transfer schemes.

3.6.5.2 Green economy and women empowerment

Women's participation in economic activities in China has steadily increased in the past decades. According to recent statistics, out of China's total working population of 758 million, 337 million or 44.8% of the total were female. Women's labour market participation rate increased to 46% in 2009, although it was still 13.5% lower than their male counterparts.[26]

Poverty, which is closely related to ecosystem degradation and resource exhaustion, has a disproportionately adverse impact on women. Unfortunately, the "female face of poverty" has also become more prevailing, when the combination of climate, energy and economic crises has made the problem of poverty even more complex. For instance, workload for women in the poor rural areas has become increasingly heavier due to both energy and water shortages as they now have to spend more time and energy obtaining these basic resources. Also, due to heavy reliance on biomass fuel (e.g. wood, dung, crop residues, etc.) and bad agricultural practice, women and children in poor rural areas suffer from acute respiratory infections caused by in-door air pollution and other chronic health damages associated with

26 All-China Women's Federation (Beijing). 27 June 2010. 337 million women engaged in work 2009. http://www.womenofchina.cn/html/report/131344-1.htm.

excessive use of chemical fertilisers and pesticides. Furthermore, due to the global financial crisis, a large number of female migrant workers (who came from rural areas) in the export-oriented processing industry and service industry have been laid-off. Female university graduates experienced even greater difficulty in entering into the labour market. While economic contraction has made career development prospect for female professionals less favourable in the private sector, the large physical investment supported by the stimulus package had produced a gender-biased outcome in terms of job creation and retention, which was unfavourable to the female labour force.

Despite the current structural and social barriers, women are an important driver for change in the green transformation. As a matter of fact, women have already actively participated in and made significant contribution to the current green development. For instance:

(1) As a result of migration to the urban areas, more than 84 million male workers have left the agriculture sector. This made female workers the key remaining labour force in the agriculture sector and the participation rate of female labour force in the agricultural sector reached 60%. Capacity building and technical support for women on sustainable agriculture practice, e.g. use of fertilizer and pesticides, thus play an important role for the green agriculture transformation. According to the survey conducted by the All-China Women's Federation, more than 0.7 million female workers in the Chinese agriculture have received various forms of technical training in sustainable agriculture by 2010.

(2) Forest resource management is another area where women have played a significant role, supported by government funding programmes. For the period between 1993 and 2008, The State Forestry Administration of China has supported the development of the "Green Demonstration Base", with a specific focus on women-driven forest resource management practices. As a result, more than 11 million households engaged in large-scale economic activities in forestry recovery and fruit trees planting, with women as the driving force.

(3) Women can also lead China's green transformation through green consumption, especially in urban areas. According to a survey conducted in 2005 in 8 major Chinese cities, more than 77% of women made the key choices and decisions on the households' consumption goods (e.g. food, clothes and home appliance). The awareness of the environmental impacts of different products was already higher among the surveyed female consumers compared to the surveyed male consumers. Furthermore, female respondents also showed a stronger awareness of "green food", "green transport" and "green home

appliance".[27] This has laid a solid foundation for further promoting green consumption among Chinese consumers.

Women are the underutilised potential and new driving force for a more equitable and sustainable livelihood under the green development. Concrete and effective measures need to be put in place to encourage the participation of women in the green transformation, including:

(1) Inclusion of the gender dimension in decision-making at the institutional and policy level in the green transformation process.

(2) Provision of capacity building and technical training related to green jobs that enhances the accessibility of women. The government needs to improve women's job opportunities in the fields of environmental protection, resource management and other traditional "green" sectors (handcrafts, building and transport, etc.); in addition, it also needs to encourage and support women's participation in non-traditional sectors, in particular in new and high-tech sectors.

(3) Support for the civil society and NGOs that play a key role in the green economy transformation, with a specific focus on empowering women's status and contribution. Facilitate and support women associations to participate in green transformation policy debates and decision-making, both domestically and globally.

3.6.6 Green consumption as a "push" for green transformation

As domestic consumption fuelled by rapid income growth is expected to become the main driver of China's future economic growth, green consumption can be an effective "push" for the green transformation. Consequently, green consumer values – the conceptualisation and understanding of what a sustainable lifestyle and "green" consumption is about in both the private and the public sectors – will become even more important. From a market economic perspective, the influence of green consumption on the demand for not only green products (and services) but also the "greening" of the whole production chain will have a profound impact on resource utilisation and the environment. To accelerate the green transformation of consumption pattern will require a broad participation from and concerted efforts by both the private and the public sectors. Concrete measures that can be proposed include:

(1) The government should lead by example in green public procurement:

1) Exercise budgetary prudence in day-to-day operation and public procurement in order to increase resource saving and efficiency of resource utilisation;

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27 For more details, see China Development Brief (Beijing), 8 May 2009. Green consumption awareness survey (in Chinese). http://www.chinadevelopmentbrief.org.cn/newsview.php?id=534&page=0.

2) Set up a green procurement information network with an open and transparent monitoring system for the public.

(2) Promote the development of green production and supply chain and stimulate the development of green product and service markets.

(3) Strengthen market regulation and monitoring of green product market through a more robust green product certification system, market management and supervision, and mandatory exit system and accountability mechanisms.

(4) Carry out information dissemination and educational activities to communicate the importance of green values for both the supply and the demand sides through:

1) Mainstream news media – guiding public debates and fostering public opinion on green consumption;

2) Schools and other educational institutions – introducing and disseminating the concept of sustainable and green consumption;

3) Consumer associations, environmental NGOs and other civil society– promoting sustainable consumption and lifestyle.

3.7 Policy Measures to Support and Accelerate China's Green Transformation

An integrated and coordinated approach at all levels of government and sectors is needed to achieve a green transformation. This will require improvement in the current and introduction of new supporting system and policy measures, particularly in fostering a closer relationship or symbiosis between the government and the private sector. While further enhancement of the legal and regulatory system is needed, administrative measures alone – which suffer from ineffective enforcement and inability to induce enduring behavioural changes and long-term impact – could not solve the daunting challenges faced by China. Furthermore, investments in environmental protection in the past few years have relied disproportionately on government spending, which is increasingly insufficient in the face of the growing scope and scale of the environmental problems. Therefore, financial resources for green transformation need to be both strengthened and diversified. Against this backdrop, the key focus areas for future improvement are discussed below.

3.7.1 Improve regulatory and legal system

China's legislative and legal system has made progress in the area of environmental and ecological preservation and protection, which provides a legal basis for China's green development. For instance, the "crime against environmental protection" has been included in China's "Criminal Law". Meanwhile, various regulatory measures, such as standards for emissions, products and production have also been tightened, with specific purposes of environmental protection, emission control as well as improving industrial structure and economic growth pattern. The following supporting measures and improvement will further strengthen and accelerate the development of the legislative and legal system:

(1) Strengthen government's responsibility at all levels through the amendment of the "Environmental Protection Law" – strong emphasis should be given to regulating the government's decisions and actions affecting the environment, and enhancing the effectiveness of government's environmental oversight.

(2) Strengthen environmental civil liability by exploring the possible environmental pollution/damage compensation related laws and regulations – improving the legislative framework for the protection of environmental rights of the public.

(3) "Greening" of the legal system through coordination and harmonisation of environmental protection related legislations with others, such as the Civil Law, Commercial Law, Economic Law and Criminal Law – improving the effectiveness of the legal system in protecting China's environment.

(4) Strengthen the enforcement of green economy related legislations and regulations through enhancing law enforcement supervision system and capacity building – improvement in institutions, procedures, staff quality and standardised system of law enforcement.

3.7.2 Strengthen fiscal policy and deepen tax reforms

3.7.2.1 Substantially increase fiscal inputs to support the green transformation

(1) Establish support mechanisms that secure a stable increase in financial support for green development.

(2) Consolidate existing environment-related special funds at the central government level to increase the efficiency of fund utilisation and to avoid fragmented efforts. These existing funds need to be consolidated to create a unified large-scale green economic development special fund.

(3) Innovative fiscal measures should be introduced: In terms of the target of subsidies, it is necessary to shift from solely production- oriented subsidies towards a mixture of

production- and consumption-oriented subsidies. In terms of the type of subsidies, indirect subsidies such as interest rebates and loan guarantee should be more widely used, which can mobilise investments by other banks and the private sector.

(4) Establish multi-tier and coordinated co-finance/co-funding mechanisms with joint efforts by the national, regional and local governments. Coordination mechanisms for various policy instruments, such as tax, finance and resource pricing, should be established.

3.7.2.2 Continue to enlarge the scale and scope of green public procurement

Compared to the OECD countries where public procurement accounts for 30%—40% of total government fiscal revenue, the level of public procurement is still relatively low in China despite the rapid growth. For example, in 2008 government procurement in China reached 599 billion RMB, which accounted for 9.6% of its fiscal revenue. Given its future scale and scope for expansion, "green" public procurement has a huge potential in stimulating significant green public spending and private consumption. Further improvement of the current public procurement policy includes:

(1) Further increase the scope and share of "green" public procurement. The mandated government procurement of energy efficient products was expanded from central and provincial governments' purchases in 2005 to all government levels in 2007. By the end of 2010, green procurement covered 30 product categories and involved around 500 suppliers, which provided more than 14,000 products. However, the potential for expansion is still great.

(2) Improve government procurement budget management and increase the transparency of the procurement process.

3.7.2.3 Improve the fiscal transfer scheme to facilitate a strengthened and more "equitable" public service provision

To secure public investment in environmental protection as well as welfare provision, stable tax bases and tax revenue streams at both the national and the regional levels are required. The sharing of public finances between the central and local government needs to be determined scientifically to ensure that revenue division reflects the reality on the ground – public revenues should match the responsibility and the role of each level of government. Fiscal entitlements should also come with the corresponding fiscal accountability and responsibility to ensure the quality of public service provision. More specially, improvement in the fiscal transfer scheme involves:

(1) Institutionalise a system of "equitable" access to basic public services. Both the level and the structure of public spending need to be optimised. Priority should be given to basic public services e.g. basic medical care, education and social security benefits etc.

(2) Improve and regulate transfer payments between the central and the local government and within regions to achieve equitable access to public service provision. ① The overall level of fiscal transfer from the central to the local governments should be increased to incentivise local governments to strengthen and expand their public service provision. ② Special regional/local funds from the central government should be managed more efficiently, with a clear policy guidance as well as better monitoring and supervision system. ③ Fiscal transfer from the provincial to the local governments should be strengthened. Furthermore, local tax system needs to be improved to consolidate tax bases at the local level.

3.7.2.4 Deepen tax reforms and institutional innovations in the tax system

China's tax reform adheres to the principles of "*simplifying the tax system, broadening the tax base, lowing the tax rate and strengthening enforcement*". China's "green tax reform" essentially involves a transformation from a fee-based to a tax-based system, the introduction of new environmentally related taxes and adjustment of the design and rate of various taxes directly and indirectly related to environmental protection and energy saving (see Figure 3-9). The structural reform of the tax system aims to create an effective "green" tax base while at the same time maintain the macroeconomic "fiscal neutrality".

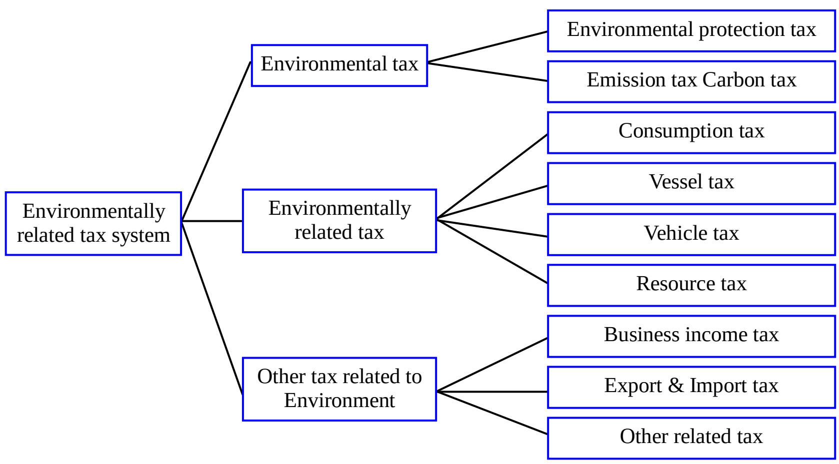

Figure 3-9 Future environmentally related tax structure of China

The current Chinese system relies heavily on a fee-based system to regulate emissions and pollution control. One of the key problems with the current system is the low level of charges/fees for industrial discharges. According to some estimates, pollution charges may only amount to 50% of the (marginal) treatment cost, using the operating costs of pollutant treatment equipment as a proxy. [28]Consequently, most enterprises would rather pay the fees than take serious actions to treat industrial discharges. The problem is further aggravated by weak enforcement at the regional and local levels, which resulted in either heavily discounted or delayed payments. Therefore, tax system innovation and reform will need to focus on the following aspects:

(1) Accelerate the reform of resource tax: Adjust the method of tax collection through a combination of price-based and quantity-based methods; appropriately increase tax rates on scarce resources, high-polluting and high energy-consuming mineral products; and carry out a gradual but comprehensive reform of the fee-based system, with the ultimate aim of incorporating the fees into a tax-based system.

(2) Adjust consumption tax through extension of consumption tax to high energy- and resource-consuming products that do not meet the energy-saving standards and which have so far been exempted from consumption tax; increase in the current tax rates on fuel and other high energy-consuming products; and decrease in the tax rates on low-emission vehicles and motorcycles, and consumption tax rebates for certain energy-saving products that meet the government standards.

(3) Adjust vehicle and vessel taxes through adjustment of the basis for tax collection, e.g. emission volume or vehicle's net weight; and increased and differentiated tax rates for vehicles. Following these reform guidelines, the legislation for vehicle and vessel taxes was published for public consultation in 2010 and approved by the National People's Congress in 2011. In terms of concrete measures, the tax rates will be differentiated according to the emission volume or displacement of vehicles. Tax rebates will also be given to hybrid and new energy vehicles.

(4) Introduce an environmental tax or environmental protection tax (including carbon tax). To deal with the problem of climate change, a tax on carbon dioxide emissions should form an integral part of China's environmentally-related tax system. The carbon tax can start from a low rate but its adoption will send a clear and timely signal to the market.

(5) Reform and reduce some of the business taxes to incentivise green transformation and innovation in the business sector, such as:

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28 See e.g. Su Ming et al. 3 March 2009. *Fiscal policy for promoting environmental protection* (in Chinese). http://cks.mof.gov.cn/crifs/html/default/keyandyuxueshu/_history/2866.html.

(1) VAT reform that will gradually replace business tax with VAT, starting in the transport, logistics and building sectors.

(2) Tax rebates for emerging and strategic industries and the service sector to encourage green investments, R&D and innovation.

(3) Tax rebates for SMEs, in particular S&T and innovation based SMEs, to encourage their innovation activities as well as to help overcome financial barriers.

Box 3-8 Political economy of CO_2 tax in OECD countries

The main "obstacles" to the introduction of CO_2 tax (which is a potentially significant source of revenues) are the fears of negative impacts on sectoral competitiveness and on households (especially low-income households, elderly people, or people living in certain regions). While these concerns should be taken into account in a tax reform, there are several ways to address these issues without compromising the intended environmental impacts of a CO_2 tax.

An important lesson for China is that it is possible to overcome these "obstacles" and introduce a CO_2 tax. A number of countries (Denmark, Finland, Norway, Sweden, United Kingdom etc.) have had a CO_2 tax in place for up to 20 years without obvious negative impacts on their economic development. Also, given the "lead-in" time available to the business sector, opposition to this tax has been very modest indeed. A case study prepared for the OECD also documented that firms that faced the full tax rate had fared as well as firms that were offered a reduced rate, and had in fact innovated more.

Source: Inputs provided by the OECD to the CCICED Green Economy Task Force, 2011.

3.7.3 Develop green finance through a concerted effort by the government, finance and business sectors

Green finance has recently received substantial attention from a broad range of governmental agencies as well as positive response from the financial and business sectors. Since 1995, a series of policies and regulations have been introduced (see Table 3-5). For instance, the Ministry of Environmental Protection (MEP) and the People's Bank of China have established an information sharing mechanism, which included details of 15,000 environmental law violations by businesses into a database that is available to commercial banks.

Table 3-5 Policy and regulatory measures for supporting the development of green credit

Agency	Policy documents	Key measures/messages
People's Bank of China 1995	The circular on issues related to bank credits and strengthening of environmental protection.	Protection of ecological resources and prevention of pollution as a key factor in approval of bank loans.
NDRC, People's Bank of China China Banking Regulatory Commission (CBRC) 2004	The circular on issues related to credit risk control through coordination between industrial policies and credit policy.	Differentiated evaluation and support, according to the impact on natural resources and environment.
MEP China Development Bank 2005	Development Finance Collaboration Framework Agreement.	Provision of 50 billion RMB bank loans as long-term and stable financial support to key projects and large enterprises in the environmental protection sector in the "11th Five-Year Plan".
MEP People's Bank of China 2006	The circular on issues related to business environmental information disclosure.	Starting from information on violations of environmental law, to gradually set up a business environmental information disclosure system for credit approval, including information of environmental impact assessment, clear production audit etc.
People's Bank of China 2007	Guidelines for improving and enhancing financial services to support energy-saving and emissions reduction.	Differentiated evaluation and support, according to the impact on natural resources and environment.
People's Bank of China, MEP CBRC 2007	Suggestions on environmental protection enforcement and prevention of credit risks.	Tighten project and credit approval of new projects. Strictly prohibit bank loans to new projects that seriously violate environmental protection.
CBRC 2007	Guidelines for credit approval for energy-saving and emissions reduction.	Control the total amount of credits approved. Optimise the credit structure with the objective of promoting a sustainable and coordinated development between the economy and the financial sector.
MEP CBRC 2008	Agreement on information exchange and sharing.	Establish an information sharing mechanism between MEP and other macroeconomic governmental agencies for the first time.
People's Bank of China, MEP CBRC 2009	The circular on issues related to full implementation of green credit policy and further improvement in information sharing.	Establish a regular information submission and exchange mechanism at national, regional and local levels.
People's Bank of China, CBRC China Securities Regulatory Commission (CSRC) China Insurance Regulatory Commission (CIRC) 2009	Guidelines for further improving financial services for supporting the revitalisation of key industries and controlling production over-capacity building.	Further strengthen financial support for energy-saving and ecological protection; Strengthen financial support for the development of low-carbon economy; Encourage the financial sector to develop innovative low-carbon financial products; Enhance green credit support for projects and enterprises that meet energy-saving and emission reduction requirement/standards.

Source: "China Green Credit Report, 2010". Policy Research Centre for Environment and Economy (PRCEE), Ministry of Environmental Protection of China, 2011.

In the "12th Five-Year Plan", various green financial instruments/schemes, in particular "green credits" and "green security", will become important instruments to support energy-saving and emissions reduction and to spur green innovations. More specifically:

(1) More financial institutions will provide green credits and other financial instruments (e.g. bank loans, interest rebate etc.) to support projects, investments and innovation in the fields of energy-saving and emission reduction;

(2) Financial institutions will penalise (such as higher interest rates and refusal or cancellation of bank loans) applicants with poor environmental compliance records and/or with serious environmental violations;

(3) Financial institutions will use green credits to supervise and guide the use of bank loans in order to reduce environmental risks and promote corporate social responsibility, as well as mitigate the financial risks undertaken by the financial institutions themselves.

Government policies in the traditional environmental protection sector as well as the emerging and strategic industries will help to develop green credits in China. Combining government policies with flexible market-based approaches and an increasing interest of the financial sector in green investments, this will be a concerted effort between the government, finance and business sectors. The use of green credits will require greater openness and transparency, consisting of more information disclosure by the governmental agencies and financial institutions as well as closer monitoring by the general public. To further accelerate the development of green credits and other related green finance instruments, the following supporting measures will be important:

(1) Strengthen technical support to financial institutions when green finance regulations and policy measures are introduced. To make green credits more feasible and operational, the financial sector will need access to detailed and targeted technical information. This can be achieved by developing industry- and region-focused practical guidelines/information tools on environmental and safety standards.

(2) Further strengthen the collaboration between governmental agencies and financial institutions in the field of environmental protection. In particular, the current one-way information disclosure system – governmental agencies providing information to commercial banks – needs to be upgraded to a mutual and open information sharing process, where information related to environmental and financial risks can be more easily shared between stakeholders.

3.7.4 Create a new catalyst by combining environmental policy and green innovation

Despite the exciting and new progress in China's S&T and innovation policy, significant policy gaps in China's national (and regional) innovation system still exist and need to be addressed urgently in order to prepare the ground for large-scale green innovation. For instance, there is an urgent need to modernise the basic research, human resource and skill development to increase the responsiveness of public research to the opportunities and challenges in the green development. Furthermore, to increase the speed and scale of China's green technology transformation and to enhance its competitiveness, the gap between research (both basic and applied) and technology commercialisation and industrialisation need to be bridged quickly. Moreover, in alignment with environmental standard setting and the development of "green public procurement", "regulation-induced innovation" will also become more important.

In the international context, using environmental policy as an efficient tool in conjunction with investment in green R&D to spur green innovation has become one of the key focuses of green growth policy-making. In the Chinese context, the ambitious plans for the emerging and strategic industries, a demand–driven economy and energy efficiency and environmental protection have created favourable macroeconomic conditions and regulatory environment for green technology and innovation. Under the "12th Five-Year Plan", emission standards of SO_2 and NO_x will be revised to bring China to be in line with international standards (see Figure 3-10).

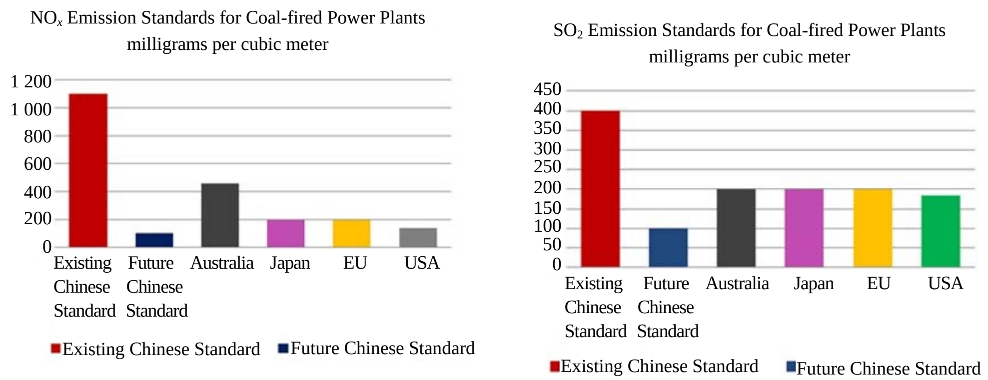

Figure 3-10 Chinese SO_2 and NO_x standards in an international comparison

Source: "The China greentech report 2011", pp 66. Reproduced in the CCIECD Green Economy Task Force report.

The experience of NO_x emission charge in Sweden provides a useful example regarding the use of stringent environmental standards to spur innovation and reduce abatement costs (see Box 3-9). This can be a useful reference case for China when introducing NO_x emission reduction target and in relation to the reform of its environmental charge/fee system. With a "smart" policy mix, comprising of stringent environmental standards, government support for research and incentives for innovation (both public and private), there is a real potential for China to solve the double market failures, i.e. "innovation undersupply and pollution oversupply".

Box 3-9 The innovation effect of Sweden's NOx emission charge

The NO_x emission charge was introduced in 1992, starting from a relatively high threshold (40 SEK per kg NO_x). The objective was to reduce the overall NO_x emission by 30% between 1980 and 1995. The unique design of the charge was that, under the system, plants paid this fixed charge per kg NO_x emitted and the revenues were (almost) entirely refunded to the paying plants, in relation to their respective fraction of total useful energy produced.

Most interestingly, the NO_x charge system has also spurred innovation, which could be observed from the downward shift of the marginal abatement cost curve (see Figure 3-11). This was a result of the adoption of innovation in abatement technologies, e.g. physical mitigation technology through investments in new equipment and non-physical mitigation technology in the forms of improved combustion process and/or cleaner production process. These innovations have made it possible to produce energy with less NO_x emission without increasing costs.

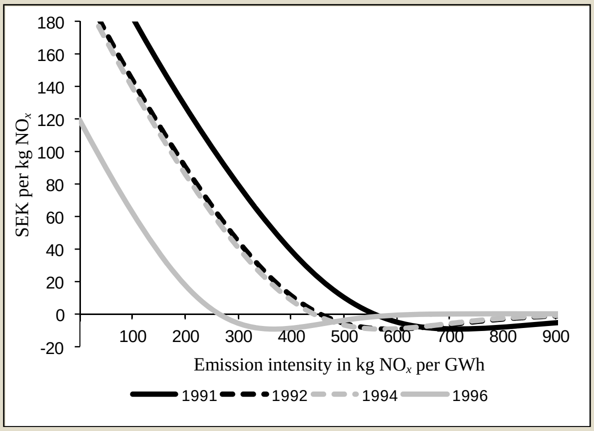

Figure 3-11 Marginal abatement cost curves of taxed emitters

Source: "Taxation, Innovation and the Environment" OECD, 2011.

3.8 Key Conclusions and Key Recommendations on Promoting China's Green Economy

China has embarked on the pathway towards a green economy in the past years. The resolute and unambiguous policy messages from its "12th Five-Year Plan" (2011—2015) have not only reinforced this strong political commitment and leadership, but also called for more integrated, innovative and effective strategic frameworks and actions.

While "business as usual" is not an option, there are no off-the-shelf solutions to help China accelerate its move from an unbalanced, uncoordinated and unsustainable development towards a green, competitive and inclusive economy. China needs to seek its own pathway, in the face of the distinctive scale and complexity of multiple challenges in terms of ecological, resource, economic and social security concerns. The growth model characterised by high resource utilisation, high energy intensity, high emission, low recycling and low efficiency has created serious resource bottlenecks and resulted in comprehensive environmental and ecological impacts. Also, the continuous industrialisation, urbanisation, and modernisation of the agriculture sector will remain both challenges faced by China and catalysts for transformational changes in the foreseeable future. At the same time, China needs to seize the unique green growth opportunity, and to achieve the "first mover and fast mover" advantages by promoting green investment, green innovation and green job creation beyond those defensive interests.

The "12^{th} Five-Year Plan" represents a critical juncture in China's development – as China scale up and speed up its economic, environmental and social transformations. Fundamental changes towards a green mind-set as well as innovative strategic policy-making and effective implementations towards greener economic and industrial structures will be the key to treating the cause, instead of the symptoms. The "trial and error" and learning-by-doing process of achieving a green transformation in both the public and the private domains will require an exceptional level of openness and creativity as well as co-ordination and partnership. The success in the "12^{th} Five-Year Plan" will lay a solid foundation for even more swift and forceful transformational changes in the "13^{th} Five-Year Plan" (2016—2020) as China faces ever greater environmental and resource challenges. China's successful first steps towards a green economy will also have repercussions on the global economy in both the short and the long terms. Instead of being a source of resource exhaustion and unsustainable growth, China can become a promoter of resource conservation, a green technology enabler (especially in North-South-South technology transfer and diffusion), and a strong driver for new sources of green growth – overcoming the "environmental and equality deficits" and moving away from a jobless growth trajectory.

Key principles that will guide China's green economic development need to be progressive in nature, including a balanced and mutually supportive and reinforcing relationship between the economy and the environment, and a refined understanding of economic and social progress within the China-specific context. In other words, the speed, efficiency, quality and equity of economic development will need to be given more equal priorities.

Therefore, new values, skills, governance and incentive structures will be the most important transformational drivers for China's fundamental and structural changes toward a green economy, especially in relation to policy making, market development and their inter-dependency:

(1) Fundamental change in values and behaviour – from national, regional, local to individual levels, concerning wealth including natural assets and social cohesion as well as how wealth is created, moving away from GDP obsession, unsustainable lifestyles and over-consumption at the expense of the environment and a harmonious society;

(2) Transformation of the role of government and its relation with the business sector, through improvement in the quality and effectiveness of policy implementation and being a strategic leader, a facilitator of a well-functioning market and an efficient public service provider;

(3) Transformational and innovative incentive mechanisms and structure – to encourage green production, investment and green consumption, as well as to remove distortions resulting from both policy- and market failures;

(4) Skills development and innovation capacity building based on a strategic understanding of the new and multidisciplinary skill profiles that the green economy requires – towards a more labour-intensive, equality-based and service-driven economy.

To address the existing structural issues at the national, regional and sectoral levels as well as to create favourable enabling conditions for the future green economic development, the Task Force propose key recommendations, according to the following structure:

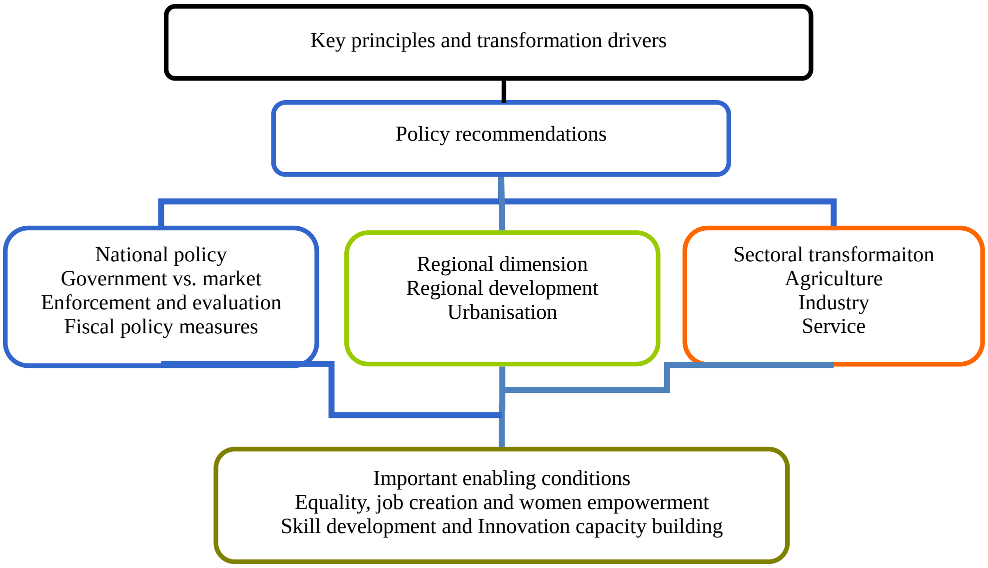

Figure 3-12　Structure of key recommendations proposed by the task force

3.8.1 Key recommendations on national policy

Key recommendation 1: The transformation of the government's functions to create favourable institutional and market conditions for the green economy

In the transformation towards a green economy, enterprises are the key implementers. The role of the government and its relation with the market and the private sector need to be modified and balanced, in order to improve economic and resource efficiency. A sound policy and regulatory framework, efficient market monitoring and oversight as well as appropriate incentive mechanisms are the keystones of a well-functioning market, which can make green investment and green business more attractive, viable and profitable. Accordingly, the government should accelerate the transformation of its functions. Priorities should be given to strengthening the regulatory role of the government and environmental oversight of economic activities, while reducing the government's direct interventions in market behaviour and operation.

(1) Reduce government interference in the market and efficiently utilise the fundamental role of the market to allocate resources. Instead of over-relying on administrative measures and public spending, conducive institutional framework and market conditions are key to attracting and allocating resources more efficiently towards a green transformation. More specifically:

1) The government should avoid creating barriers to market entry for green investment and businesses and clamp down on the local protectionism that prevents fair competition and market access;

2) The government should avoid market distortion through excessive use of administrative measures, which leads to interference in price setting and market operation. These interventions would in turn send misleading and distorted market signals related to environment and resources;

3) The autonomy of the private sector, in terms of decision-making in project investment and business development, should be respected, instead of being overtaken by the government decision and involvement;

4) The crowding-out of private investments due to excessive and redundant public investments in the name of various demonstration projects should be strictly controlled.

The role of the government should be more clearly defined by targeting these areas. The corresponding monitoring mechanisms for decision-making and enforcement should be established and strictly followed.

(2) Clarify the responsibilities of the government and strengthen its role in market

supervision and public service provision. Short-sighted and unsustainable business practices are the result of both biased price signals and misaligned incentives as well as the weakness of market supervision and regulation. Therefore, key government priorities for green transformation should include clearly defined government regulatory responsibilities and accountability as well as improvements in compensation mechanisms and public service provision. This is particularly important for key sectors such as environmental protection, resource conservation, safety management and fair competition. Neither economic growth nor local interests should hinder the enforcement of laws and regulations related to environmental protection and resource utilisation. More specifically:

1) Strictly control and firmly combat illegal business practice. This is the bottom line for securing a fair market competition and sustainable development;

2) Backward production capacity should not be protected for the sake of local economic interest. Law and regulations related to environmental protection should be strictly enforced;

3) A compensation mechanism and accountability system for environmental damages should be established to provide effective remedies for both private and public environmental damages. The focus of environmental supervision and enforcement also needs to be gradually changed from imposing penalty for exceeding environmental standard/cap to providing compensations for environmental damage caused by infringements of law and regulations;

4) From a legal perspective, the government’s regulatory responsibility should be clarified;

5) A strict accountability system and a comprehensive performance evaluation should be established, accompanied by effective and regular market oversight and management;

6) Strictly follow the law and encourage public disclosure of information concerning the government’s supervision and management to facilitate public participation and media scrutiny;

7) Good governance based on the rule-of-law, transparency and equitability on all levels of the government should be the crucial guiding principles for an effective green transformation;

(3) Utilise the economic policy tool box in a targeted and integrated way to guide the transformation towards green investment, green business practice and green consumption. More specifically, public funding, taxes and various financing instruments should be used as levers to accelerate the green transformation through their influence on prices and demand-supply conditions, and to enhance financial resources for green investments and

green innovations.

Key recommendation 2: Establish a comprehensive evaluating system to ensure coherence and effectiveness of green economic development policy and decision- making

In order to facilitate the green economic transition, policy coherence and mutual supportiveness are vital, while the creation of new problems in the process of solving existing ones must be avoided. For instance, many investment projects focus only on economic efficiency while ignoring the environmental impact; some environmental protection measures that concentrate on achieving emission reduction targets are highly energy intensive; and finally, many renewable energy and energy efficiency projects lead to substantial environmental and ecological impacts. Given the great diversities between regions in terms of the level of development and region-specific conditions, the “one-rule-for-all” approach of target-setting and evaluation system will fail to meet the differentiated needs and address the real problems.

(1) Establish a comprehensive evaluation system/mechanism for key development initiatives and projects. In particular, the government should set up expert groups to carry out both ex-ante evaluation and evidence-based ex-post impact assessment on key policy and investment initiatives related to energy, environment and resources, in order to scrutinise their overall economic, environmental and social impact.

(2) Establish a comprehensive environmental risk assessment system - taking into account region- and industry-specific conditions and characteristics. The purpose is to set up specific and differentiated objectives and targets for environmental management in the regional green economic development and industrial upgrading and modernisation. When setting up these targets, regional conditions and industrial characteristics must be taken into account to avoid a “one-rule-for-all” approach.

Key recommendation 3: Carry out a comprehensive greening of the fiscal policy and tax system

Generally, the market force alone cannot solve issues related to resource use and environment. Therefore, the role of the government in guiding the economic reforms through various public supports, taxes and pricing mechanisms should be strengthened. Comprehensive fiscal policy reforms should have a strong focus on improving the incentive structures – to encourage green investment, green business and production practices, and entrepreneurship as key drivers in accelerating the green transformation. Furthermore, while China is already leading the world in green investments, future investments need to be both strengthened and diversified – with a stronger participation of both domestic and foreign actors from the private sector. Moreover, being fiscally neutral is not enough to address distributional concerns associated with structural adjustment and changes. Targeted compensatory measures are needed to compensate the adversely affected and the most vulnerable groups.

(1) Establish support mechanisms that secure a stable increase in financial support for green development. To establish a multi-tier and co-ordinated co-finance/co-funding mechanism with joint efforts by the national, regional and local government. Coordination mechanisms for various policy instruments, such as taxes, finance and prices should be established.

(2) Deepen tax reforms and further strengthen resource-related price reforms that are favourable to green economic development, such as:

1) Accelerate the reform of resource taxes;

2) Adjust the consumption tax in line with polices related to energy-saving and emissions reduction; introduce environmental taxes or environmental protection taxes, including carbon tax;

3) Reform and reduce some of the business taxes to promote the development of emerging and strategic industries, a modern service sector and entrepreneurship as key drivers in accelerating the green transformation;

4) Remove environmentally harmful subsidies, with removing subsidies for fertilizer production as one of the priority areas;

5) Deepen the pricing reform for key resources, e.g. water, electricity, oil and gas so that prices can better reflect resource scarcity as well as the polluter pays principle, etc.

(3) Promote the development of green finance which has a particular strategic focus and importance for the development of S&T and innovation-based SMEs. Support enterprises' energy-saving and emissions reduction actions, as well as reduce environmental and financial risks of enterprises and financial institutions through green credits and other innovative financial instruments.

3.8.2 Key recommendations on a differentiated green regional development

Key recommendation 4: Avoid unsustainable relocation of backward technologies and production facilities and achieve a coordinated green regional economic development

As the result of the "industrial gradient transfer" from the eastern coastal region, the less-developed interior and western regions have grown rapidly during the "11th Five-Year Plan", while their transition from a resource-based development model to a modern industry-based development model has proceeded relatively slowly. To avoid these regions from being locked in a low-quality destructive development, the "industrial gradient transfer" needs to be managed properly and take place in a sustainable way, through better coordination between the central, regional and local governments and stricter monitoring and control.

(1) Tighten and/or enforce the environmental standards for project/investment approval to prevent pollution transfer (from developed to less developed regions):

1) Strengthen and enforce the environmental impact assessment and the "three-simultaneity" principles;

2) Set up an information system for the re-allocation or transfer of highly polluting enterprises;

3) Monitor and supervise local decommissioning of obsolete and highly polluting equipment.

The key to achieve a co-ordinated green regional development is to define economic development priorities of different regions according to their level of economic development and ecological endowments as well as the need to protect and preserve these endowments. Through the public transfer schemes and market-based compensation mechanisms, both burden-sharing and benefit-sharing mechanisms can be implemented to reduce imbalance across regions. This is particularly relevant and important for the development of compensation mechanisms for green transformation in resource-exhausted regions and cities.

(2) Encourage the development of green regional development strategies based on region-specific green development potentials, such as:

1) Fully explore the potential and utilise the capacity of the Eastern region, in the fields of industry clustering, S&T and innovation capacity, environmental protection as well as financial services;

2) Take advantage of the improved transport infrastructure and human resource endowment in the Central and the Western regions, and turn them into China's new and green manufacturing bases;

3) Take advantage of the resource abundance as well as the richness of its biodiversity and ecosystem in the Western region to develop sustainable mining, equipment manufacturing and new energies as well as to create new growth opportunities, e.g. eco-tourism.

Key recommendation 5: Adopt a more concentrated approach to China's green urbanisation

In the rapid ongoing process of urbanisation, cities are playing an increasingly critical role in driving economic and environmental impact. China has yet to decide on which model of urbanisation is best for its future. However, some clear empirical evidence suggests that, two concentrated growth scenarios, i.e. super-cities and hub and spoke are preferable to a dispersed urbanisation scenario. The advantages include higher per capita GDP, less loss of arable land, more efficient energy use, mass-transit and pollution control. A plan pushing China toward a more concentrated approach to urban development can thus deliver the optimal trade-off between benefits and burdens of urbanization. Such a policy, however, would require a deliberate shift from the current development pattern of disproportionate growth in middle sized urban areas.

(1) Encourage concentrated growth nationally: Municipal government collects taxes and makes many decisions, such as granting industry subsidies and retail licenses that have a direct economic impact. These local decisions have a strong and irreversible effect on the quality of Chinese urban life. The central government, however, can guide local actions, set common standards and monitor enforcement by cities to move the country away from the current trend of dispersed urbanisation and toward a more concentrated approach.

(2) Use infrastructure approvals to shape clusters: The central authorities should also encourage infrastructure investments that focus on super-cities or hub-and-spoke clusters. Capital projects such as refineries, ports, and large universities could be placed strategically to spur the growth of the largest cities.

(3) Use land conversion processes to spur density: Land conversion rights are governed nationally and central officials have already tightened the quota for land that can be developed for urban use. Violations are rampant, however, and current land use policy fragments the urban periphery. By recognizing the role of market mechanism in more efficient resource allocation and in managing the national land conversion process, municipalities can be encouraged to seek breakthrough concepts that do not reduce agricultural land in total while maximizing its value as urban infill.

3.8.3 Key recommendations on a green transformation at the sectoral level

Key recommendation 6: Develop and strengthen an integrated approach to greening the traditional industrial sector

China's industrialisation process faces daunting challenges and also important strategic opportunities under the "12^{th} Five-Year Plan", which requires a multifaceted, innovative and open industrial transformation. At the same time, an integrated approach is needed to set up effective and efficient pollution prevention and control system and energy efficiency management in the industrial sector. Related policies and regulations, such as emission standards, should increasingly aim at reducing emission and promoting resource and energy utilisation at the industry-wide level, rather than dealing with single pollutants and pollutant sources.

(1) Enforce and accelerate the phasing out of backward technologies and production facilities:

1) Introduce market exit mechanisms for backward and highly polluting enterprises. Regulations and standards for compensations for capacity elimination should be set up;

2) Encourage and facilitate voluntary elimination of backward production capacity or technology innovation and upgrading of highly polluting enterprises through a combination of carrot and stick measures.

(2) Undertake integrated pollution prevention and control and energy efficiency measures, striving for co-control and co-benefit:

1) Better utilisation of waste heat from industries;

2) Treatment and recycling of external waste using industry facilities, e.g. waste treatment in cement kilns;

3) Limit the exploitation of natural gypsum and enhance utilisation of industrial by-product gypsum.

Key recommendation 7: Promote a green agricultural development in the modernisation process

While the Chinese agricultural sector is undergoing a rapid process of industrialisation and modernisation, it is important to seize the opportunities of efficiency gains from economies of scale and more advanced production processes while at the same time deal with the new environmental challenges. In particular, the large-scale production and utilisation of renewable energy and organic fertilisers are important for both economic and resource efficiency and reduction of non-point source pollution in the agricultural sector.

(1) Support large-scale and industrialised production process of organic fertilisers:

1) Develop an industrialised production of organic fertilisers in conjunction with the industrialisation of livestock production to increase organic fertiliser use;

2) Improve the efficiency of fertiliser use through technical support and capacity building for farmers.

(2) Encourage large-scale and industrialised livestock and production of farm products:

1) Provide special funding and subsidies for the setting up of waste treatment facilities according to the scale of waste treatment and the efficiency in emissions reduction;

2) Promote concentrated and large-scale waste treatment.

Key recommendation 8: Fully leverage the role of the service sector as a catalyst for green transformation

The role of the service sector in the structural adjustment – from capital-intensive and heavy industry-dependent growth to a more labour-intensive and knowledge/skill-driven economy has been underutilised. The contribution of the service sector to a greener economy is at least twofold: ① a larger share of the service sector in GDP and a less energy- and resource-intensive economy through a greener service sector; ② technology services can help improve the environmental performance of the industrial sector. In relation to the latter, services can help transform not only the manufactured products (including their re-processing, re-use, recycling or disposal) but also the production processes, such as more efficient engineering design and energy and pollution management. These types of manufacturing-related services and R&D have become key drivers for the development of the service sector, and are a key source of revenues and jobs along extended value chains in many OECD countries. However, due to the backward production capacity as well as the overall low skill level in the service sector, these developments have only just begun in China.

(1) Develop a strong manufacturing-service linkage as a driver for upgrading in both sectors. This needs to be supported by the development of manufacturing-service green skills, capacity building and job profiles, e.g. education of designers, planning of density-driven infrastructure and integrated resource management for the manufacturing sector.

(2) Incentivise the re-allocation of capital and investment to drive employment in the service sector. This development is dependent on at least two key factors: ① reform in the financial sector to engineer a shift towards investments in more dynamic and innovative service companies, instead of making redundant investments in less productive and less efficient industrial enterprises; ② the development of skill- and innovation-based SMEs.

3.8.4 Key recommendations concerning important enabling conditions

Key recommendation 9: Make green transformation a more inclusive and empowering process

China has made remarkable progress in its effort to alleviate poverty in the past three decades. However, a combination of the climate, energy and economic crises has made the problem of poverty more complex, which in turn exacerbated the female face of poverty. A green economy needs to be inclusive and empowering for all actors in the society, especially women who generally tend to fare worse than men. Hence, green economy is not only about development but also a driver of women's empowerment. China has already made good progress in creating new green jobs in its poor and rural areas through ambitious programmes in forestation and renewable energy development, which has also benefited its female work force. Furthermore, as the proportion of women in its urban and rural work force continues to increase, women have become an important driving force in China's green development, instead of only being victims. Nevertheless, developmental co-benefits and new opportunities – in particular in terms of job creation which is the most effective vehicle in reducing poverty and creating social cohesion – should be further explored:

(1) Make green economy a job-generating, instead of a jobless growth, with a clear focus on:

1) Green job creation with strong positive developmental effects in the poor and rural areas;

2) Promoting labour-intensive and high-quality manufacturing jobs in the process of greening and modernising China's traditional industries and manufacturing-related service sector;

3) Accelerating the development of green sectors, in particular the energy-saving and environmental protection sector to create both manufacturing and service jobs;

4) Enhancing resource- and eco-efficiency, so that green growth, efficiency improvement and job creation are mutually reinforced and the job-generating potential of the economy as a whole is strengthened.

(2) Make the green job creation process an empowering process for women and enhance the accessibility of women. The Chinese government should focus its efforts on improving women's job opportunities in both traditional green sectors (environmental protection, resource management, handcrafts, building and transport, etc.) and in non-traditional sectors, particularly in new and high-tech sectors.

Key recommendation 10: Make green innovation a catalyst for China's modernisation and leapfrogging

Green innovation can be a new and important catalyst, not only for turning China's environmental problems and energy bottlenecks into new growth opportunities in resource efficiency and renewable energy, but also for modernising China's national innovation system on a broad front - from the basic research system to high-end manufacturing. The development of the emerging and strategic industries outlined in the "12th Five-Year Plan" opens up a new window of opportunities for the modernisation and leapfrogging in an innovation-driven industrial sector. The market size, manufacturing capacity, and increasingly, also the local innovation environment and infrastructure have made China an attractive destination for international technology and know-how transfer, and increased its potential to become a global green innovation hub. However, to fully unleash and utilise its innovation potential, significant capacity, skill and policy gaps need to be filled and the scope of collaboration needs to be enlarged:

(1) Undertake a green innovation oriented modernisation of China's basic research, S&T and human resource development system, with a specific focus on:

1) The multidisciplinary, interdisciplinary and intersectoral nature of green technology, R&D and innovation;

2) Stronger links between cutting-edge basic research and large-sale technology uptake/commercialisation in the market.

(2) Strengthen the mechanisms of regulation-induced innovation through the alignment of environmental policy tools, as such standard setting, green public procurement and incentives for innovation. This will be a strong lever for developing knowledge- and skill-intensive and cost-efficient energy-saving and emissions reduction actions.

(3) Make the development of SMEs an integral part of the development of emerging and strategic industries. Public-private partnerships as well as public-public partnerships with an international dimension to support technology transfer and mutual market and skill development for both Chinese and foreign SMEs.

(4) Enhance the openness of the national green innovation system for creating pragmatic and creative platforms and approaches for technology innovation, deployment and diffusion to strengthen partnerships and competitiveness. This can take the forms of:

1) A green technology innovation and investment platform, with an international dimension and a focus on supporting large-scale science-industry collaboration initiatives, built on strong private-public partnerships. Some of the international experience, e.g. sustainability-focused Centres of Excellence in the EU member states and the EU's Joint Technology Initiatives (JTIs) could provide a useful model for China's green technology and innovation capacity enhancement;

2) A "protect-and-share" IPR regime, technology development, transfer and diffusion mechanism to facilitate China's bridging role in North-South-South green technology and innovation collaboration.

3.9 Acknowledgments

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Chapter 4　China's Low Carbon Industrialization Strategy

4.1　Introduction

4.1.1　Why China needs a low carbon industrialization strategy

To enhance the prospect for competitive and sustainable growth in 2020 and beyond, and to deliver the "12th Five-Year Plan" objectives, China should act now to develop a comprehensive, innovation-based low carbon industrialization strategy.

Today, China's energy-intensive[1] industries remain critical to the national economy. Ongoing rapid industrialization and urbanization will be accompanied by growth in the heavy chemical industries, and the expansion of the iron and steel, vehicle manufacturing, shipbuilding and mechanical engineering industries, all of which require a large volume of materials and energy. In China's rapidly expanding economy, industry accounts for roughly 70% of energy consumption, and the bulk of total greenhouse gas emissions.

Upgrading the efficiency of the heavy industries in China will continue to be critical for controlling demand and reducing environmental impact. However, according to the "12th Five-Year Plan", emissions from heavy industry in China will increase until at least 2020, even if challenging energy-intensity targets are introduced for each sector. In the next few years, China can lay the groundwork for a more transformative phase of industrialization in the 2020s and beyond, driven by technological breakthroughs, restructuring of the economy and institutional reform. Through such measures, absolute emissions reductions can be achieved in some sectors in the 2020s.

Moving to a low carbon economy is of critical strategic importance for China's future growth prospects, as has been made clear by its senior leaders. Innovation is already a

1 In this report, China's national energy intensity is defined as "energy consumption divided by GDP" (tonnes of coal equivalent / GDP). In individual sectors, energy intensity is defined as "energy consumption per tonne of production" (tce / tonne) or alternatively as "energy consumption per unit value added" (tce / RMB). Carbon intensity is treated in the same way as energy intensity: i.e. at the national level it is defined as "greenhouse gas emissions (in CO_2e) divided by GDP".

priority for China, whether for upgrading old industries or to support new, technology-rich sectors. Research and development (R&D) investment as a share of GDP will climb to 2.2% by 2015 – up from just 1% ten years ago. But much more can be done to build a strong, inclusive enabling environment. Shifting to an innovation-driven society will require a dynamic education system, flexible institutions and enhanced international cooperation.

Achieving the goal of industrial restructuring is no mean feat, especially in the wake of the global economic downturn and high and volatile energy prices. Employment pressures make it harder to speed up structural adjustment in the short term by closing inefficient production capacity. On top of this there are sharp regional variations in the extent of industrialization, with China still needing to accomplish large-scale development in its western region.

Meanwhile, the global outlook for competitiveness is changing: The state of manufacturing has become a key indicator of success for developed countries as their governments seek to stimulate economic recovery. Chinese firms are competitive in meeting burgeoning global demand for low carbon technologies such as renewable energies, electric vehicles and green information and communications systems. According to China's "12th Five-Year Plan" these low carbon sectors have the potential to become pillar industries in the next ten years, together contributing around 15% of GDP. Meeting this goal depends on refocusing China's industrial assets and upgrading its capacities for technology innovation. Finally, accelerating the process of economic restructuring is set to be an important strategic theme in the coming years. Green growth and low carbon industrial transition must be a key part of the solution.

Governments and businesses increasingly recognize that those who are moving fastest in the transition to a low carbon economy are likely to gain a significant competitive advantage. According to HSBC, the low carbon energy market reached USD 0.7bn in 2009 and is set to grow to between USD 1.5 and USD 2.7 trillion in 2020.[2] The key policy question is how states and markets can harness their industrial assets to stimulate opportunities in low carbon economic activities and energy efficiency.

With low-cost labour and inexpensive resources, China's manufacturing sector currently enjoys an unbeatable competitive edge in many products. However, rising costs of labour and resource and environmental constraints mean that China's traditional low-end industry is starting to lose its advantage over those of other countries, especially its Asian neighbours. Even so, the average salary of China's manufacturing workers is still only a small percentage of that in developed nations – and its huge domestic market and well-established industrial chain and infrastructure are still attractive for investors.

2 HSBC, 2010. *Sizing the climate economy.* www.research.hsbc.com/midas/Res/RDV?ao=20&key= wU4BbdyRmz&n= 276049.PDF.

Upgrading heavy industry will not mean the elimination of labour-intensive industries, but rather a focus on producing more high-tech, higher-value products. Achieving absolute reductions in consumption for such products will take significant effort and will not happen overnight. Labour-intensive industries are also the backbone of the economy in parts of the country, and China will continue to develop them to take in a significant quantity of rural labour.

4.1.2 A solid foundation for low carbon industrialization

There is no doubt that China has the capacity and the need to become a global leader in sustainable development and environmental technology innovation. Chinese leaders have long recognized that a more sustainable model of development is required given the global resource constraints and environmental impacts.[3]

The "11th Five-Year Plan" saw a step change in China's policies on energy and environmental protection, especially the energy-intensity target – an improvement of 20% by 2010 compared to 2005. Industrial sectors, the major focus of policy, collectively avoided 339 Mtce of energy demand by adopting new technologies, contributing 54% of the total energy saving during the period. Although overall energy consumption continued to grow strongly, the energy intensity of key sectors such as coal-fired electricity generation, cement, ammonia and chemical fibers came down by 9.5%, 24.5%, 17.3% and 30.6% (see Table 4-1).

Table 4-1 Progress on energy conservation in the "11th Five-Year Plan"

	Energy intensity			Production in 2010 (Mt)	Energy conservation during the "11th Five-Year Plan" period (Mtce)
	unit	2005	2010		
Steel	kgce/t	760	701	627	37.0
Aluminium	kWh/t	14 575	13 979	16	3.3
Copper	kgce/t	780	500	5	1.3
Cement	kgce/t	167	126	1 877	76.9
Glass sheets	kgce/weight case	22.0	16.3	663	3.8
Oil refining	kgce/t	114	100	423	5.9
Coking	kgce/t	156	117	388	15.1
Ethylene	kgce/t	1 073	950	14	1.7
Ammonia	kgce/t	1 700	1 464	52	12.2
Caustic soda	kgce/t	1 297	1 006	21	6.1
Soda ash	kgce/t	396	317	20	1.6
Calcium carbide	kWh/t	3 450	3 340	14	0.6
Chemical fibres	kgce/t	743	517	30	6.7
Total					172.1

Source: LCIS Task Force analysis.

3 Feng Zhijun, David Strangway et al., 2008. *CCICED Task Force on Innovation and Environmentally-friendly Society: Action Plan.*

In the last five years, China has also emerged as a key player in renewable energy. Starting from a low base in 2004, its annual investment in renewables looks set to overtake the EU's in the next couple of years, and it deployed more wind-power capacity in 2010 than any other country. It has also become the leading manufacturing base for both wind-power technology and solar photovoltaic cells.

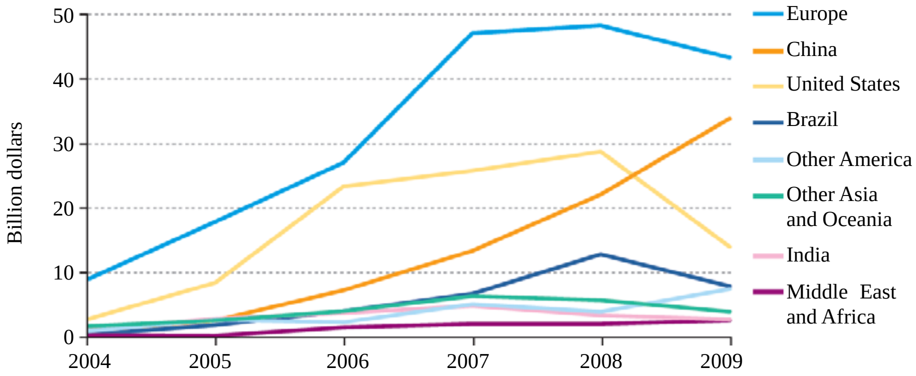

Figure 4-1 Annual investment in renewable energy assets by region

Source: IEA, 2010 (BNEF data).

If it is to capitalise on these advantages to secure and develop its low carbon industry, China needs to upgrade its domestic innovation base radically. Only a significant strengthening in this area can ensure China's ability to generate the range of options and the flexibility needed to thrive in coming years. R&D, deployment and associated infrastructure, as well as continued investment in key sectors, will play a vital part. However, China must also act more broadly, building up education and human capital at all levels and stimulating a culture of innovation across society.

Importantly, no one country will hold the key to the low carbon economy. Collaboration on the development and supply chains of important technologies will be crucial for companies seeking to gain a technological edge and penetrate global markets. Moreover, domestic policies alone are unlikely to support the global public good aspects of low carbon innovation; multilateral action is required to provide incentives for additional national actions, drive international collaboration and help correct critical market and policy failures.[4] China must maintain a vision of open innovation and investment to ensure the necessary flexibility.

4 Shane Tomlinson, Pelin Zorlu and Claire Langley, (2008). *Innovation and Technology Transfer Framework for a Global Climate Deal*. E3G and Chatham House.

4.1.3 The low carbon economy – a new form of development model

Rapid industrialization is integral to the growth strategies of many developing countries, many of which guide public and private investment into primary and secondary production – whether in steel, shipbuilding or metal-processing. Environmental and resource constraints will, however, make it increasingly difficult for emerging economies to follow this traditional pathway. The path to low carbon industrialization will necessitate the creation of new development models, driven by more sustainable, less resource-intensive growth.

Industrial sectors contribute significantly to the problem of greenhouse gas emissions. At the global level, industrial and manufacturing activities together account for over 35% of CO_2 emissions (not including the energy sector). The large primary material industries, i.e., chemical, petrochemicals, iron and steel, cement, paper and pulp, and other minerals and metals, account for more than two-thirds of this amount.

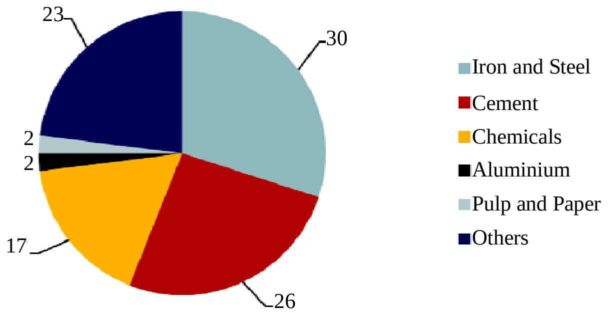

Figure 4-2 Contribution of global industrial CO_2 production by industry

Source: IEA, 2009[5].

Yet these sectors are also a key part of the solution, as industry adapts to meet new product demands from a decarbonizing economy. The transformation to a low carbon economy will entail not only a retooling of existing manufacturing processes, but a more systemic change in industrial structure. This will need to combine a shift from carbon-intensive to knowledge-intensive sectors; a focus on low carbon goods; infrastructure to support lower carbon transport and services across the economy and a shift towards more energy-efficient manufacturing processes to reduce the remaining carbon footprint of industry. Systemic change involves more than just replacing a set of technologies; it must comprise a much broader network of technological chains, physical infrastructure, user

5 IEA, 2009. *Energy Technology Transition for Industry.* International Energy Agency. Paris.

practices, markets and regulatory systems.

China will need a variety of different low carbon models to reflect the diversity of its regions in terms of income, geography, resource availability and general level of technological development. For example, Shanghai's income level is 10 times that of Guizhou, and part of China's central and western regions still have a significant labour surplus.

A pro-poor low carbon industrialization strategy must address the reality that China is still a developing country, and that regions currently relying on heavy industry will need a different approach from those with modern industries. With low carbon industrialization, the combination of upgrading traditional industry while fostering higher-value, cleaner sectors can contribute much to a more balanced regional development, which is itself a priority in the "12th Five-Year Plan". Moreover, the impacts of climate change and environmental degradation will add to the burden of poverty if left unchecked.

4.1.4 Low carbon industrialization is a pillar of the low carbon economy

In 2009 China announced a carbon-intensity target for the first time. If achieved, the amount of carbon dioxide emitted per unit of GDP will fall by 40%—45% by 2020, compared to the 2005 level. Figure 4-3 shows what happens to absolute carbon dioxide emissions under different scenarios for carbon-intensity improvement. Even in the 50% case – going beyond China's existing target – overall CO_2 emissions continue to rise strongly between 2015 and 2020. An important question for China is when overall energy consumption and emissions will peak. Nevertheless, achieving the 45% reduction target would save about 8.5 $GtCO_2$ per year in 2020 relative to a 40% reduction.

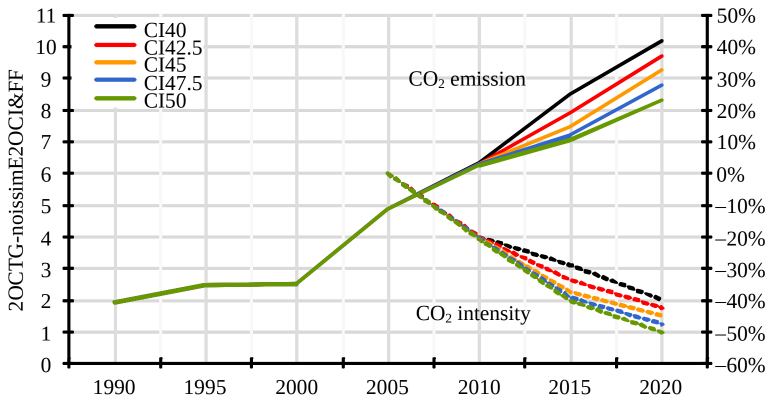

Figure 4-3 Impact of China's carbon intensity reductions on CO_2 emissions

Source: LCIS Task Force analysis.

The impact of energy intensity on emissions is highly sensitive to GDP assumptions. In Figure 4-3, annual average GDP growth rate is maintained at about 8%—9% during 2011—2015, and at about 7%—7.5% during 2016—2020.[6]

There are four key reasons why low carbon industrialization is critical to achieving a low carbon economy in China, including meeting the 40%—45% target.

4.1.4.1 Industry is a major consumer of energy and emitter of CO_2

According to the International Energy Agency, a third of the world's energy consumption and 36% of CO_2 emissions are attributable to manufacturing industries. The large primary materials industries – chemical, petrochemicals, iron and steel, cement, paper and pulp, and other minerals and metals, account for more than two-thirds of this. Overall, the energy consumption by industry globally has increased by 61% between 1971 and 2004, albeit with rapidly growing energy demand in developing countries and stagnating energy demand in OECD countries. Despite their high emissions profile, global demand for hard-to-substitute goods such as steel and petrochemicals is unlikely to fall rapidly over the next decade and beyond – the decisive period in the global response to climate change.

4.1.4.2 Heavy industry sectors will still be important for China's economic development by 2020 and 2030

If challenges in the industrial sectors can be addressed, the overall performance of China's economy will be put on a secure footing. In the next decade, as the Chinese economy and society continue to develop with gradual industrialization and urbanization, China's energy-intensive industries are expected to expand in varying degrees, resulting in a continuing increase in energy consumption and greenhouse gas emissions from these sectors.

4.1.4.3 LCI will play a significant role in the transformation of China's economic pattern

Analysis by the Task Force shows that achieving the 40%–45% carbon intensity reduction target will rely on innovation. This is partly because improving energy efficiency using existing technology will become progressively more challenging as China's industry approaches the best available standards.

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6 Scenarios were also produced for the CCICED Low Carbon Economy Task Force in 2008. The 50% improvement shown in Figure 4-4 results in a similar level of emissions in 2020 to the "enhanced low carbon scenario" in the report of the LCE TF, while a 45% improvement falls roughly half way between the LCE TF's "business as usual scenario" and "low carbon scenario".

4.1.4.4 Global economic trends after the financial crisis – the resurgence of manufacturing

Following the global economic downturn, many countries hope to seize the opportunity to develop new low carbon technologies. For China, the occasion provides a major opportunity to improve global competitiveness. The financial crisis of 2008 confirmed a global trend in the making over the past decade – that of shifting economic power across the globe, and the rise of several emerging economies as major geo-economic actors. In 2010, China overtook Japan as the world's second largest economy in terms of nominal GDP, even though, at USD 3 678, its per capita GDP is still one-tenth of Japan's.

Many developed countries have bolstered their industrial policies and are pursuing more interventionist strategies. For example, the US launched *A Strategy for American Innovation: Driving Towards Sustainable Growth and Quality Jobs* in September 2009,[7] the EU adopted *Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth* in June 2010,[8] and Japan announced details of its *New Growth Strategy by 2020* in June 2010 and approved it in January 2011[9] (see Box 4-1).

Box 4-1 Japan's new growth strategy

In mid-2010 the Japanese government announced 21 National Strategic Projects for the revitalization of the country in the 21st century. These projects affected a wide variety of sectors: energy, transport, urban construction, manufacturing and healthcare, to name but a few. Under the subheading of Green Innovation, three specific projects have been proposed:

(1) Expansion of Japan's renewable energy market:

① Expanding the purchase of renewable through the feed-in tariff system;
② Introducing smart grids to make the system more efficient and enable greater integration of renewables;
③ Promoting the construction of renewables through the creation of implementation zones;
④ Providing financial assistance to strengthen finance mechanisms;
⑤ Stimulating demand for heat from renewable energy.

(2) Future Cities Initiative:

① Creating a world-leading "future city" through future-orientated technologies, schemes and services;
② Implementing a comprehensive package of policy measures, including regulations, tax incentives, and budgetary support for key technologies;
③ Spreading the initiative throughout Asia.

(3) Forest and forestry revitalization plan:

① Raising self-sufficiency in timber to 50%, thereby helping to revitalize local economies;
② Promoting sustainable forestry practices.

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7 White House, February 2011. *A Strategy for American Innovation: Securing Our Economic Growth and Prosperity*. www.whitehouse.gov/innovation/strategy.

8 European Commission, 2011. *Europe 2020: EU's Growth Strategy*, see http://ec.europa.eu/eu2020/index_en.htm.

9 METI, 2011. *New Growth Strategy*. www.meti.go.jp/english/policy/economy/growth/index.html.

Emerging economies have maintained and accelerated support for manufacturing during the global economic downturn. Brazil's development bank, BNDES, financed 40% of the investment in infrastructure and manufacturing domestically in 2009,[10] and South Africa launched a revised Industrial Policy Framework Action Plan in February 2010. China has many initiatives to support manufacturing, from support for R&D to the training of engineers. The country's foreign investment has also increased from USD 9.1 billion in 2005 to USD 63.9 billion in 2009, mostly in the key inputs of the manufacturing processes – energy, metals and chemicals – as well as transportation and communications.[11] National and regional governments have also supported the development of special economic zones and industrial parks in China, Korea and beyond.

The World Bank has shifted its position away from the non-interventionist Washington Consensus, noting that while industrial policy has often failed, "the historical record also indicates that in all successful economies, the state has always played an important role in facilitating structural change and helping the private sector sustain it across time".[12] Infrastructure, private investment and job creation, human resource development, trade, financial inclusion, growth with resilience, food security, domestic resource mobilization and knowledge-sharing – key pillars of strong and sustainable economic growth – will all require reform and transformation.

A study by Deloitte and the US Council on Competitiveness pointed to what it described as a "new world order for manufacturing competitiveness" in less than a decade, along with a tectonic shift in regional manufacturing competence. Deloitte's Global Manufacturing Competitiveness Index (GMCI) highlights the rise in the manufacturing competitiveness of three countries in particular – China, India, and the Republic of Korea – which appears to parallel the rapid growth of the Asian market.[13] According to the GMCI, the US, Japan and Germany, the former manufacturing superpowers, are now lagging behind these three.

4.2 A Low Carbon Industrialization Strategy for China

Over the next ten years, China will make significant improvements in energy and

10 Luciano Coutinho, 2010. *Challenges for Industrial Policy, Innovation and Competitiveness in Brazil.* BNDES. Presented at the Woodrow Wilson International Centre www.wilsoncenter.org/events/docs/BNDES%20in%20Woodrow% 20Wilson%20BR-US%20BCouncil%2015%20July%202010.pdf.

11 John Bruner, 2010. *China widens its reach.* Forbes. April 21, 2010.

12 Justin Yifu Lin and Célestin Monga, 2010. *Growth Identification and Facilitation: The Role of the State in the Dynamics of Structural Change*, The World Bank, Washington DC. Available: www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2010/05/18/000158349_20100518154747/Rendered/PDF/WPS5313.pdf.

13 Deloitte Touche Tohmatsu and US Council on Competitiveness, 2010. *Global Manufacturing Competitiveness Index*, pp. 13-16.

carbon intensity, but the country can also lay the groundwork for a critical industrial transition between 2020 and 2030 through four measures: supporting emerging industries, accelerating innovation, developing infrastructure and reforming institutions.

Low carbon industrialization has three major pillars: restructuring industry to give a greater share to lower carbon, high-value industries and to change the energy mix; technical innovation, including the upgrading of heavy industries; and institutional development.

4.2.1 Optimizing China's industrial structure

Structural change will be very important for the "12th Five-Year Plan" and for the future of China's economic growth. As is clear from Figure 4-4, industry currently consumes a much higher proportion of energy than other countries. China needs to accelerate the development of tertiary industry and cultivate low carbon and strategic emerging industries.

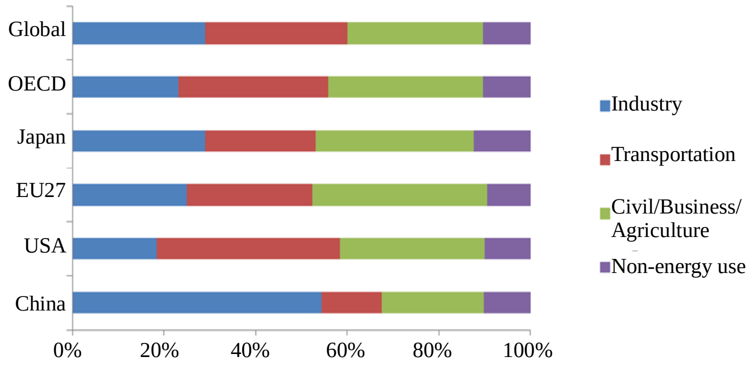

Figure 4-4 Industry's share of final energy consumption in selected countries

Source: Institute of Energy Economics Japan and Japan Energy and Economic Statistics Brochure 2010.

(1) *Guiding the merging and reorganization of enterprises*. In the "12th Five-Year Plan" period, China plans to promote competitive enterprises in the following industries: automobiles, iron and steel, cement, machinery manufacturing, aluminium electrolysis, rare earth elements, electronics and information, and pharmaceuticals. Win-win corporate partnerships will be encouraged, as well as trans-regional merging and reorganization, and a higher industrial concentration. Furthermore, China aims to encourage heavy industries to consolidate and to co-locate in industrialization zones, while outdated production facilities will be closed down. Regulations on performance standards and the efficient use of energy and materials are improving but effective monitoring by regulatory agencies and tougher penalties for non-compliance are needed.

(2) *Increasing added value and progression up the value chain*. Although China has already

become a sizable industrial nation, it is far from being a world leader in many industrial areas. Product added value rates remain low in many sectors, and economic output per unit of energy consumption and greenhouse gas emissions has much room for improvement. In 2007, the added value rate in China's manufacturing sector was 26.5%, far below the average level of 35% in developed countries, especially the US where it is 45.9%. China is set to adopt a range of measures aimed at encouraging enterprises to increase R&D investment, bring new products to market and move to the high-value end of industrial chains. This will help to promote the international competitiveness of products and raise their added value.

(3) *Cultivating strategic emerging industries*. The strategic emerging industries are planned to become the backbone of the national economy, constituting 8% of GDP by 2015 and 15% by 2020 — with much potential for this to expand by 2030. These industries not only feature high capital and technology intensiveness and higher added value compared with traditional industries, but will also help to transform and upgrade the traditional heavy industries, playing a key role in reducing energy and carbon intensity.

(4) *Optimizing the structure of Chinese industry*. In 2010, the ratio of the primary, secondary and tertiary industries in China was 10:47:43, with the proportion of tertiary industry in its national economy being 30% lower than the average in developed countries. Policy frameworks can encourage the service industries to become a major driver for economic growth in future, and because the tertiary sector tends to require less material inputs than heavy industry, such a shift would help lower China's energy and carbon intensity. The adjustment of the energy structure is a special case – here, the key is to raise the share of non-fossil fuels in primary energy consumption (see Box 4-2).

Box 4-2 Reforming the structure of the energy sector

In the coming decade, the adjustment of energy structure will also be crucial to the achievement of low carbon industrialization. To lower carbon emission intensity further, the adjustment of energy structure must involve two measures: the adjustment of the proportions of fossil to non-fossil energy, and the adjustment of the structure of fossil energy.

Raising the proportion of non-fossil energy. In 2009, the proportion of non-fossil energy to total energy consumption in China was 78%. To lower carbon emission intensity, the proportion of fossil energy consumption in industry must be reduced. The Chinese government proposes to raise the proportion of non-fossil energy to primary energy consumption to 15% by 2020.

Optimizing the pattern of fossil energy consumption. In 2009, the proportions of coal, oil and gas to total energy consumption were 70.4%, 17.9% and 3.9% respectively. In industry, the proportion of coal resources to energy consumption is also very high. Furthermore, to lower the proportion of the consumption of coal resources with low calorific value and high carbon content, China must undertake R&D and demonstration of coal-based synthetic natural gas, coal-based liquid fuel, and coal-based poly-generation; step up exploration and development of oil and gas resources, particularly promoting the rapid growth of natural gas production; and boost the development and utilization of unconventional oil and gas resources such as coal bed methane (CBM) and shale gas.

4.2.2 Promoting technological advancement

Innovation is at the core of low carbon industrialization, and essential for accelerating energy conservation, not least because the potential for emissions reduction from existing technologies is decreasing. New technologies and systems are required if China is going to tackle increasing energy and resource consumption, and innovation is also the key to industry's progress towards maximum value addition in sectors such as renewable energy and electric vehicle production.

The development of energy technologies rarely follows a linear logic or evolves within the boundaries of individual economic sectors, and many breakthrough innovations occur precisely when different fields interact. For example, innovation in solar photovoltaic technologies has benefited from developments in consumer and industrial electronics, and advances in concentrating solar power derived from aerospace and satellite technologies. It is therefore essential to create an innovation system that encourages interaction between sectors, as well as between foreign and domestic firms. It would also be a mistake to focus only on the specific priorities of a particular technology as the nature of future breakthroughs is often difficult to predict.

Innovation in the supporting infrastructure for low carbon technology deployment will also play a vital role. For example, in terms of the charging network for electric vehicles and grid extensions to connect dispersed renewable energy generation. There has been considerable interest in "smart grid" innovation in recent years, since a more flexible model for electricity would allow for greater penetration of renewables and better demand management, spreading demand so that less generating capacity is needed at peak times.

Even though global R&D investment is mostly undertaken in the private sector and is increasingly global in nature,[14] government action and public policy can help leverage the power of private markets to solve low carbon innovation challenges. While public spending on overall R&D increased by 50% between 1988 and 2004, public energy-related R&D declined by 20% over the same period. However, in recent years, partly as a result of the stimulus packages, energy expenditure has increased in a number of countries while over the same period private-sector R&D in energy decreased.[15] The other trend to note is a strong bias towards certain technologies. Nuclear power (both fission and fusion) has received over

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14 Government and non-governmental organizations spent around $350 billion on R&D globally in 2006 (40% of the total). Private sector spent the rest 60% ($525 billion) (Batelle, 2008 cited in OCC, 2008).

15 The discussion in this section is drawn from the analysis in Thomlinson et al., E3G and Chatham House (2008), Innovation report.

half of all state R&D budgets from the G7 countries over the last two decades, more than five times their combined energy efficiency budgets.[16]

In 2005, China became the third largest R&D spender worldwide (in purchasing power parity terms), after the United States and Japan. Firms in emerging economies are also increasingly investing in developed countries. A recent study showed that Chinese firms alone set up 37 R&D units abroad, of which 26 are based in developed countries (11 in the United States and 11 in the EU).[17] Emerging-economy firms have also acquired developed-country firms in order to gain access to their intellectual property and markets.

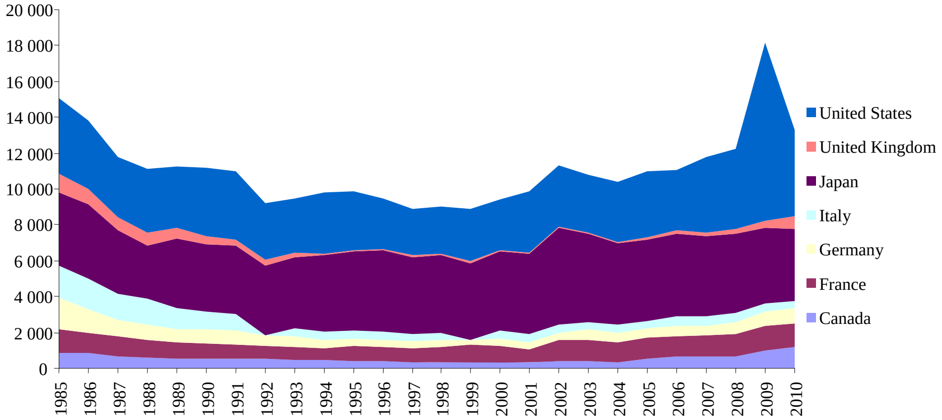

Figure 4-5 Public energy-related R&D spending in G7 countries, 1985—2010 (USD m, 2010)

Source: IEA database of R&D, 2011[18].

The challenge of bridging the gap between the R&D phase and full-scale commercialization can represent a significant limiting factor in the uptake of new technologies. The size and complexity of demonstrating these new technologies, which often includes intricate planning and infrastructural support, makes it difficult for the private sector to finance them independently. This is particularly the case with large-scale or unproven technologies, such as carbon capture and storage (CCS) and bio-refineries. Public funding, public–private partnerships and joint ventures are an effective way of raising the necessary capital and pooling expertise essential to getting a new project off the ground.

16 Glachant et al., December 2008. *Invention and transfer of climate change mitigation at global scale: a study drawing on patent data*.

17 von Zedtwitz, 2005 cited in OECD, 2008.

18 IEA, 2010. *International Energy Agency database of research and development*, accessed September 2011, http://www.iea.org/Textbase/stats/rd.asp. The 2010 value for France was unavailable so is assumed to be equal to the 2009 value.

4.2.2.1 Addressing resource and technology challenges

The scaling up of low carbon technology comes with a range of environmental, material and security risks. The predicted availability and price of a material will be an important consideration in the development of a particular design of a technology and will therefore help to frame the development path of a particular sector. These risks include:

(1) Access to materials or fuels needed for the manufacture or use of the new energy source;

(2) Use of resources – particularly if there is an impact on water or land use;

(3) Use of equipment, materials or fuels for military means – the dual-use capabilities.

For the foreseeable future low carbon technologies will depend on critical inputs from heavy industry – from the steel, concrete and plastics required for wind turbines to insulation materials and the batteries in electric cars. The EU wind industry alone consumes 700,000 tonnes of steel.[19] The 20GW of new wind capacity in China in 2010 is equivalent to about 2% of Chinese steel production in the same year.[20] High-voltage transmission networks will be another major area of steel demand. One million electric vehicles would require perhaps one-fifth of the current global production of lithium carbonate.[21]

Rare earth elements (REE) are a group of 17 elements (atomic numbers 57–71 along with Scandium and Yttrium) whose unique properties currently make them indispensable in a wide variety of advanced technologies. For example, some advanced wind turbines use permanent magnets instead of traditional gears, but about 2 tonnes of neodymium are required for each windmill. Demand for REE used in batteries is expected to grow at 10%—16% between 2008 and 2012, and those used in the manufacturing of batteries at 15%—20% per year.[22]

Today, access to REE for clean energy production is already creating trade tensions between China and the US. This is a result of China's recently imposed trade restriction on the export of Neodymium (Nd), Europium (Eu), Cerium (Ce) and Lanthanum (La) to 35,000 tonnes per year, and complete stop on exports of Thulium (Tm), Terbium (Tb), Dysprosium (Dy), Yttrium (Y) and Lutetium (Lu), as China states that it needs these REM resources for its own economic development in the coming years.[23] However, REE are not the only elements needed for new energy technologies. Table 4-2 shows a range of other materials that

19 World Steel Association www.worldsteel.org/pictures/programfiles/Wind%20energy%20case%20study.pdf.

20 Chatham House calculations, 2011, based on current technology.

21 Chatham House calculations based on 20kg Lithium Carbonate per vehicle – amount varies considerably by technology choice.

22 NEF, 2009. *Unearthing the Rare Earth Market for Clean Energy Investors,* New Energy Finance, January 2009.

23 Smith, 2010. Written Testimony, Mark A. Smith, Chief Executive Officer, Molycorp Minerals, LLC House Science and Technology Committee, Subcommittee on Investigations and Oversight "Rare Earth Minerals and 21st Century Industry", March 16, 2010.

will be needed in significantly greater volumes for key technologies in the low carbon economy.

Table 4-2 Raw materials used in new energy technologies

Raw material (application)	
Fuel cells	Platinum Palladium Rare earth metals Cobalt
Hybrid cars	Samarium (permanent magnets) Neodymium (high performance magnets) Silver (advanced electromotor generator) Platinum group metals (catalysts)
Alternative energies	Silicon (solar cells) Gallium (solar cells) Silver (solar cells, energy collection, transmission, high performance mirrors) Gold (high-performance mirrors)
Energy storage	Lithium (rechargeable batteries) Zinc (rechargeable batteries) Tantalum (rechargeable batteries) Cobalt (rechargeable batteries)

Source: Materials Innovation Institute, November 2009[24].

4.2.2.2 Access to new technologies

For smaller businesses, or for new entrants, access to new technology and software is critical in enhancing the chance of securing financial support, whether venture capital or equity investments. Companies may use patents to deter the entry of competitors, and shape the industry into an oligopoly able to charge prices above marginal costs and thus potentially support research.[25] However, the likelihood that the patent system will encourage research, that there will be cross-licences to disseminate technology and that such cross-licences will encourage innovation and implementation are all dependent on the competitive conditions of the industry.

24 Mi2, 2009. *Material Scarcity, Materials Innovation Institute*, November 2009.

25 See, for example, J. Barton, *Antitrust treatment of oligopolies with mutually blocking patent portfolios*, Antitrust Law Journal 69:851-882 (2001).

4.2.2.3 Price stability

Higher oil prices make non-fossil-fuel alternatives comparatively cheaper and as such can help determine the rate of their deployment. However, somewhat perversely, the wider the deployment of low carbon technologies and practices, the smaller the demand for fossil fuels, which in turn will reduce their price, making low carbon fuels less economically attractive. Even so, if assumptions are made that the finite nature of fossil fuels (in particular oil) and the global growth in demand will ultimately lead to higher energy prices, the gap between the current costs of fossil fuels and the alternatives could narrow rapidly.

Projections of the overall cost of the transition to a low carbon economy are therefore highly sensitive to assumptions about future energy and resource prices. McKinsey's 2009 report on a global carbon abatement cost curve explains that:

If we assume an average price of USD 120 per barrel rather than the USD 60 a barrel price assumed by the IEA in the BAU forecast we use, and that other energy prices increase proportionally, this reduces the total cost of abatement in 2030 by approximately €19 per tCO_2e, equivalent to cutting the total cost of abatement in 2030 by approximately €700 billion annually. As a very rough rule of thumb increasing oil prices by USD 10 (€6.7) per barrel cuts average abatement costs by €3 per tCO_2e within the USD 60–120 per barrel range.[26]

In another report by McKinsey, undertaken for the Republic of Ireland, the same variation in oil prices had a profound impact on the economic viability and carbon abatement costs of renewable energy technology. In this case onshore wind had a carbon abatement cost of €10/tCO_2 in the USD 60 scenario but a saving of €82/tCO_2 in the USD 120 scenario.[27]

In any case, even within a short time period the estimated cost of new technologies can vary significantly. In some areas, learning curves, economies of scale and new efficiency in production are driving down the cost of energy production. For example, a study by Lawrence Berkeley National Laboratory on solar PV found that average installation costs had decreased 30% over the past decade, falling from USD 10.80 per watt in 1998 to USD 7.7/W by 2009. However, the report noted that US costs are still significantly higher than those of other countries such as Germany and Japan, where average installed costs stand at USD 4.7/W and USD 5.9/W respectively. However, in other cases costs are not decreasing and may even be increasing. The CEO of the largest US nuclear utility Exelon has recently stated that "economics of low carbon options have changed dramatically" in just two years, with the company's new-nuclear cost estimates having more than doubled to about USD

26 McKinsey, 2009. *Version 2 of the Global Greenhouse Gas Abatement Cost Curve*.

27 SEI, 2009. *Irelands Low Carbon Opportunity, Sustainable Energy Ireland*, Assessment carried out by McKinsey, July 2009.

100/t CO_2, ten times the cost estimated by McKinsey.[28]

In most cases these low carbon and resource-efficient options bring significant additional societal benefits such as improved local environments, price stability and local and national job creation. However, the most important additional benefit relates to security of resource supply and increasingly price security. Diversifying away from fossil fuels or reducing their use will aid a country or region's energy independence, and therefore reduce the risk of supply interruption.

4.2.3 Institutional strengthening and reform

The next wave of improvement on energy and carbon intensity in China will require a stronger focus on institutional barriers. Institutional performance is also the key to implementing core policies, from energy efficiency targets to green taxation systems. China should make comprehensive use of tools such as market entry rules, energy and carbon pricing, fiscal measures, taxes and financial policies to improve the incentive system and framework for technical innovation. Although the state has traditionally supported new and emerging industries in China, a proliferation of multiple, independent policy plans has often undermined attempts to develop these industries into market leaders.

Today, the supporting infrastructure for technological innovation is inadequate. Research institutions are scattered across many universities with limited networks, and common platforms for the development and commercialization of standardized technologies have been slow to develop. In addition, firms in the emerging pillar in China typically have weaker R&D capabilities than their competitors in developed countries. This is especially true of smaller firms in China, which often have very limited R&D capacities.

New bridges are required between advanced academic institutions and entrepreneurial businesses to help turn new advances into low carbon growth. Scientific research in China currently depends on higher education and scientific research institutions. These focus on research and development breakthroughs rather than scaling up deployment of new products or fostering new industries. At the same time, many enterprises – some restricted by inappropriate infrastructure or insufficient funds –some inexperienced and with no long-term development plan – continue to rely on well-established technologies and are not enthusiastic about cooperating with universities to help bring new innovations to market. To bridge this commercialisation gap, China could draw on the experience of the UK's Carbon Trust and the Sustainable Development Technology Canada – two competing models for bringing low

28 John Rowe, 2010. *Fixing the Carbon Problem Without Breaking the Economy*. Exelon, 12 May 2010.

carbon technologies to the mass market. The Carbon Trust claims to have helped drive around GBP 1 billion of additional investment into the development and deployment of low-carbon technologies, markets, products and services between 2001 and 2009.[29]

There is also a lack of technical standards, testing and accreditation in many of the emerging sectors in China. The experience of the renewables industry highlights the problems that this can generate: initially firms rushed into the industry, causing strong competition. However, policy incentives and the lack of an entrance threshold led to the industry becoming inundated with newcomers. There are now over 70 wind-power generator manufactures, the largest four of which have a total capacity of over 12 GW, and there are more than 30 polycrystalline silicon manufacturers. Lacking core technology and innovation capacity, these companies have tended to compete on price at the expense of product quality and consistency. Owing to the explosive growth of the industry, many products have only had a very short cycle from R&D to mass production and before sufficient testing regimes had been implemented, so potential problems may not have been fully exposed or effectively resolved.

4.3 Heavy Industry is Key in the Short to Medium Term

The energy consumption of the heavy industry sectors in China is set out in Figure 4-6. These sectors have an enormous contribution to make in terms of short-term energy and emissions reductions over the next ten years and beyond.

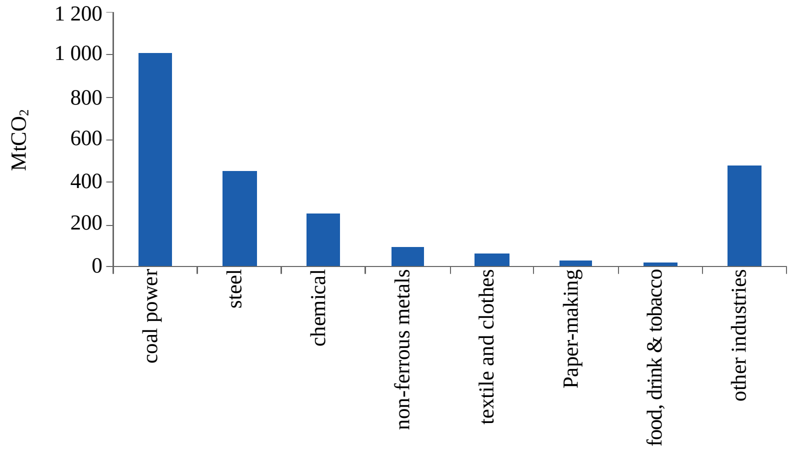

Figure 4-6 Energy consumption of heavy industries in China in 2010

Source: LCIS Task Force analysis.

29 OECD, 2010. *Better Policies to Support Eco-innovation*. See case studies on Carbon Trust and SDTC.

In terms of economic restructuring, the proportion of industrial added value coming from these energy-intensive industrial sectors will decrease by about 5% in 2020 compared with 2005, avoiding 4–5 Gtce energy consumption and 9-11 $GtCO_2$.

For rapid progress, barriers such as perceived technical risk, financial risk, and lack of investment and information will need to be overcome. Most importantly, clear, credible and long-term policy frameworks are required to push forward on energy- intensity improvements. For more advanced technologies, further research and development are required. Some of the major projects for heavy industry in the "12th Five-Year Plan" are listed in Box 4-3.

Box 4-3 Projects in the "12th Five-Year Plan"

① *Energy conservation and transition*

Continuing cogeneration, motor equipment energy optimization, surplus heat/pressure utilization, boiler (kiln) improvement, oil saving/replacement, building and traffic energy savings, and green lighting.

② *Popularizing energy conserving products*

Directing financial subsidies to energy-saving and high-efficiency products in electrical appliances, automobiles, motor equipment and lighting.

③ *Commercialization of energy-conserving technology*

Supporting the demonstration of key energy conservation technologies, products relating to the utilization of surplus heat and pressure, and high-efficiency generators; promoting the large-scale production and application of products with crucial energy conservation technologies.

④ *Contracted energy management for ESCOs*

Encouraging energy conservation service companies to use contracted energy management to reach the energy conservation target, and supporting the development and growth of the energy-conservation service industry.

Source: The "12th Five-Year Plan" .

4.3.1 Conserving energy

In the next decade, the energy-intensive industrial sectors can avoid a total of 456 Mtce of energy by 2020 if they adopt 79 key technologies[30] identified by this Task Force, equivalent to 1.22 $GtCO_2$ (see Figure 4-7).

30 Those 79 kinds of existing industrial energy conservation technologies include: 18 in electricity (4 are advanced thermal power generation technologies) ; 11 in steel; 15 in building materials; 17 in petrochemical industry; 9 in non-ferrous metal; 5 in textile; 4 in papermaking.

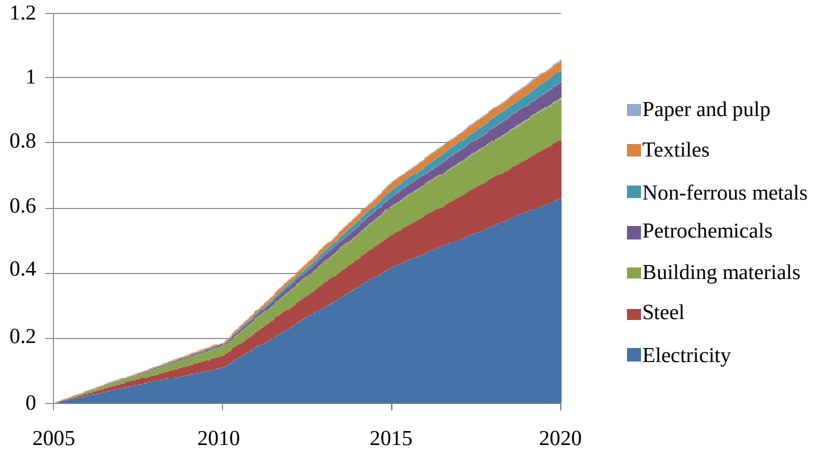

Figure 4-7 The potential impact of 79 kinds of industrial energy conservation technologies on China's CO_2 emissions (2006—2020 in $GtCO_2$)

Source: LCIS Task Force analysis.

However, this would just be scratching the surface of what is possible. If all the available energy-efficiency technologies (both existing and emerging) were to be widely and immediately deployed, 6.5–7.5 Gtce of energy demand could be avoided by 2020, equivalent to 17–19 $GtCO_2$. The most important technologies for energy efficiency in the steel, non-ferrous metals, petrochemicals and buildings materials sectors are set out in Box 4-4.

It is critical that investment for the development and promotion of industrial energy conservation technologies is delivered as soon as possible. The required investment in the 79 priority technologies alone would cost industry nearly RMB 1 trillion in the period 2011—2020. If all of the energy technologies that can be used in energy-intensive industrial sectors are promoted and applied in a timely fashion, investment could reach RMB 1.6–2.0 trillion over the next decade. However, these investment costs do not reflect the many savings that would be achieved through the application of such technologies. As China gradually moves towards a market price for energy, the payback periods for investments will also speed up.

Table 4-3 sets out the progress that Chinese industry has made in closing the gap with the average level of energy efficiency in developed countries ("international advanced level" – IAL) in each sector. For example, coal power required nearly 19% more fuel for every unit of power produced in 2005 than in OECD countries. By 2009 this had been reduced to 9%. For steel, the gap had closed from 17% to 6%. The changes are effected through the upgrading or closure of older plants (although a significant number of smaller plants are not recorded in the figures) as well as through more efficient new capacity.

Box 4-4 Key technologies for energy efficiency in heavy industry

Steel:

① Develop coke dry quenching equipment compatible with coke ovens.

② Equip all newly built blast furnaces with top pressure power generation equipment.

③ Employ advanced technologies and equipment such as feeding furnaces with carefully selected ores, using enriched coal spray, hot metal pre-treatment, large blast furnaces, converters and electric arc furnaces, external refining, continuous casting, tandem rolling and Thermo Mechanical Control Process.

④ Recycling and utilization of gases from coke ovens, blast furnaces, converters, combined cycle power generation with gas and steam, top pressure power generation of blast furnaces, evaporative cooling, smoke gas, dusts and solid wastes.

Non-ferrous metals:

① Utilize large and energy-efficient equipment in mines.

② Use oxygen-enriched flash and bath smelting technology in copper smelting, large prebaked cell in electrolytic aluminium, Queneau-Schuhmann-Lurgi process (QSL) and other direct smelting technology in smelting lead, and develop new zinc hydrometallurgy technology.

Petrochemicals:

① Employ technologies related to the optimized configuration of oil extraction equipment, energy-saving for heavy oil thermal recovery, optimized operation of water-flooding systems, carbon dioxide reinjection, energy saving for oil-gas tight line gathering and transportation, recycling of burned gases in the oilfield.

② Improve the mix of raw materials for ethylene production. Adopt advanced technology to improve ethylene cracking furnaces. Employ energy-saving technology in ammonia synthesis plants. Utilize new catalyst and energy-efficient equipment. Promote reclamation of stack-gas afterheat technology in natural-gas based ammonia synthesis. Speed up the conversion from crude oil to natural gas in petroleum-based ammonia synthesis. Adopt energy-efficient equipment and pressure swing absorption technology in small and middle-sized ammonia synthesis.

③ Replace traditional fixed-bed gasification technology with coal water slurry or advanced ash coal gasification technology. Gradually replace use of the metal-anode-diaphragm cell process to produce caustic soda by use of the ion-exchange membrane method.

Building materials:

① *Cement:* Develop new decomposition-outside-kiln technology. Actively promote energy-saving grinding equipment and kiln waste heat power generation technology. Upgrade middle-sized and large rotary kilns, grinding machines, dryers. Gradually eliminate shaft kilns, wet-process kilns, dry and hollow kilns and other outdated technologies. Replace mineral fuels with flammable wastes. Ensure comprehensive use of industrial solid wastes and tailings.

② *Glass*: develop advanced float and eliminate outdated vertical and horizontal drawing technology. Promote inclusive heat preservation technology for both furnaces and kilns as well as oxygen-rich and oxy-fuel combustion technology.

③ *Ceramics*: eliminate outdated kilns such as downdraft kilns, pusher kilns and beehive kilns, and promote roller kilns.

④ *Sanitary ware*: change fuel mix to adopt clean gas combustion and no-ring firing process. Promote new wall materials and high-quality environment-friendly sound- and heatproof materials, waterproof materials and sealing materials, increase the proportion of high-performance concretes to ensure longer building life.

Table 4-3 Major industrial products in China versus IAL of energy intensity

Total Energy Consumption (kgce/t unless otherwise stated)	China			International Advanced Level	Gap (2005)		Gap (2009)	
	2005	2008	2009		Energy consumption	Percentage gap	Energy consumption	Percentage gap
Thermal efficiency of electricity generation (gce/kWh)	370	345	339	312	58	18.6	27	8.7
Aluminium (kWh/t)	14 680	14 323	14 131	14 100	580	4.1	31	0.2
Copper smelting	780	564	548	500	280	56.0	48	9.6
Steel* (kWh/t)	714	663	644	610	104	17.0	34	5.6
Cement	167	151	139	118	49	41.5	21	17.6
Oil refining	114	106	106	73	41	56.2	33	45.3
Ethylene	1 073	970	954	629	444	70.6	325	51.7
Ammonia	1 650	1 549	1 521	1 000	650	65.0	521	52.1
Caustic soda	1 297	1 154	1 075	910	387	42.5	165	18.1
Soda ash	396	345	306	310	86	27.7	–4	–1.2
Paper and paperboard	1 380	1 158	—	640	740	115.6	518	80.9

* Steel figures refer to large and medium size enterprises only. For more information on the data presented in this table please see the full version of the LCIS TF report.

Source: LCIS Task Force analysis of industry sources[31].

Significant potential savings exist even beyond the IAL level. This is because the average industrial plant in developed countries is older than in China and will often be much less efficient than the best available technologies. For example, according to UNIDO, producing one tonne of aluminium required 13.4MWh of electricity with the best available technology in 2007, whereas in a selection of industrialized countries it ranged from 14.8 to 15.8MWh/t at that time. The IEA estimates that China could still save an additional 0.9GJ/tonne of steel.[32]

All energy-intensive sectors are expected to make very significant cuts in energy intensity over the next ten years. Analysis by the Task Force indicates that paper and cement production have the potential to make the largest savings per unit of product, but all of these sectors have the potential to reduce carbon intensity by 2020 by at least 15% from 2005 levels (see Figure 4-8).

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31 Industry sources: State Statistics Bureau, Ministry of Industry and Information Technology, China Electricity Council, China Iron and Steel Association, China Building Materials Industries Association, China Association for Chemical Energy Saving Technologies, Handbook of Energy & Economic Statistics in Japan (2010) by the Institute of Energy Economics, Japan, Journal of the Japan Institute of Energy, Iron & Steel Institute Japan and Korea Iron & Steel Association.

32 IEA, 2009. *Energy Technology Transition for Industry*, International Energy Agency 2009.

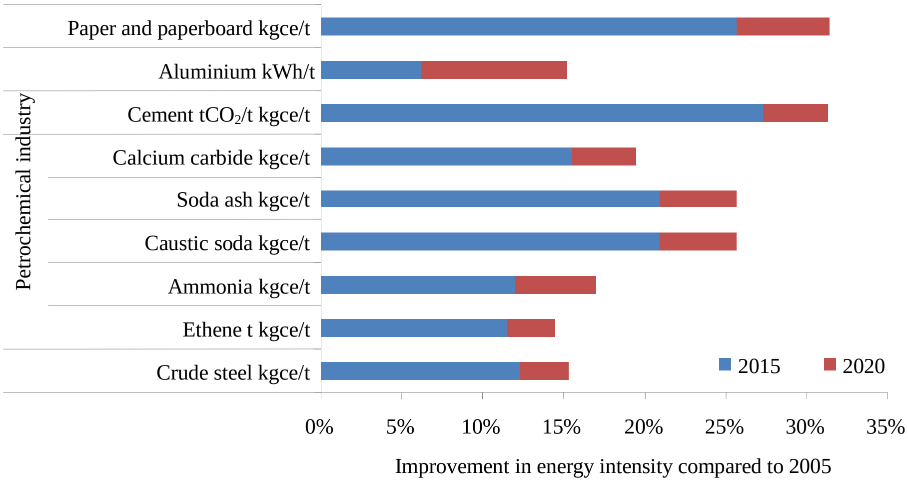

Figure 4-8 Potential for energy intensity improvement by 2020 in energy- intensive sectors (2005 baseline)

Source: LCIS Task Force analysis.

Despite these improvements in intensity, growth in demand for these products means that absolute energy consumption and demand will continue to increase for the next few years at least. Despite this, analysis by the Task Force suggests that by 2020 this situation may already have been reversed for some of the heavy industries (see Table 4-4. Overall, emissions from these seven heavy industries will climb dramatically by about 50% between 2005 and 2015, but just 6% between 2015 and 2020.

Table 4-4 Projections for heavy industries: production, energy consumption & carbon emissions

	Production (Mt)			Energy consumption (Mtce)			Carbon emissions ($MtCO_2$)		
	2005	2015	2020	2005	2015	2020	2005	2015	2020
Crude steel	353	710	800	262	462	501	769	1214	1277
Ethene	7.6	20.0	28.2	8.2	19.1	26.1	19.0	44.4	60.5
Ammonia	46.0	55.0	58.7	81.5	85.9	86.4	188.3	198.4	199.6
Caustic soda	12.4	28.0	37.6	16.8	29.9	37.7	38.7	69.1	87.1
Soda ash	14.1	27.0	35.9	7.5	11.7	14.5	17.3	27.1	33.4
Calcium carbide	8.9	18.0	22.2	18.7	31.9	37.4	43.2	73.6	86.3
Cement	1070.0	2100.0	2400.0	159.6	227.6	245.8	368.8	525.8	567.7
Aluminium	7.8	20.0	24.7	42.0	87.5	94.6	67.8	141.5	153.0
Paper	62.1	133.0	145.0	32.6	51.9	50.2	75.3	119.8	116.1

Source: LCIS Task Force analysis.

For example, in the case of steel a 15% improvement in energy intensity between 2010 and 2020 would still result in absolute increases in energy consumption over the period, owing to a doubling in steel demand (see Figure 4-9). However, total CO_2 emissions would only increase slightly under these assumptions.

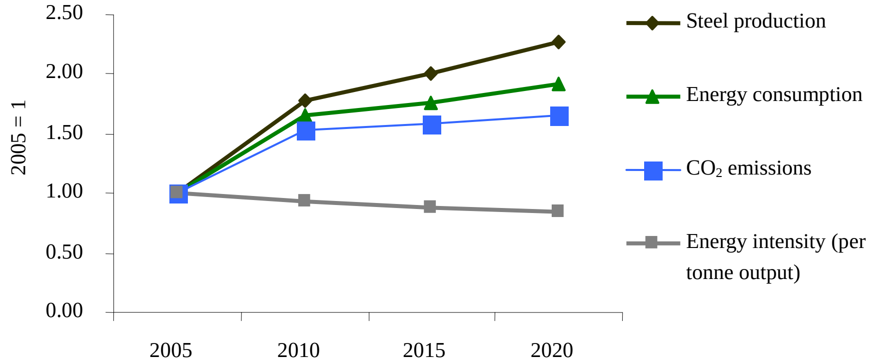

Figure 4-9 Steel sector – expected change in production, energy intensity, CO_2 emissions and energy consumption by 2020

Source: LCIS Task Force analysis.

The picture is similar for the cement industry. Here, carbon emissions are already close to peaking but will remain fairly flat over the next decade, climbing slightly by 2020 – in this case energy- intensity improvements largely offset the overall demand for cement, which is still increasing (see Figure 4-10).

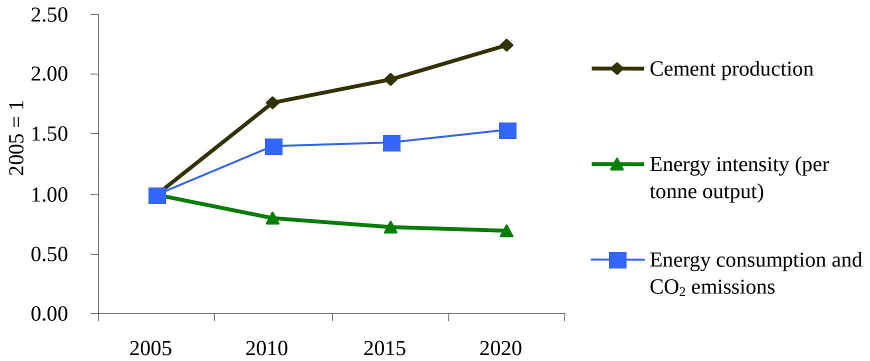

Figure 4-10 Cement: expected change in production, energy-intensity improvements and total energy consumption by 2020

Source: LCIS Task Force analysis.

Carbon emissions from the aluminum and papermaking industries are also expected to peak around 2020, but emissions from some petrochemical subsectors (e.g. ethane and calcium carbide) will still be climbing rapidly at this time.

4.3.2 The circular economy

The Chinese government has made progress towards achieving a circular economy – a key strategy for its national economy and social development, backed by the Circular Economy Promotion Law. This is also an important component of the LCIS.

According to China's cleaner production website, the concept can be defined as interlinked manufacturing and service businesses seeking the enhancement of economic and environmental performance through collaboration in managing environmental and resource issues. The focus is on the exchange of materials where one facility's waste, including energy, water, materials and information, is another facility's input.[33] In short, the idea is that significant additional efficiency gains can be achieved through cooperation between sectors and businesses on resource flows, energy and waste.

Today, China's energy-intensive industrial sectors consider improving their resource efficiency to be the primary target in the development of a circular economy. But as ever more waste accumulates, technologies for waste utilization and recycling will grow, so that energy saving, reutilization of waste and reclamation will deserve equal focus. The circular economy can help China's energy-intensive industrial sectors increase resource output efficiency, improve waste recycling efficiency, lower the consumption of energy, water and raw materials per unit, and reduce waste amounts and carbon dioxide emissions. According to China's circular economy yearbook 2010,[34] using waste steel in steelmaking requires 60% less energy than making primary steel from iron ore.

Most energy-intensive industrial sectors already have some foundation on which to develop a circular economy. For example, steel, non-ferrous metals, electrical power, the chemical industry, building materials and paper-making businesses have conducted pilot projects and have demonstrated the benefits of cooperation with other firms and efforts on recycling.

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33 China's Cleaner Production website: www.chinacp.org.cn/eng/cppolicystrategy/circular_economy.html.

34 Circular Economy Yearbook 2010, China Financial & Economic Publishing House.

Box 4-5 Key circular economy projects in the "12th Five-Year Plan"

① *Comprehensive utilization of resources*

Utilizing large bulk solid wastes such as, fly ash, coal refuse, industrial by-product gypsum, smelting wastes, chemical waste residue, tailings, construction wastes, as well as straw and waste wood. Several such bases will be established during the "12th Five-Year Plan".

② *Recycling system for waste products*

Demonstration areas in up to 80 cities will feature advanced waste product recycling systems, to achieve high rates of recycling of key products.

③ *Demonstration bases of "mineral industry in city"*

The circular economy in the mineral industry will be pursued in demonstration zones in 50 cities, deploying advanced technology and management and enhanced regulation of environmental standards. The demonstration areas will have a broad scope, including recycling of waste metals, waste electrical and electronic products, waste paper and plastics.

④ *Industrialization of re-manufacturing*

Several national re-manufacturing zones will be established, focusing on developing the size and quality of re-manufactured output from sectors such as automotive parts, construction machines, mining machines, machine tools and office supplies.

⑤ *Reclamation of kitchenware waste*

Several kitchenware waste reclamation facilities will be constructed in 100 cities, to improve the utilization and harmless disposal of kitchenware waste.

⑥ *Recycling transformation in industrial park*

Key industrial parks and industry cluster areas will make a major push on recycling.

⑦ *Promotion of resource-recycling technology*

Demonstration projects and service platforms consistent with the circular economy.

Source: The "12th Five-Year Plan".

The central and local governments in China have already introduced important measures to promote the circular economy, including planning and guidance, pilot projects, economic incentives and regulatory restrictions. The "12th Five-Year Plan" sets a target of 72% utilization for industrial waste by 2015, and an increase of 15% in the yield rate of resources. More supportive fiscal and financial policies will be introduced and laws, regulations and standards will be refined. China will establish lists of technologies and products to be included under the circular economy strategy. It will also set up a labelling system for re-manufactured products as well as a statistical and evaluation system. Energy- conservation technologies and techniques such as recycling, re-manufacturing and zero emission production, as well as cooperation between industries, will be developed and implemented.

At local government level, many provincial and municipal governments (such as in Gansu, Henan, Hebei, Zhejiang, Shenzhen and Dalian) have made local plans for the development of the circular economy, or plans focusing on special industrial sectors. Some local governments (such as Fujian) have already set up special funds dedicated to shifting to a circular economy.

Gansu province expects that its circular economy programme will deliver a 35% improvement in the energy intensity of nickel production, reducing it to 3.59tce/t by 2015. The province's recycling ratio for waste iron and steel, non-ferrous metals, paper, plastic and rubber will rise to 78%, 84%, 75%, 75% and 87% respectively. Altogether, 10Mtce of energy will be saved and more than 20 $MtCO_2$ will be avoided through these measures.[35]

4.3.2.1 Metal recycling

The proportion of secondary metals in China is far below that in developed countries. According to the China Non-Metallic Minerals Industry Association, China's secondary lead output in 2009 reached 1.23 mt or 33% of total lead output, compared with an average of 60% in OECD countries. Secondary copper output reached 2 mt, less than 40% of total copper output, compared with 60% in the US, 45% in Japan and 80% in Germany. Most Chinese metal recycling enterprises are small and inefficient, failing to achieve economies of scale. Moreover they often lack advanced technical equipment.

Making full use of scrap metals is important because recycling can have a remarkable effect on energy conservation and emissions reduction. For example, by 2015, secondary copper utilization can save 5.6 Mtce and avoid 103.9 $MtCO_2$.

4.3.2.2 Combined heat and power generation

CHP is a highly efficient way of utilizing energy, simultaneously generating both electrical energy and thermal energy. By avoiding condensation losses, the standard coal consumption rate of CHP is lower than separate generation by 15–20 kg/GJ for heat, and by 30–50 g/kWh for power. It is estimated that, compared with separate generation of heat and power, 0.8 Mtce could be saved by installing 1GW CHP units.

4.3.2.3 Cogeneration

Cogeneration means transforming excess thermal energy during the production process to electrical energy. It has significant implications for lowering industrial energy consumption and emissions, especially in energy-intensive industries, and has been implemented in many industries, such as cement, iron and steel, glass, chemicals, and non-ferrous metals. Nonetheless, further support is needed to scale up the use of

35 The overall plan of circular economy in Gansu.

cogeneration including an on-grid tariff and a pricing policy for waste heat.

4.3.3 Adjusting the energy supply structure

Compared with the global primary energy supply structure, China's primary energy supply structure is high carbon in nature, with coal constituting 70% of the total supply, while non-fossil energy sources constitute only a small part. This reliance on coal is a key cause of China's high level of carbon dioxide emissions per GDP. Shifting away from coal can make a great contribution to the transition of energy- intensive industrial sectors to a low carbon pattern, and to the reduction of carbon dioxide emission. In China's "12th Five-Year Plan", a target has been introduced requiring the proportion of non-fossil energy sources in the primary energy supply to increase from 8.3% in 2010 to 11.4% in 2015.

Box 4-6 Key energy projects in the "12th Five-Year Plan"

① *The exploration and transformation of coal*

Accelerating the construction of coal production bases in Northern Shaanxi, Huanglong, Shendong, Mengdong and Ningdong; developing coal bases in the northern, middle and eastern part of Shanxi, Yunnan and Guizhou; establishing coal bases in Xinjiang and setting up several large coal-fired power plants based on those bases.

② *Stabilization of oil output and increase in gas output*

Promoting the formation of five large-scale oil and gas production zones in Tarim and Junggar Basin, Songliao Basin, Ordos Basin, Bohai Bay Basin and Sichuan Basin. Speeding up the exploration of oil and gas resources in offshore and deep-sea areas. Developing the extraction and utilization of coal bed methane in coal-mining areas and increasing the oil-refining capacity.

③ *Nuclear power*

Accelerating the development of nuclear power in coastal provinces, maintaining th development of nuclear power in middle areas, and setting up nuclear power stations with a total capacity of 40GW.

④ *Renewable energy*

Building large hydropower stations on the Jinsha river, Yalong river, Dadu river and other main rivers with a total capacity of 1.2TW. Setting up six large wind- power stations, whose newly installed turbines will have a total capacity of more than 70GW. Building solar power stations with capacity of 5GW in key areas such as Tibet, Inner Mongolia, Gansu, Ningxia, Qinghai, Xinjiang and Yunnan.

⑤ *Network of oil and gas pipelines*

Constructing the pipelines in the second phase of the Sino-Kazakhstan oil projects, in Chinese areas involved in the Sino-Myanmar oil and gas project, in the second phase of the Central Asian natural gas project, as well as pipelines in the third and fourth project of the West to East Gas Pipeline Project. The total length of the pipelines under construction is 150,000 km. Also accelerating the construction of gas storage facilities.

⑥ *Power grid*

Accelerating the construction of large coal-fired power stations, hydropower stations and wind-power stations which can provide electricity to other regions, building up several cross-regional power transmission channels with advanced UHV technology. A total of 200,000 km of electrical power transmission channels with a capacity of 330 kV and above has already been constructed. Conducting pilot projects to build intelligent electric grid and intelligent substations. Expanding the application of intelligent electric meters and installing charging facilities for electric cars.

Source: The "12th Five-Year Plan".

By 2015, the proportion of coal energy in primary energy consumption will drop by 7 percentage points from the 2010 level, and the proportions of natural gas, hydropower, nuclear power and new energies (wind power, solar power and biomass) will increase by 4%, 1.3% and 1.8% respectively. However, overall growth will mean that coal demand continues to rise.

The power sector has already taken several important measures to adjust its structure and accelerate the transition to a low carbon economy but these will be accelerated in the next ten years. Five large power-generating companies have adjusted their power supply structure and made this transition the main priority of their strategic plans. In addition, China's two grid companies have developed their own green development strategies. One of the most important parts is to accelerate the construction of advanced cross-region electricity transmission channels, which can set up a transmission platform to support these structural adjustments.

There will be another rapid expansion in the Chinese power sector over the next decade – by 2020, the total installed capacity of generators will reach 1.7 TW. The installed capacity of the new generators will total 0.8 TW, providing huge capacity for the sector to adjust its power supply structure.

The 15% target implies 600 Mtce of avoided coal consumption. By 2020, the installed capacity of non-fossil energy will have increased by 500 GW compared with 2005 and the proportion of the installed capacity of coal fired plant will decrease from 73.6% in 2005 to 60%. Most of the remaining capacity will be highly efficient and, compared with current performance levels, will avoid 260 Mtce of energy consumption. By 2020 there will be 60GW of gas generation capacity. The greater relative efficiency of combined cycle gas plant over coal generation, and the lower emissions per unit of output, will avoid about 32 Mtce and 140 MtCO_2.

4.4 Emerging Industries – Catalysing Low Carbon Transformation

After 32 years of reform and opening up, China is at a crossroads. Economic development is facing increasing pressure from resource restraints and environmental degradation. With the advantages of its cheap resources and labour force fading away, China's future development depends on enhancing endogenous development momentum and international competitiveness.

The "12th Five-Year Plan" identifies seven emerging strategic industries that will play a key role in China's economy: energy conservation and environment protection; new energy technologies, including renewables and nuclear; new energy vehicles, including electric vehicles; biotechnology; information technology; advanced materials and equipment manufacturing. This is a major strategic move for China, designed to promote sustainable growth and ensure that China will be at the forefront of science, technology and innovation in the future. This chapter sets out the pivotal role of the emerging pillar industries for China's low carbon industrialization strategy.

The development of low carbon industries is a priority for major economies attempting to kick-start their economies in the wake of the global financial and economic crises, in particular to create jobs and achieve low carbon green growth. The US, for example, has invested significantly in researching and promoting alternative energy and electric vehicles; the EU has emphasized "green" innovation and investment as well as a rapid transformation to a low carbon economy; Japan has significantly enhanced the budget for new energy R&D and utilization. In addition, countries around the world have invested in the information and communications sector and strengthened support for biotechnology and nanotechnology.

China has a vast potential domestic market for the promotion and application of new technologies, as well as a broad industrial platform to support the commercialization of new technologies. If the current opportunities for innovation are seized, it is likely that the technology gap between China and developed countries can be narrowed, eliminated, or even reversed. China is catching up with OECD countries in terms of patenting activity in low carbon technology, a proxy for innovation activity, but it is still some way behind the leaders – the US, Germany and Japan (see Box 4-7).

Innovation is not just about R&D: it is an evolutionary process involving a complex mix of public- and private- sector actors and dynamic interactions between consumers and producers. Successful innovation requires a balance between "push" and "pull" factors, with varying levels of public–private finance and policy interventions at different stages from R&D to mass deployment. In OECD countries, private businesses account for the bulk of R&D in terms of both funding and performance. However, government remains crucial for creating the right conditions for accelerating the rate of innovation and diffusion and in many cases public investments in innovation have led to key breakthroughs. A crucial consideration for governments, therefore, should be creating the right balance of risk and reward in innovation markets to leverage private-sector activity.

Box 4-7 China and low carbon energy innovation

The geographical distribution of patenting and how it changes over time provides an indication of innovative activity and trends. China is increasingly popular as a destination for patent filing, which reflects an intention to invest, sell or license a technology. This is not surprising given the size of the potential markets in China.

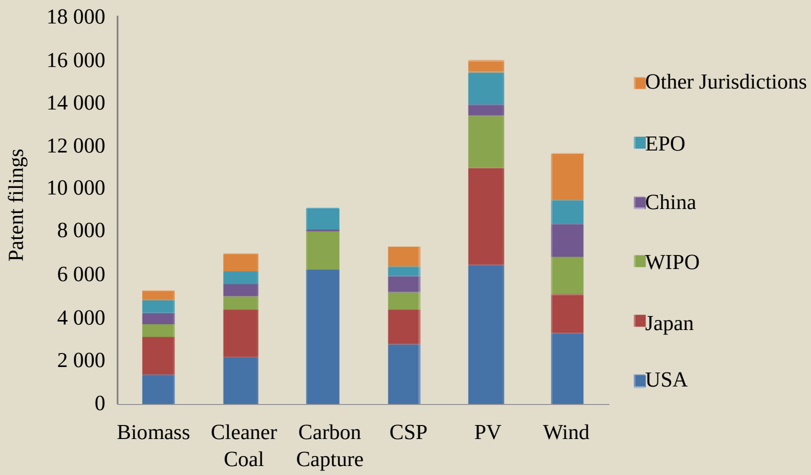

Figure 4-11 Patent filing locations for six energy technologies

The country of origin of the patenting organization shows where R&D activity is taking place. The US is far ahead by this measure, but China has recently joined Japan and Germany in the second tier.

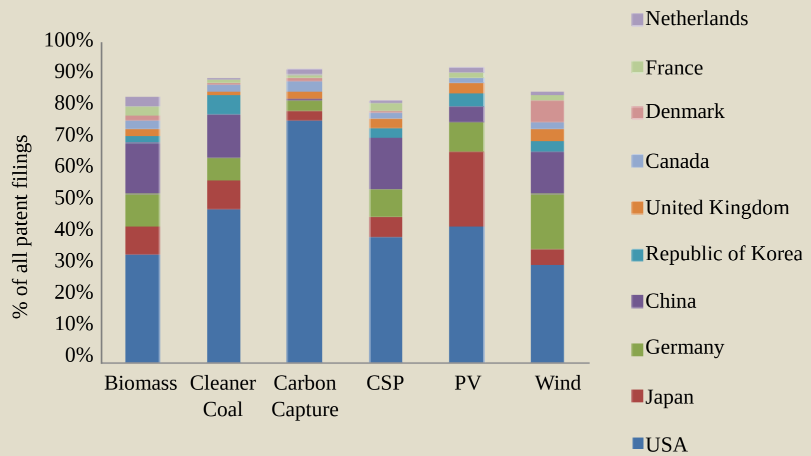

Figure 4-12 Patent assignee origins

Indeed, China is catching up fast, as shown by the example of wind power. In the last five years, firms based in China have registered more patents than anywhere outside the US.

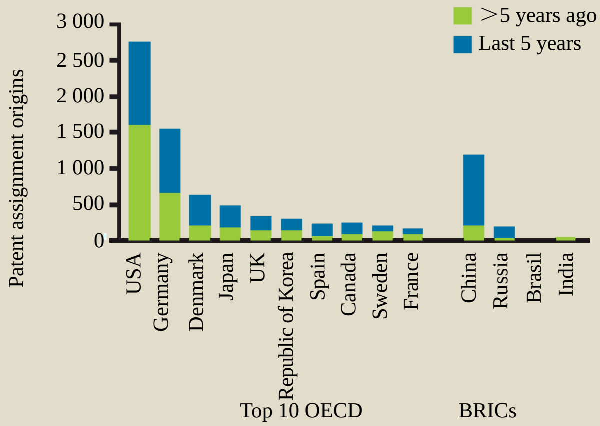

Figure 4-13 Patent assignee origins – wind power

Source: Chatham House, 2009.

The development of energy-saving technologies, advanced vehicles and biological industries can directly improve energy intensity, replace fossil fuels, and reduce pollutant and industrial carbon emissions through the provision of equipment and materials that enhance industrial systems. The new generation of technology developed through the emerging industries will also provide indirect support for the low carbon industrialization process. For example, wind and solar power are intermittent by nature and the large-scale deployment of such renewables could be facilitated by a smarter grid. By 2020 the emerging sectors together have the potential to avoid 4.6 GtCO_2 of emissions (see Table 4-5). However, their decisive contribution to low carbon transformation will emerge in the 2020s if the groundwork is laid during the "12th Five-Year Plan".

Table 4-5 Impact of emerging industries on CO_2 emissions

	CO_2 emissions avoided		Note
	2015	2020	
Energy-saving and environmental protection	818 Mt	1.9 Gt	Direct effect
New energy	1.2 Gt	1.8 Gt	Direct effect
New energy vehicles		300 Mt	Logistics and transportation
Biological industry	Can replace oil and gas as feedstocks and fuels		Direct effect
Information Communication industry	615 Mt of emissions will be reduced by 2020 and the ratio of direct to indirect emissions reduction is 1:5		The ratio of direct to indirect emissions reduction is 1:5
New materials	Will have an important impact on resource- saving, environmental treatment, material recycling and reutilization		Indirect effect
High-end manufacturing industry			

Source: LCIS Task Force.

4.4.1 Energy-saving and environmental technology

This rapidly expanding sector includes a broad range of technologies, products and services aimed at saving energy, preventing and treating pollution and protecting ecological systems. During the "11th Five-Year Plan" the sector grew by over 20% per year so that by 2009 it had an added value of RMB 1.9 trillion, more than half of which was in the area of resource efficiency and utilization, including recycling, waste and water treatment. Within the energy-saving sector, the service industry accounted for over RMB 50 billion (see Figure 4-14).

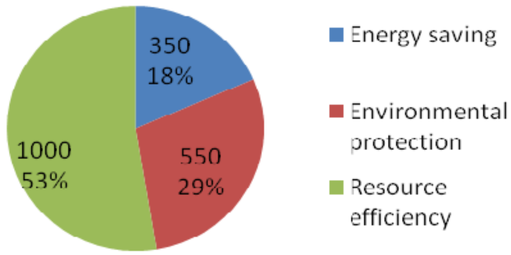

Figure 4-14 Breakdown of energy-saving and environmental protection sector in 2009 (RMB bn)

Source: LCIS Task Force analysis of industry sources[36].

Part of the explanation for the explosive growth is that industrialization and urbanization have increased the scale of the environmental challenge: industrial waste, for example, has grown at an average of 13% annually over the past five years. Recycling of non-ferrous metal is booming but it still comprises just 24% of China's annual production of such metals.[37] In 2010, 75% of urban sewage was treated but there are still 61 cities without a sewage treatment plant, and virtually no sewage treatment facilities exist in rural areas. Landfill continues to be the dominant form of waste management in China, with incineration and composting making up less than 20% of the total, much lower than in Japan and South Korea.[38]

As described in 4.3, Chinese industry still lags behind its advanced foreign counterparts in terms of energy consumption per unit of output (see Table 4-3). The energy-saving and environmental protection sector will play a key role in closing this gap, helping to reduce per

36 China Statistical Yearbook, China Energy Conservation Association, China Environmental Protection Industry Association, Chinese Renewable Energy Industries Association and China Environment Service Industry Association.

37 Secondary Metal Branch of China Nonferrous Metals Industry Association.

38 China's National Development and Reform Commission.

unit energy consumption, promote resource reutilization and cut costs. If all the measures set out in Table 4-6 were achieved, 2.1 GtCO_2 could be avoided by 2020.

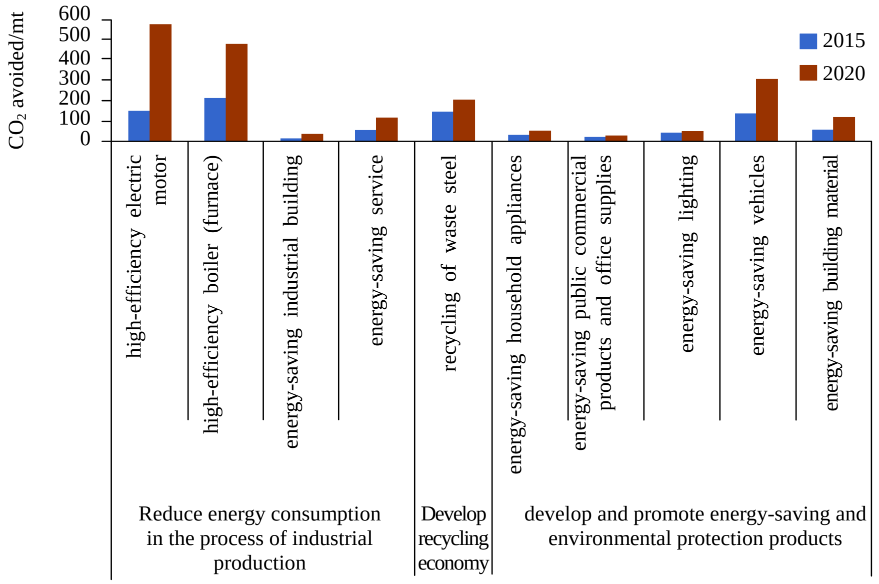

Figure 4-15 Impact of energy-saving and environmental technologies and services on CO_2 emissions

Source: LCIS Task Force analysis.

As is clear from Figure 4-15, efficient motors, boilers and vehicles are three critical areas to address. The electricity consumption for industrial motor systems (including the electric motor, water pump, fan and compressor) is responsible for 80% of the total electricity consumption in China, but high-efficiency energy-saving models make up just 3% of all motors installed and have a current market share of only 30%.[39] The smart grid will play an important role too: demand-side management has an important role to play, but will require significant upgrading of information and control systems. Large efficiency gains are possible by aligning the specifications of transformers and machinery with electricity distribution (further details can be found in Table 4-8).

The design of industrial buildings should be given much greater attention in future. If 20% of existing industrial buildings received an energy-saving upgrade by 2020 and energy consumption dropped by an average of 15%, 345 MtCO_2 could be avoided. Moreover,

39 Zhang Shaochun (Deputy Minister of Financial Department), "Accelerate the promotion of high-efficiency electric motor and boost the scaled application in China", March, 2011.

energy-efficient buildings require a range of materials such as thermal insulation for walls, reinforced fly-ash brick and draught-free, double-glazed windows. By 2020 an additional 113 $MtCO_2$ could be avoided through such measures.

This emerging sector also has a key role to play in developing China's circular economy. At the production end this includes new technologies and facilities for the separation, enrichment and use of minerals. It also means technologies and systems which allow the upgrading and reuse of existing machinery and materials. Increasing the share of metals, rubber and plastic made from recycled material will have a significant impact on greenhouse gas emissions. A tonne of secondary copper requires only 27% of the energy used to produce a tonne of primary copper. By 2020 is it expected that renewable aluminium, renewable copper and waste steel will reach 65%, 75% and 25% respectively of the total market for each metal. Reaching these levels will require investment in technologies and services along the supply chain.

Household appliances are responsible for about 13.5% of the total electricity demand in China, and this percentage is set to grow with increasing living standards. Energy-saving household appliances currently account for only 15%—30% of the market; if the average consumption of household appliances can decrease by 30% in 2010, 67 TWh will be avoided, equivalent to 50 $MtCO_2$. In addition, lighting is responsible for roughly 10%—12% of the total power demand. About 1.4 billion incandescent lamps are in use in China today. During the three years from 2008 to 2010, nearly 350 million energy saving lamps were accumulatively promoted with the help of financial subsidies. If 150 million lamps can be added each year, it will take 7—8 years to replace all the ordinary incandescent lamps. Taking the conservative estimate that each lamp saves 50 kWh per year, 70 GWh would be avoided by 2020, or 53.1 $MtCO_2$.

4.4.2 Lower carbon energy

Generation of electricity and heat was by far the largest producer of CO_2 emissions in 2008 and was responsible for 41% of global CO_2 emissions. This sector relies heavily on coal, the most carbon-intensive of fossil fuels.

Decarbonization in the power sector can be divided into three areas:

(1) Reducing consumer energy demand (e.g. encouraging the public not to use lighting unnecessarily);

(2) Increasing efficiency at the power station, in transmission (including smart grid technologies) and at end-use (efficient buildings, lighting and appliances);

(3) Switching from fossil fuels to renewables and nuclear, from higher carbon fossil

fuels to gas, and the use of CCS. Decarbonization can also be achieved through the use of combined heat and power.

The "new energy industry" emerging pillar focuses on the third dimension. China's non-fossil energy accounted for 8.1% of the total energy consumption in 2010. As noted in 4.3, the "12th Five-Year Plan" specifies that by 2015 this should have risen to 11.4%, keeping China on track to meet its target of 15% non-fossil energy by 2020.

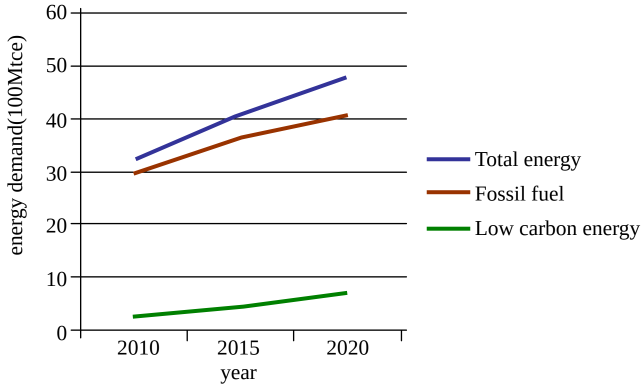

Figure 4-16 Projected energy consumption: proportion met by fossil and non-fossil energy, 2010–2020

Source: LCIS Task Force analysis.

By 2015, renewables and nuclear power can replace 467 Mtce, equivalent to 1.15 $GtCO_2$, reducing carbon intensity per unit GDP emission by 3%. By 2020, 720 Mtce, equivalent to 1.771 $GtCO_2$, can be avoided compared with business as usual, further reducing per unit GDP emissions by 3%–4% (see Table 4-6).

Table 4-6 Projection of non-fossil energy and impact on CO_2 emissions

	2010	2015	2020
Total energy consumption (Mtce)	3240	4100	4800
Proportion of non-fossil energy (%)	8.11	11.4	15
Hydropower installed capacity (GW)	213.4	280	430
Wind installed capacity (GW)	31.07	90	150
Nuclear installed capacity (GW)	10.82	40	80
Solar installed capacity (GW)	0.6	5	20
Alternative energy (Mtce)	263	467	720
CO_2 emissions avoided ($MtCO_2$)	646	1150	1771

Source: LCIS Task Force analysis.

China still has to import many high-value components of low carbon energy technology – for example, in wind power these include the control system and bearings, and its nuclear energy continues to use designs based on imported models. Improving domestic innovation capacity is a priority for the "12th Five-Year Plan" – putting China in a position to design and manufacture globally competitive high-tech components while pursuing breakthroughs in third-generation nuclear power, large-scale wind turbines, solar polycrystalline silicon manufacturing and other key technologies. By 2020, the focus of the industry will have shifted from low labour cost to high-value components and utilizing economies of scale.

There are also practical and regulatory obstacles to the scaling up of renewable energy. Box 4-8 describes the challenge of connecting wind power to the grid.

Box 4-8 Wind power: grid strengthening and technology deployment

The natural distribution of new energy resources is somewhat scattered, and the power generated from them fluctuates. The generated electricity has to be distributed over a large geographic area, in order to buffer power fluctuation on the grid. China's wind resources are mostly far away from the load centres, and require large-scale power transmission. There are major bottlenecks resulting from the high concentration of wind power in a few areas, such as Jilin Province. At times, power generated from wind accounts for 25% of the total load, which is detrimental to the safe operation of the power grid until it can be upgraded. This acts as a constraint on the further development of wind power.

At the end of 2010 total wind-power capacity in China was 45 GW, but only 31 GW had been connected to the grid. The huge idle capacity of wind power is partially attributed to temporary factors, such as the comparatively slow pace of grid construction. However, the fundamental cause lies in the industrial structure, including a lack of coordination between new energy development and power grid construction, delayed transfer of the rising costs of power generation, and lack of mandatory requirements for and supervision of power grid companies.

Source: Task Force analysis.

4.4.3 Vehicle efficiency and electric vehicles

Global automobile demand is set to grow rapidly, largely driven by increasing car ownership in developing countries as incomes rise. In the IEA's baseline scenario, the total stock increases from about 750 million in 2007 to 1600 by 2035 (see Figure 4-17). This represents a major area of potential growth in greenhouse gas emissions.

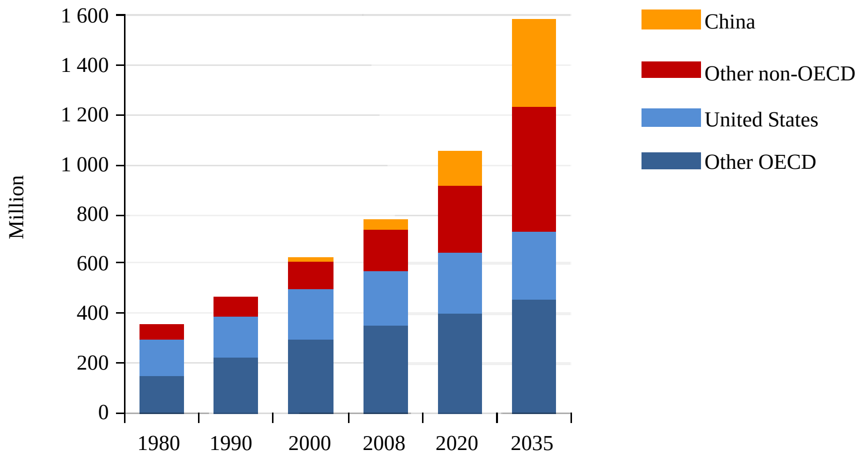

Figure 4-17 Passenger vehicles in the IEA's new policies scenario

Source: IEA 2010.

The number of vehicles owned by Chinese citizens continues to rise rapidly, as shown by Figure 4-18. In 2000, the total number of civil automobiles stood at 16 million; by 2009, the figure had reached 57 million, a threefold increase over eight years, with an annual growth rate of 15.2%. In the decades to come, the number of personal automobiles will continue to grow at a very high rate; the total is forecast to reach 153 million by 2020 and 241 million by 2030.

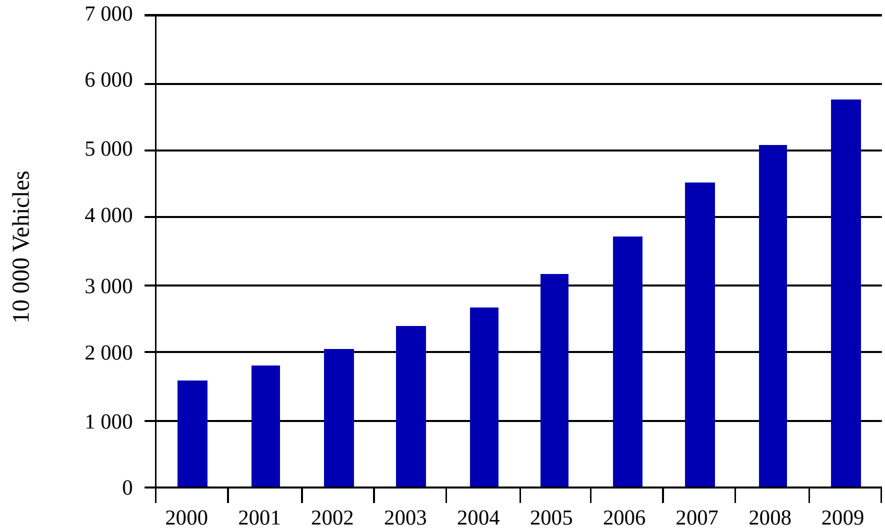

Figure 4-18 Number of automobiles on China's roads (2000–2009)

Source: China Energy Yearbook.

This poses major challenges to China's energy security. Automobiles were responsible for 29% of oil consumption in 2008, up from 25% in 2005.[40] If the current growth pattern, mileage pattern and fuel efficiency were to remain unchanged, by 2020 China's automobile oil consumption would reach 333 Mtoe, and by 2030 over 500 Mtoe.

The three main options for reducing automobile emissions are to encourage a modal shift to alternative forms of transport; improve the efficiency of internal combustion engines; or switch to lower carbon fuels. The International Council on Clean Transportation provides a comparison of global vehicle efficiency standards. Figure 4-19 shows international standards in gCO_2/km normalized to the "New European Driving Cycle" methodology. Japan has had the toughest targets since the 1970s, but the EU has closed the gap in recent years. Japan is now in the process of determining a standard for passenger car fuel economy for 2020, and a formal proposal is expected by the third quarter of 2011.[41] There is a significant lag between the introduction of targets and the impact on the total vehicle fleet. For example, in the EU new passenger cars are about twice as efficient as the average for the whole car fleet.[42]

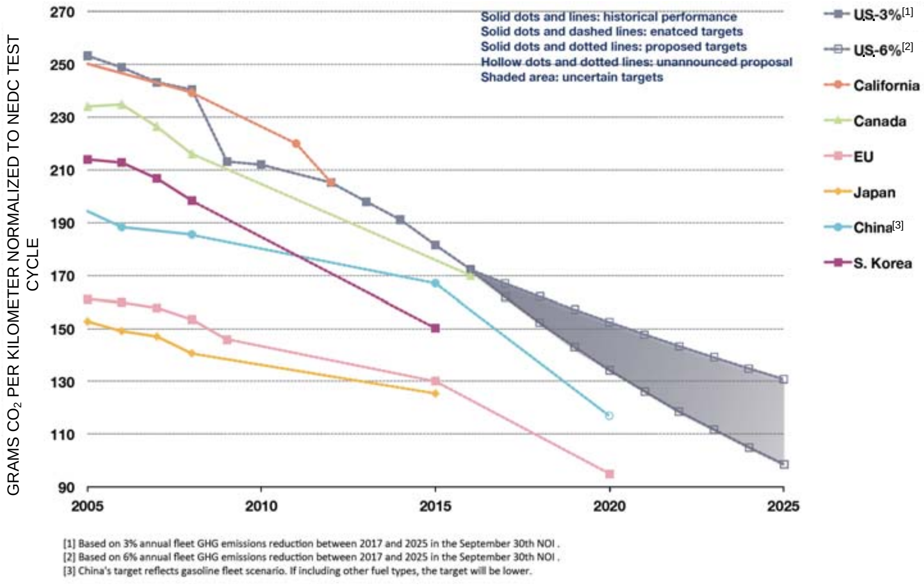

Figure 4-19 Evolution in vehicle emissions standards

Source: ICCT, 2011.

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40 The ratio is a result of total consumption of petrol and diesel divided by the overall oil consumption.

41 ICCT, 2011. *Global Light-duty Vehicles: Fuel Economy and Greenhouse Gas Emissions Standards* www.theicct.org/info/documents/PVstds_update_apr2011.pdf.

42 Odysee, 2009. "Energy Efficiency Indicators in Europe" www.odyssee-indicators.org/reports/transport/transport09.pdf.

In the EU, an ambitious compromise deal was agreed in December 2008, despite industrial pressures caused by the financial crisis. This deal will gradually limit CO_2 emissions to 120g/km for 65% of new cars in 2012, 75% in 2013, 80% in 2014 and 100% in 2015 (2004, 161g/km). A target of 130g/km is to be reached by improvements in vehicle motor technology. A further 10g/km reduction should be obtained by other technical improvements, such as better tyres or the use of biofuels.[43] According to the FIA, using current projections of vehicle numbers, cutting global average automotive fuel consumption (litres of fuel /100 km) by 50% would avoid emissions by over 1 $GtCO_2$ a year by 2025 and over 2 $GtCO_2$ per year by 2050, and result in savings in annual oil import bills alone worth over USD 300 billion in 2025 and USD 600 billion in 2050 (based on an oil price of USD 100 per barrel).[44]

Further emissions savings can be made by substituting sustainable biofuels for petrol and diesel in internal combustion engines. However, biofuels are at the centre of an often heated international debate involving questions of energy security, climate change, food prices, land use, biodiversity conservation and social development.[45] Government policies to support the production and use of biofuels are motivated by their potential to reduce greenhouse gas emissions as an alternative to fossil fuels. But the record price spikes for food commodities in 2008, for example, have been blamed in part on the diversion of food crops for biofuel production. Other analyses have suggested that estimates of biofuels-related carbon benefits generally fail to include emissions from land-use changes.[46] The World Bank has drawn attention to the economic viability of current biofuel programs, including upward pressure on food prices as well as intensified competition for land and water.[47] Other critics have also raised concerns over social problems related to land use, often exacerbated by the lack of clear tenure rights. Growing criticism of biofuels has put many governments under pressure to rethink their policies. The EU, while retaining its 10% target for biofuels by 2020, has opted to include some sustainability criteria. The challenge for governments will be to provide this support in a way that is backed by evidence and is sufficiently neutral to move towards the most promising biofuels.

Second-generation biofuels technology focuses on breaking down lignin and cellulose

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43 Between 2012 and 2018, the fine for non-compliance will be as follows: €5 for the first gram of CO_2, €15 for the second gram, €25 for the third and €95 from the fourth gram of CO_2 onwards. From 2019 manufacturers will have to pay €95 for each gram exceeding the target.

44 FIA, 2010. "50 by 2050". www.fiafoundation.org/50by50/documents/50BY50_report.pdf.

45 Bernice Lee, 2009. "Managing the Interlocking Climate and Resource Challenges", International Affairs. November 2009.

46 Timothy Searchinger et al. 2009, "Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change", Science 319: 5867, 29 Feb. 2008, pp. 1238–1240.

47 World Bank, World Development Report 2008: agriculture for development (New York, 2008).

from woody substances to release sugars that can then be fermented in a process similar to that used in first-generation biofuels. This has the potential to greatly increase the volume of available material without competing with food crops and can achieve far higher greenhouse gas emissions reductions. However the main technologies are not yet scaled up commercially and technical challenges remain. The impact on soil quality of growing second-generation biofuels is also under consideration. China is second only to the United States in terms of academic research and patenting applications in this area[48] and biofuels company Novozymes is exploring the potential for commercialisation of second generation fuels in partnership with China Oil and Foodstuffs Corp., Ltd. (COFCO), China's largest oils and food importer and exporter, and China Petrochemical Corp (part of the major Chinese oil company Sinopec).[49]

In the last few years electric vehicles have increasingly come to be considered the most promising alternative to the internal combustion engine. Many developed countries and China have made commitments to deploy electric vehicles (see Table 4-7). The EV20 alliance of companies announced in September 2010 that its members would add one million EVs to the roads by 2015, above the targets already announced by companies.

Table 4-7 Electric vehicle targets

Austria	2020: 100,000 EVs deployed
Australia	2012: first cars on road; 2018: mass deployment; 2050: up to 65% of car stock
Canada	2018: 500,000 EVs deployed
China	2015: 500,000 EVs deployed
Denmark	2020: 200,000 EVs
France	2020: 2,000,000 EVs
Germany	2020: 1,000,000 EVs deployed
Ireland	2020: 10% EV market share
Israel	2011: 40,000 EVs; 2012: 40,000 to 100,000 EVs annually
Japan	2020: 50% market share of next-generation vehicles
New Zealand	2020: 5% market share; 2040: 60% market share
Spain	2014: 1,000,000 EVs deployed
Sweden	2020: 600,000 EVs deployed
United Kingdom	No target figures, but policy to support EVs
United States	2015: 1,000,000 deployed

Source: Foley et al., 2010[50].

48 Chemical Abstracts Service (2010). China Takes Lead in the Commercialization of Bioethanol. American Chemical Society www.cas.org/ASSETS/EC83F01563A74A51A1F651C3148A0F22/CASChemResearchReport6.23.10.pdf.
49 China Daily, 2011. "Dancing to a different tune" (interview with the head of Novozymes). www.chinadaily.com.cn/cndy/2011-09/29/content_13814014.htm.
50 Aoife Foley, Hannah Daly and Brian Ó Gallachóir, 2010. Quantifying the Energy & Carbon Emissions Implications of a 10% Electric Vehicles Target. www.kth.se/polopoly_fs/1.64178!Paper_B5_Foley.pdf.

The key issues for scaling up electric vehicles is battery technology (rates of recharge and discharge, energy density and battery life); charging infrastructure; and the associated costs and financing options. Electric vehicles will only make a major dent in the internal combustion engine market when they compete more closely on price, and the upfront cost of an electric vehicle is currently high, with the battery being a major factor in this. While improvements in battery technology and a modest increase in manufacturing capacity are helping to bring down the costs, the battery remains problematic from the economic standpoint, both because of the upfront cost and because of its uncertain residual value when it is no longer useable.[51] In the short term, many governments are offering incentives that help reduce the cost of electric vehicles and companies are starting to offer a broader range of financing options to help spread the cost.

Box 4-9 CO_2 emissions from electric vehicles in China

Electric vehicles in China would be charged on a power system still dominated by coal. This raises the question: would China be better off using efficient internal combustion engines in the medium term? Although it is a complicated picture, early deployment of EVs will probably result in a similar level of emissions as efficient internal combustion engine vehicles (ICEVs) and over the medium term they promise deeper reductions as the power sector becomes more efficient and switches to renewables and nuclear power.

Today, the emissions from a pure electric vehicle are similar to the average ICEV sold in China. Based on projected emissions per unit electricity in 2020, an EV would result in about 130 gCO_2e/km, similar to the US proposed target for 2016 for ICVEs sold in that year.[52] But if electric vehicles are produced on a large scale, it may be fairer to compare them with the emissions performance of the new electricity capacity built to support them – and on this basis, Chinese EVs will be at parity with the relatively ambitious EU target for ICVE vehicles sold in 2020 – 95 gCO_2/km – as early as 2015. This is not to mention the potential benefit of using EVs as storage on the grid, reducing the need for carbon-intensive peak generating capacity.

4.4.4 Information and communications technology

Information and communications technology (ICT) is already an important driving force of the global economy, and will provide the tools and information necessary to

51 The Climate Group. 2010. "Financing Electric Vehicles". http://www.theclimategroup.org/our-news/news/ 2010/10/28/financing-electric-vehicles/.

52 This assumes that 10% additional emissions occur during upstream oil and processing and the same amount for transmission losses in the power grid. Importantly, this calculation is not based on a life cycle assessment of the vehicles. However, the life cycle impacts for both types of vehicles are typically relatively small compared to the operation-based emissions. See http://pubs.acs.org/doi/pdfplus/10.1021/es903729a Dominica Notter et al. 2010. Contribution of Li-Ion Batteries to the Environmental Impact of Electric Vehicles. Environmental Science & Technology. Vol. 44, No. 17, 2010.

improve environmental performance across and between other sectors in the economy. It also promises to open up whole new areas of resource and energy efficiency, for example by enabling the collection of data right along the supply chain.

The ICT industry can make an important contribution by limiting its own emissions. In China, ICT was responsible for about 2.5% of GHG emissions in 2007.[53] If the current trend of energy efficiency remains unchanged, by 2020 emissions from the ICT industry will reach 415 $MtCO_2$, accounting for 4% of total emissions.[54] However, the major contribution of the ICT industry will be in enabling emissions reductions in other sectors. According to the Climate Group, these potential savings are about five times greater globally than the energy and emissions of the ICT industry itself. By 2020, ICT can reduce global emission by 7.8 $GtCO_2$, reducing emissions compared to business as usual by about 15%. The energy efficiency savings would amount to nearly 600 billion euros (USD 946.5 billion).

ICT will deliver energy savings and emissions reductions in a host of different ways. Some of the largest gains in the short term are summarized in the remainder of this section.

4.4.4.1 Smart logistics

By optimizing the logistics sector, ICT could reduce transportation-related emissions in the sector by 16% and its storage-related emissions by 27% worldwide. By 2020, the application of ICT in logistics could reduce the world's CO_2 emissions by 1.52 Gt, an equivalent of 280 billion euros (USD 441.7 billion). WWF and China Mobile found that smart technology in China's highway logistics could reduce the number of lorries travelling with empty loads from 30% to 15%. The emission reduction opportunities of smart logistics are estimated at up to 78 $MtCO_2$, 128 $MtCO_2$ and 207 $MtCO_2$ respectively in 2010, 2020 and 2030.[55]

4.4.4.2 Smart buildings

The construction industry ranks second to manufacturing worldwide in terms of energy consumption. Smart building technology is expected to reduce emissions by 1.68 $GtCO_2$ by 2020, equivalent to about USD 340.8 billion. China's buildings consume 4,000–5,000 kWh of electricity every year, 22%—24% of the total electricity generation,

53 Xie Mengzhe, *ICT's Potential contribution to China's achieving the development goal of low-carbon economy*, 2010

54 Ibid.

55 WWF and China, 2010. Low Carbon Telecommunication Solutions in China: Current Reductions and Future Potential. www.wwfchina.org/english/downloads/ClimateChange/China_Mobile_English%20summary.pdf.

and electricity consumption per building area is 26–27 kWh/m^2, or 2–3 times that of developed countries. Because China is a relatively late entrant in this sector, companies in developed countries are the leaders of most core technologies and the market for smart construction products is also dominated by foreign enterprises. China's current focus on smart buildings is in R&D of advanced ICT, along with the rapid development of its domestic smart building industry.

4.4.4.3 Smart grid

In China, the smart grid concept includes everything from high-voltage direct current (HVDC) power lines to the use of storage technologies (including batteries in electric vehicles) and the integration of decentralized renewable energy technologies with the grid. The aim is to establish a next-generation power grid characterized by safety, reliability, economy, high efficiency and environmental protection. Analysis by the Task Force suggests that if China can largely complete the reform of the traditional grid to a smart grid by 2020, an amount of energy consumption equivalent to 220 Mtce can be saved compared with business as usual. This would be equal to emissions reductions of nearly 500 $MtCO_2$, 4.9 Mt sulfur dioxide and 2.2 Mt nitrous oxides (NO_x) can be avoided (see Table 4-8).

Table 4-8 Potential for avoiding energy consumption and emissions due to the smart grid

Specific links	Energy (Mtce)	Carbon dioxide (Mt)	Sulfur dioxide	NO_x
Line loss reduction	2.1	4.5	0.1	0.02
Fuel consumption for electricity generation reduction	61	129.3	1.3	0.6
Electricity consumption reduction	120	254.4	2.6	1.2
New energy and renewable energy	40	84.8	0.9	0.4
Electric vehicles	—	21	—	—
Total	223.1	494.0	4.9	2.2

Source: LCIS Task Force analysis.

At present, China's smart grid is in the early exploration and piloting phase. Because the smart grid is heavily dependent on ICT, its future development is closely linked to advancement in this area. Key technologies include communications and sensor technology; accurate parameter-measurement technology for understanding the real-time operation of the grid; automatic control technologies; and finally, decision-support technology.

4.4.4.4 Smart work

"Smart work" means working with the assistance of advanced communications tools such as the internet to avoid rush-hour traffic jams, inflexible workplaces and numerous other business travel issues connected with traditional work patterns, creating economic benefits for enterprises and environmental benefits for the general public. According to projections, if 5% of commuters can start tele-working by 2020, 15% of business travel can be replaced by e-conferencing and as a result global emissions will be reduced by 100 $MtCO_2$.

4.4.5 Biotechnology

China is the leading developing country in the areas of life sciences and biotechnology and its industry and skills base continues to strengthen. In addition, the country has extremely rich biological resources. This is one sector in which developed countries have yet to develop a strong hold over the high end of the market. China's bio-industry has a relatively small gap to close in terms of technology, talents and the scientific research base. Based on conservative projections, by 2020 China's bio-medicine market, broadly defined, will be worth RMB 4 trillion, bio-manufacturing RMB 1 trillion, bio-agriculture RMB 500 billion, bio-energy RMB 3000 billion and bio-environmental-protection RMB 100 billion; overall, the bio-industry market could be worth about RMB 6 trillion.

According to WWF, by 2030 the global industrial bio-manufacturing technology could find savings of 1–2.5 $GtCO_2$ annually.[56] In the medium term the sector has the potential to find transformative alternatives to the use of fossil fuels to produce heavy chemicals and plastics. In other words, it makes great strategic sense in terms of encouraging sustainable development, developing China's industrial economy, reducing reliance on oil resources and cutting carbon dioxide emissions to develop bio-manufacturing, increase the percentage of green, low carbon and renewable bio-chemical production, and reorganize material flows in the petrochemical industry.

4.4.6 Advanced materials and high-end equipment manufacturing

The "advanced materials" sector develops and supplies materials with superior performance and special functions as well as traditional materials with improved

56 WWF, 2010. *Industrial Biotechnology More than green fuel In a dirty economy?* www.bio-economy.net/ reports/ files/wwf_biotech.pdf.

functionality. This includes materials with a range of different physical attributes, functions and applications. Innovative materials are essential for the development of the other emerging sectors. Solar power, for example, requires advances in polycrystalline silicon, and battery technology is the key to electric vehicles. Lightweight and strong new structural materials, including high-performance compound fibre materials and light metal materials (such as aluminium, magnesium, titanium and their alloys) can conserve energy and reduce emissions in a range of sectors such as aerospace, automobiles, communications, transportation, shipping, construction and other industries.

New materials are also needed to improve the quality of building materials, which largely determines their efficiency. Every year, about 2 billion m^2 of housing is constructed in China, while 70% of heat is currently lost from buildings through windows and exterior walls. If the current scale and level of energy consumption in construction remain unaltered, the annual energy consumption will be equivalent to 1.2 TWh of electricity and 410 Mtce by 2020, almost three times the current level.

4.5 Recommendations

The key policies required to implement a low carbon industrialization strategy in China are set out in Table 4-9, separated into potential actions for the 12th and 13th "Five-Year Plan" periods.

Table 4-9 Policy priorities for LCIS during 12th and 13th "Five-Year Plan" periods

Phase I 2011—2015	① Sectoral targets for energy-intensive industry are designed and introduced ② Support for strategic emerging industries is scaled up, especially on innovation that will be important for their development by 2020 and 2030 ③ China's energy pricing system and subsidies are reformed ④ A carbon tax is introduced ⑤ Pilot emissions trading schemes are started in some regions and industries ⑥ A "top runner" program is designed and implemented ⑦ China's low carbon pilot areas use targeted fiscal and tax policies and credit support to accelerate investment, supported by the national government ⑧ There is tougher enforcement of energy-efficiency standards in industry and buildings ⑨ The coverage of mandatory labelling for energy and emissions is expanded and carbon footprinting methodology is approved

Phase II 2016—2020	① Innovation is increasingly targeted at advanced, transformative technologies and materials needed to maintain competitiveness in the 2020s ② Energy prices are set according to the market ③ Carbon tax rates gradually increase, encouraging low carbon investment ④ Green taxation makes a growing contribution to China's fiscal revenue ⑤ The top-runner program is in its second phase, now covering a wide range of industrial, commercial and domestic technology categories ⑥ A national carbon emissions trading system is introduced ⑦ A fully-fledged carbon finance system is achieved ⑧ Carbon footprinting and labelling are promoted, giving much greater visibility to energy and emissions performance for consumers

Five areas of policy have been identified by the Task Force as critical to the delivery of China's LCIS.

4.5.1 Sectoral targets for energy-intensive industries

Over the past five years China has focused on regional targets for energy intensity and action by local government. Moving forward, some policy challenges, such as standards and technology platforms for innovation, can only be tackled effectively at national and sectoral level.

Energy-intensity targets should be introduced for seven heavy industry sectors: electricity, steel, building materials, petrochemicals, non-ferrous metals, textiles and paper and pulp. Potential energy-intensity targets are displayed in Table 4-10. These are based on detailed analysis by the Task Force, taking into account the experience of China's industry during the "11th Five-Year Plan" period and assessments of the technical and practical potential to upgrade each sector. Extensive discussions were conducted by the Task Force, with industry bodies as well as academic experts.

Table 4-10 Selected energy intensity improvement potentials for heavy industries

	Energy intensity in 2005	Decline by 2015 (%)	Decline by 2020 (%)
Electricity Thermal efficiency of electricity generation (gce/kWh)	370	13.5	16.2
Steel			
Crude steel kgce/t	741	12.3	15.3
Petrochemicals			
Ethene kgce/t	1 081	11.5	14.5
Synthesis ammonia kgce/t	1 774	12	17

	Energy intensity in 2005	Decline by 2015 (%)	Decline by 2020 (%)
Caustic soda kgce/t	1 351	20.9	25.7
Soda ash kgce/t	530	20.9	25.7
Calcium carbide kgce/t	2 095	15.5	19.5
Building materials			
Cement kgce/t	149.2	27.3	31.3
Non-ferrous metals			
Electrolytic aluminium kWh/t	14 575	6.2	15.2
Textiles			
Chemical fibers kgce/t	743	18.4	23.3
Paper-making			
Paper and paperboard kgce/t	525	25.7	31.4

4.5.2 Scaling up support for seven emerging industries

The "12th Five-Year Plan" has identified seven emerging industries that could contribute 15% of China's GDP in 2020 and will play a key role in achieving a low carbon economy: The products and services of these sectors will contribute to reductions in energy intensity in the heavy industries.

Scaling up of these emerging industries, rightly considered a strategic priority, will require detailed sector-by-sector planning. These emerging sectors are: energy conservation and environment protection; new energy technologies; new energy vehicles; biotechnology; information technology; advanced materials; and equipment manufacturing.

A special fund should be set up by the central finance authority for the development of the emerging industries, integrating the various special funds for industrial development and R&D in China and bolstered by additional resources. The central government should set up a pilot fund targeted at the supporting infrastructure (such as the smart grid) needed for large-scale deployment of low carbon technology in key locations and other key projects for the emerging industries. Local financial authorities should also set up industrial development funds consistent with their priorities for these sectors.

The private sector will play a growing role in the expansion of the emerging sectors, and encouraging small and medium-sized enterprises (SMEs) and foreign firms to enter these sectors will be ever more important. It is critical to remove barriers to entry that are based on the size or geographical origins of companies, to encourage companies with technology prowess and strong environmental performance.

Tax incentives should be boosted to encourage private investment in the development of the emerging industries and to guide consumption. This will help companies to overcome high human capital and R&D expenses as well as to aid commercialization at the early stages of product development. Discounted loans, risk compensation and other policies should be used by government to encourage financial institutions to develop tailored solutions for the emerging industries.

China should encourage the use of innovative finance for low carbon projects, reducing the barriers to investment for small and medium-sized businesses in particular. Trust funds, private equity, venture capital, social capital and international carbon finance all have an important role to play in low carbon and emission- reduction projects. With the emergence of an emissions trading system, carbon financial products such as swaps, options and futures should also be developed.

4.5.3 A major push on low carbon innovation

Achieving both short-term technology improvements and medium-term strategic objectives requires the reinforcement of an innovation culture in China. Thinking beyond the 2020 target, it is clear that there is still be much to be done before China becomes a true low carbon economy; the focus will need to shift from carbon- intensity improvements to absolute reductions of greenhouse gases. The ongoing process of industrialization means that total emissions will have increased substantially by 2020. This will need to be addressed in the 2030s and the 2040s and must be the focus of long-term innovation.

China should raise its R&D budget so that low carbon technology takes a growing share of the overall R&D budget and climbs significantly in absolute terms. Large- scale projects that conserve energy, reduce emissions and demonstrate the potential of the low carbon transformation are also needed to bring innovative low carbon technologies to the mass market.

The time is right for a world-class national energy laboratory to be established in China, with the ability to support innovation from basic research all the way to demonstration and commercialization. This could play a similar role to the national laboratories for energy technology and renewable energy in the United States. With regards commercialisation, China can draw on the experience of the UK's Carbon Trust and Sustainable Development Technology Canada. The institute should be open to companies, universities and other research organizations.

Sectoral platforms are needed so that industry can work with government to develop joint solutions, for example on technology standards. Cross-sectoral hubs should also be established to facilitate exchanges between the different sectors – for example between the power sector, electric vehicle manufacturers and information technology providers. Scaling up the deployment of low carbon technologies will depend on bringing together technologies and systems from multiple sectors.

China should seek to strengthen international cooperation on technology and innovation. Given the scale of the challenge and the complexity of some technology systems, no single country or company can be a world leader in low carbon solutions without effective international linkages.

4.5.4 Effective regulation and technology standards

A "Top Runner" program should be introduced along the lines of the policy in Japan, covering a wide range of industrial, domestic and commercial technologies. Under such schemes, today's best available technology becomes the minimum standard for all products manufactured and imported by a given year in the future, at which point the process begins again – so that standards are continuously raised. To complement this approach the existing scheme of mandatory efficiency labelling should be expanded to cover many more products. A carbon footprinting methodology should also be established and promoted so that the life-cycle greenhouse gas emissions associated with products are visible to consumers. Table 4-11 shows the key regulatory measures that could be introduced during the "12th Five-Year Plan".

Table 4-11 Key regulatory measures and technology standards

1.	Introduce a "Top Runner" program for key industrial equipment and energy-consuming products
2.	Strengthen energy-efficiency standards for industrial equipment with high energy consumption such as draught fans, water pumps, voltage transformers, and motors
3.	Review and potentially tighten efficiency standards for major energy-consuming products such as household appliances, lighting fixtures, office equipment, and motor vehicles
4.	Introduce energy efficiency labels and certification across a wide range of energy-saving products, based on a new standards carbon footprinting methodology
5.	Revise standards for the energy efficiency of buildings
6.	Establish standards for temperature control (heating and cooling) in buildings
7.	Assess and review energy efficiency standards for fixed asset investment projects

Action is needed to ensure that when industrial assets are developed or upgraded they meet strict energy and emissions standards; from now on, regulators should refuse to examine projects and prevent their implementation if they have not followed a formal assessment procedure. Similarly, large-scale public and residential buildings should be subject to detailed assessment of their energy efficiency – and if they fail they should not be approved for development.

New or reformed laws and regulations are needed in a range of key areas including energy, natural resources and environmental protection. As a priority, China should introduce an energy law and a law on “Responding to Climate Change”, consistent with China’s situation, with the aim of encouraging utilization of clean energy and low carbon energy. Revisions to the existing Laws on coal, electricity, energy conservation and renewable energy are also needed to harmonize and simplify the legislative framework covering the relevant industries.

4.5.5 Energy pricing reform and green taxation

The system of energy pricing in China should be reformed to reflect market supply and demand, resource constraints and environmental impacts. Energy prices should be set by the market through competition. Where natural monopolies exist, clear rules should be set by regulatory authorities based on transparent cost and pricing information.

The external costs of energy development, conversion and utilization should be fully reflected in the prices of energy products; for example, the principle of making all costs visible applies to nuclear power (from the costs of nuclear accidents to decommissioning and waste management) as well as the coal industry and renewables sector.

China should aim in the medium term for an end to demand-side subsidies in the energy sector, with disadvantaged groups protected instead through the fiscal system, infrastructure development or other measures. In the near future, however, the priority should be to make invisible subsidies transparent and to replace the current system of cross-subsidization with a basic energy consumption subsidy for poor people in both rural and urban areas, supported by public finance.

China’s tax system should be reformed so that environmental and resource pressures are taken into account, investment is channelled to green technologies and green infrastructure, and consumers are encouraged to buy green products. Green taxes should cover areas such as discharges of air and water pollutants and wastewater and solid waste management. Policy priorities for green taxation are set out in Table 4-12.

Table 4-12 Green fiscal policies

Support for energy conservation	Support for clean energy deployment	Support for low carbon technology R&D
Establish a national "special fund for energy conservation"	Increase the size of the "development fund for renewable energy"	At least 5% of public R&D expenditure should be focused on basic and applied low-carbon technology
Reductions in the corporate tax rate for energy-saving and environmental-friendly projects	Wider use of concessional loans and new advice for banks on their loan policies for renewable energy	Tax benefits for enterprises to offset their R&D investments
Subsidy for high energy efficiency consumer products	Subsidies for solar power and small-scale wind power for homes	Government support for large scale industrial pilots
Enlarge the range and proportion of energy-saving products purchased by the government including energy service agreements	Reduce import tariffs and value added tax on renewable energy technology and equipment	Harmonise financial support policies of energy conservation R&D and deployment

The government should impose a carbon tax during the "12th Five-Year Plan" period to encourage investment in low carbon technology innovation and its large-scale deployment. The carbon tax should start from a relatively low tax rate (e.g. RMB 10 per tonne of CO_2) allowing time for China's industry to adjust, but then increase in step with economic development.

It is important that the tax level is predictable in terms of its implementation schedule and levels. Future tax levels should therefore be set by a transparent formula taking into account the domestic situation but also the need for coordinated international efforts to tackle climate change. The proposed levels for the carbon tax as assessed by the Task Force are set out in Table 4-13. These have been determined through a combination of modelling analysis and consultation with sector experts and the Ministry of Finance.

Table 4-13 Preliminary design of CO_2 tax rate

Tax rate	2012	2020
Carbon tax (RMB per tonne of CO_2)	10	40
Raw coal carbon tax (RMB per tonne)	19.4	77.6
Crude oil (RMB per tonne)	30.3	121.2
Gasoline carbon tax (RMB per tonne)	29.5	118
Diesel carbon tax (RMB per tonne)	31.3	125.2
Natural gas carbon tax (RMB per 1000 cubic metre)	22	88

Chapter 5 Investment, Trade, and Environment

5.1 The Relationship among Investment, Trade, and the Environment: Our Framework of Analysis

5.1.1 Background

> **Recommendation:** China needs to take proactive positions regarding environment and development that will: ① ensure that those investing within China operate at the highest standards of CSR; ② secure goodwill and the right to operate in countries abroad for Chinese ventures, based on the quality and style of investment and benefits for local people; and ③ seek bilateral, regional, and international trade, environment, and other agreements that take into account Chinese interests and concerns for a green economy, and indeed, for the transition to ecological civilization. China should aim to be an open and declared advocate in developing and promoting international green transformation.
>
> *See 5.6 for more discussion about . this recommendation.*

China has achieved much in the 30 years that have passed since the onset of major reforms. In 2010, China became the second largest economy in the world as its gross domestic product (GDP) soared to USD 5.9 trillion. That figure has been growing at a rate of 10% per year. At the same time, though, China's per capita GDP was only USD 4,382 in 2010, 95th in the world. The accelerated development of the Chinese economy, coupled with the intensity and speed of its reform process, has allowed international investment and trade to become important means towards promoting the development of the country. At the same time, they have facilitated China's involvement in economic globalization. By the end of 2009, China had approved over 660,000 foreign investments totaling USD 997.4 billion, the highest cumulative figure among developing countries over a 17-year period. Even in 2008 and 2009, when the world was swept by the financial crisis, the size of foreign direct investment in China dropped only slightly. China's FDI in 2009 was USD 230 billion, seven times over 2003 levels when the "going global" strategy was launched. The total import and export volume in China's foreign trade in 2009 amounted to USD 2.2

trillion, including an export volume of USD 1.2 trillion (equivalent to 10% of global trade export volume). Such an amount of exports placed it first among exporting nations, even ahead of traditional exporters like Germany. At the same time, it imported USD 1.0 trillion, achieving a trade surplus of USD 196 billion.

With globalization and increasingly serious global environmental problems, sustainable development and human survival itself have been confronted with increasingly stringent challenges. Problems such as pollution, climate change, and energy shortages are now at the forefront worldwide. Traditional energy-consumption and industrial-development patterns are no longer viable. As the role of international investment and trade becomes more important, the analysis of the investment, trade, and environment nexus also becomes imperative.

Because of their nature, investment and trade interact with each other and impact the environment in similar ways. The relationships are multi-dimensional and very complex. Trade can have positive impacts on the environment, but it can—and often does—also lead to environmental degradation. The difference lies in how well established the governance rules are around trade. The same applies to FDI: on the one hand, it may increase the host country's pollution levels when it flows from countries or regions with strict environmental regulations to countries or regions with more lenient environmental regulation, thus causing the transfer of polluting industries and increasing the level of pollution in the host country; on the other hand, the advanced technologies brought by FDI to the host country may often improve the efficiency and recycling of resources, thereby leading to reduced emissions and pollution in the host country.

With expanding globalization, investment and trade will often overlap and interact as cause and effect. Trade-oriented investments are closely related to the target resources and market strategies of a host country. While investment in a coal-mining operation can be made with the highest regard for social and environmental conditions, the actual commodity, when traded, will transfer pollution. The analysis of the interaction of investment, trade, and environment is just starting, but it is clear that international investment and trade are connected at multiple points in the industrial and consumption value chains. They interact with resource supply, production efficiency, emission levels, market share, consumption options, and related emission levels. They are crucial to the energy security and to development, and are therefore very influential in defining their status and importance.

5.1.2 Environmental impacts of international trade

The impact of international trade on the environment and society is comprehensively reflected through *scale*, *structure*, and *technology* effects. The scale effect means that larger-scale trade activities lead to more serious environmental degradation; the structure effect means that the in-depth development of trade activities promotes the upgrading and restructuring of industrial structures, thus exerting positive impacts on the environment; and the technology effect means that the specialized professional division of labor, advanced technology, and management experience introduced through trade, cause the reduction of pollutant per unit of output, thereby gradually improving environmental quality.

The environmental impact of international trade can also be viewed from the long- and short-term consequences it brings. In the long term, environmental pollution caused by international trade takes on the inverted U form; in the short term, as trading rivals are at different stages of development, the three effects—technology, structure and scale—are reciprocal and the impact of international trade on the environment and social development differs for each party. These effects are further expanded into several other hypotheses, such as the "Environmental Kuznets Curve (EKC)" hypothesis; the "race to the bottom" hypothesis; and the "pollution haven" hypothesis.

China and other developing countries have entered a critical period of industrialization and global green shift, generating much debate about the impact of international trade on the environment. Some have said that China is practicing "neo-colonialism", robbing resources, occupying markets, and slowing global progress towards sustainable development. Others claim that China uses developing countries in Africa and Southeast Asia as "pollution havens" to transfer emissions by taking advantage of the lower local environmental standards and loose enforcement conditions. This causes host countries to "race to the bottom" as they lessen environmental standards to attract foreign investment; it's a process that stifles sustainable development in the host country and, indeed, globally.

Whether true or not, such accusations are often expressed by more developed countries that are competing for markets and resources with China and are disturbed by its rising influence and appetite. Whatever the case, the social and environmental issues that are revealed are certainly worth closer examination. In a context of growing international globalization and trade liberalization, it is likely that the traditional laws of economics seeking optimization of resources will stimulate the transfers of industries among countries at varying technological levels and developmental stages. Research shows that industrial transfer has indeed occurred in international economic and trade development in the past, but hypotheses such as "pollution haven" and "race to the bottom" do not always hold true.

Indeed, industrial transfer can be the result of rising domestic production costs related to the adoption of stricter pollution standards in a developed country. Such industrialized countries have, through imports and investments, transferred pollution-intensive and resource- and energy-intensive industries to other countries, giving rise to the effect of "pollution havens". H.D. Robinson[1] revealed that the United States tended to import more pollution-intensive products, thereby replacing the domestic pollution-intensive industries in the exporting country. Mani and Wheeler[2] discovered that the output ratio of polluting and clean industries in OECD countries is continuously dropping, while the import-export ratio of polluting industries is rising year by year; on the other side of the coin, the output ratio of polluting and clean industries of developing countries in Latin America and Asia is gradually increasing, while the import-export ratio of polluting industries is dropping. Low and Yeats[3] have pointed out that in the course of global industrial transfer, as developed countries trade with developing countries, the concentration of pollution intensity in developing countries is higher.

Industrial transfer will not necessarily have only negative impacts on the environment and society of the host country. The scale effect might aggravate environmental deterioration. However, when the change in product structure is a shift from pollution-intensive to cleaner products, or clean production technology is adopted, environmental conditions will be improved after trade is liberalized. When income reaches a certain level, and when the promoting role of the technology effect and the structure effect is prevailing, the environmental and social impact of international trade could be positive.

Certainly when the scale effect prevails in trade, its impact can be quite negative. The air pollution level of countries like China, Mexico, and Brazil has worsened while they are all "going global"[4]. In countries with low environmental-protection standards and weak law enforcement, international trade exerts huge competitive pressure on the host country. Indeed, tremendous environmental and social problems prevail in those cases[5,6,7]. The environmental and social impacts of international investment and trade vary from case to

1 Robinson, H. D. (1988). "International Pollution Abatement: The Impact on the Balance of Trade." Canadian Journal of Economics, 21, pp.187-199.

2 Mani, M., Wheeler, D. (1998). In search of pollution havens? Dirty industry in the world economy: 1960–1995. Journal of Environment and Development 7(3): 215–247.

3 Low P. and A. Yeats (1992). Do "Dirty" Industries Migrate? World Bank Discussion Papers.

4 D.Wheeler. Racing to the Bottom? Foreign investment and air pollution in developing countries [J]. Journal of Environment and Development, 2001, 10 (3):225-245.

5 D.Wheeler. Racing to the Bottom? Foreign investment and air pollution in developing countries [J]. Journal of Environment and Development, 2001, 10 (3):225-245.

6 Daniel C. Esty and Damien Geradin (1997). Market Access, Competitiveness, and Harmonization: Environmental Protection in Regional Trade Agreements. Harv. Envtl. L. Rev. 21.

7 Daniel C. Esty and Damien Geradin (1997). Market Access, Competitiveness, and Harmonization: Environmental Protection in Regional Trade Agreements. Harv. Envtl. L. Rev. 21.

case, and each example should be studied on its own terms.

Whatever the case, developing countries need in general to engage in a green shift and adopt strict environmental regulations governing their international trade. In some countries, there is a cause-and-effect relationship between strict environmental regulation and improved international competitiveness. Environmental regulations often increase the costs of production at first, but usually they will ultimately benefit the progress of business due to the gains in efficiencies, reduced waste, better safety and quality, and lower energy consumption.

5.1.3 Environmental impacts of international investment

The impacts of international investment and international trade on the environment and society can be quite similar. Large-scale international trade has promoted the transnational transfer of industries, thereby creating a new context for international investment. This, in turn, opens up a country's overseas resources and market space, and supports domestic economic development. In fact, international investment is more direct and complicated than international trade in terms of its environmental and social impacts. The academic circles have classified social and environmental impacts of international investment as follows: the halo effect, the regulation effect, the scale effect, the structure effect, and the technology effect. Each effect is a double-edged sword—in other words; it can be simultaneously good and bad for the host country's environment. Likewise, different investment subjects can also cause different environmental consequences. These cases are described in Table 5-1.

Table 5-1 Effects of international investment

Definition of effect	Positive effects	Negative effects
Halo effect Foreign-invested enterprises that adopt more environmentally-friendly behaviours and use better environmental technologies than the host country.	① Promotes the economic restructuring of the host country. ② Enhances the public's environmental awareness.	Risks concealing the double standard.
Regulation effect "Investment-attracting" behaviour of the host government seeking FDI with strong environmental and CSR values.	Well-funded foreign enterprises can enhance the regional economy when environmental regulations pose challenges.	Increases pollution and emissions in regions with loose environmental regulations.

Definition of effect	Positive effects	Negative effects
Scale effect Impact on the environment when FDI expands the scope of business activities in the host country.	① Foreign-funded enterprises that value sustainable development bring advanced environment and development concepts, consistent with a society's desire to strengthen environmental protection. ② Introducing transnational corporations with excellent abilities and perspectives on management and sustainable development helps host countries accelerate their own transitions.	In the event of rapid growth or significant decline, many medium and small foreign-funded enterprises will have trouble keeping up with the obligations in environmental regulations.
Structure effect Changes taking place in different departments of the host country caused by FDI, thereby changing the economic structure.	Depending on existing levels of pollution in the host country, foreign investment can inspire upgrades to a host country's industrial structure.	① It could become increasingly difficult to control pollution due to an imbalance of investment in different industries and regions. ② Foreign investment in China is mainly composed of small and medium enterprises, and the positive scale effect is lessened.
Technology effect The phenomenon that foreign investment increases the rate of technology upgrading, dissemination, and transfer.	① Transnational corporations with advanced technologies promote the deployment of environmental protection technologies. ② The entry of transnational corporations with advanced technologies helps improve technology at the host country's own enterprises.	

5.1.4 Main contents of research

China's economic development has entered a critical period of green shift. This is occurring while the world is undergoing a severe economic crisis, which can lead to new investment opportunities as development gaps can be resolved through new and more sustainable solutions. This can be an important period for China and other developing countries to explore strategic and unprecedented opportunities.

Green shift is a comprehensive concept that encompasses a low-carbon, environmentally-friendly, recycling economy. China's Twelfth Five-Year Plan has pointed out that the country's green shift represents the evolution from an unbalanced, uncoordinated, and unsustainable economic development pattern, to a more balanced, coordinated, and sustainable approach. At the same time, the green shift aims to reduce and eliminate the resource and environmental constraints of economic growth. It marks a transition from the traditional economic development pattern to a more intensive one. Investment, trade, and the environment are of critical importance in realizing the green shift to a balanced, coordinated, and sustainable economic development. Properly designed and utilized, trade and investment will drive and support the green shift; poorly designed, they could become a source of imbalance, chaos, and lack of sustainability.

China's rapid economic development poses serious environmental concerns. In 2010, China's carbon dioxide emissions were 8.33 billion Mt, accounting for 25% of the world's total — that's more than any other country[8,9]; the amount of primary energy consumption was 3.25 billion Mt of standard coal equivalent, with an average annual increase rate of 8.8%, ranking it number one in the world[10]. At the same time, China's fossil fuel resources are characterized by a lack of petroleum, small amounts of gas, and a wealth of coal. The currently estimated reserve and production ratio of petroleum is 11.3 years; natural gas, 32.3 years; and coal, 41 years. The proven reserves will increase, but not infinitely. Resource-intensive, energy-intensive, and pollution-intensive products comprise a very large proportion of China's exports. This reality has brought about a net loss to China's environment as a large amount of embedded carbon dioxide (CO_2) is transferred overseas through international trade. According to the Tyndall Centre for Climate Change Research (2007), the net export of embedded CO_2 in products traded by China is 1.1 billion Mt/year. A quarter of greenhouse gas emissions in China, including CO_2, are used for export. The current economic model in China, which exchanges resources for markets and environment for growth, must be reviewed. The drive towards a green shift should be actively and seriously pursued.

China's economic and trade cooperation with other developing countries is still in its infancy and can still be improved with regulations and other measures that support effective environmental stewardship. At this stage, China and other developing countries have the advantage of being relative late-comers to high levels of international trade and investment. Proper trade and investment approaches can not only promote China's green shift but also play an important and positive role in the green shift of host and partner countries. Effective

8 Nina Chestney. China's CO_2 emissions rose 10 pct in 2010-BP data. LONDON, June 8, Reuters: http://in.reuters.com/article/2011/06/08/energy-bp-emissions-idINLDE75716Y20110608?feedType=RSS&feedName=everything&virtualBrandChannel=11709.

9 BP Annual Statistical Review of World Energy 2011.

10 National Bureau of PRC. Statistical Bulletin of National Economy and Social Development in the Year 2010. Feb.28th, 2011.

environmental regulations relating to international investment and trade can become important drivers for a global green shift, a worldwide transition to sustainable development. Given the size of China's economy, its technological expertise, and the nature of the timing, China is in a position to lead on the issue.

The TF has focused on studying the green shift of FDI in China, China's ODI, and China's international trade, and CSR. The main questions affecting FDI in China are what sorts of investment should be encouraged and what policy measures should be adopted to ensure that FDI contributes to the green shift and sustainable development. As to ODI, the main question is about what policies China should develop to strengthen corporate social and environmental responsibility, improve the country's reputation, and enhance the image of China's overseas enterprises. In terms of international trade, the main questions are about what policies China should adopt to accelerate the shift to sustainable trade. In order to better understand these questions, the TF selected Indonesia, South Africa, and Zambia for first-hand examination. These were chosen based on locations where China's ODI and trade were more concentrated, and where the TF had access to local partner organizations and reliable local data.

Another important element of this research is to study how China should be involved in making and adapting international rules to promote a green shift. The relationship among investment, trade, and the environment, to a very large extent, depends on the formulation of domestic policy, but it also requires good quality international guidance and regulations. Strong domestic policies and international rules can complement each other. As China engages in the global governance process and participates actively in developing international environmental rules, it should always keep in mind that it is still a developing economy that must actively safeguard the interests of its own economic development and environment. How to balance the interests between the two will be a major challenge. Despite China's status as a major developing power, there are still considerable development hurdles at home, the solutions for which are not always understood abroad. This is a real challenge that requires China to act consistently at home and abroad when it comes to environmental governance. This is why China must take more initiative in participating in international rule-making processes on investment, trade, and environment. It must ensure its space next to the developing world while preserving its interests and relations among more advanced trading partners.

Recommendation: China should use FDI to help promote its green transformation and sustainable development by ensuring a more balanced sectoral and regional distribution of FDI, with environmental concerns dealt with in a consistent manner.

See 5.6 for more discussion about this recommendation.

5.2 The Environmental Impact of Foreign Direct Investment (FDI)

Attracting foreign capital has become an important way for China to participate in economic globalization. As one of the key sources of funding fixed assets in China, FDI promotes—in varying degrees—economic development; the expansion of employment opportunities; the improvement of employment quality; and the increase of government revenues. At the same time, foreign enterprises also enjoy the benefits of China's rapid development. According to the survey report published by the US-China Business Council in 2011, nearly 90% of American companies say that their business performance in China meets or exceeds global levels[11].

But FDI can also be considered a "double-edged sword" for host countries like China. The large-scale influx of FDI into sectors such as manufacturing, natural resources, and infrastructure construction, will heighten environmental pressures on the country. The major objectives of this chapter are:

(1) To review the sustainability of China's policies for attracting foreign investment during the three decades of reform;

(2) To analyze ways to guide foreign investment flows so that they positively and truly promote a green shift; and

(3) To study the enhancement of the halo effect and the spillover effect of foreign investment, in an effort to build the capacity of Chinese enterprises in terms of environmental management and environmentally friendly technology, and help China improve the market system in support of sustainable development.

5.2.1 Definition of FDI and its current status in China

FDI, according to the definition in China's National Yearbook, refers to investment by foreign enterprises and economic organizations or individuals (including overseas Chinese residents of Hong Kong, Macao, and Taiwan, and Chinese enterprises registered overseas) to open solely foreign-funded enterprises; run Chinese-foreign equity joint ventures; participate in cooperative joint ventures or co-develop resources with any enterprises or economic organizations within the territory of China in the form of spot exchange, real object, or technology (including re-investment of income from foreign investment); as well as the actions of any enterprise borrowing funds from overseas within the total amount of project

11 Europe China Economic&Trade Review，Jan. 2011: www.europe1china.com.

investment approved by relevant government authorities.[12] Currently, foreign investment in China has the following prominent characteristics:

(1) FDI in China comes from diverse sources. More than 170 countries and regions invest in China. According to the actual accumulated investment numbers (see Figure 5-1), half of the FDI is from Hong Kong, Macao and Taiwan, a quarter is from Europe, the US and Japan, about one-tenth is from Southeast Asian countries, and the rest is from tax havens. The actual investment from Hong Kong, Macao, and Taiwan has reached USD 74.8 billion, which represents 70.77% of the total foreign investment in China. In 2010, 1,688 enterprises (an increase of 6.97% over 2009) from 27 EU countries established their operations in China with an actual investment of USD 6.6 billion (an increase of 10.71% over 2009). Also in 2010, 1,576 US enterprises (a modest decrease of 0.76% compared to 2009) established their operations in China with an actual investment of USD 4.1 billion (an increase of 13.31% over 2009).

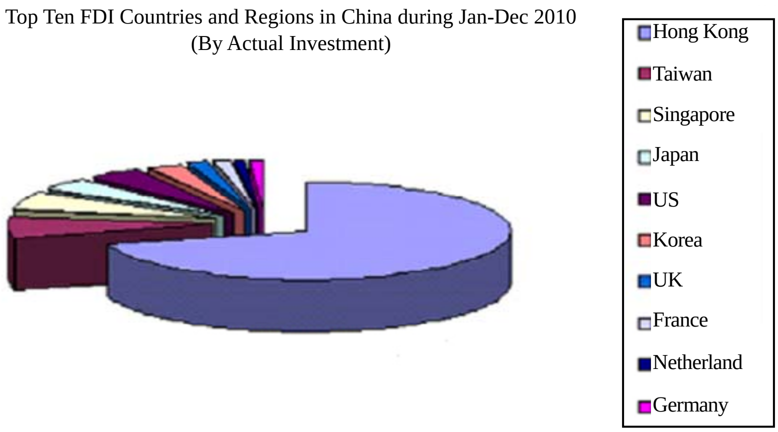

Figure 5-1 Top ten countries and regions sources of FDI in China, January to December, 2010

Source: MOFCOM.

The proportion of FDI in the manufacturing sector when measured against total FDI in China has shown a downward trend since 2005, while the proportion of FDI in the service sector has been increasing. FDI in the two sectors was roughly equal in China in 2010 (see Figure 5-2).

12 Source: *China's National Yearbook 2009*, National Statistical Bureau.

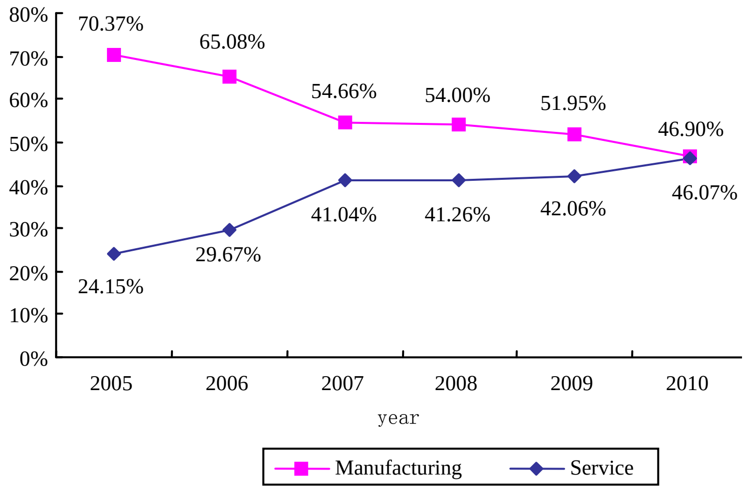

Figure 5-2 Proportion of FDI in the manufacturing and service Sectors in China, 2005–2010

Source: China's National Yearbook, National Statistical Bureau, statistics from MOFCOM.

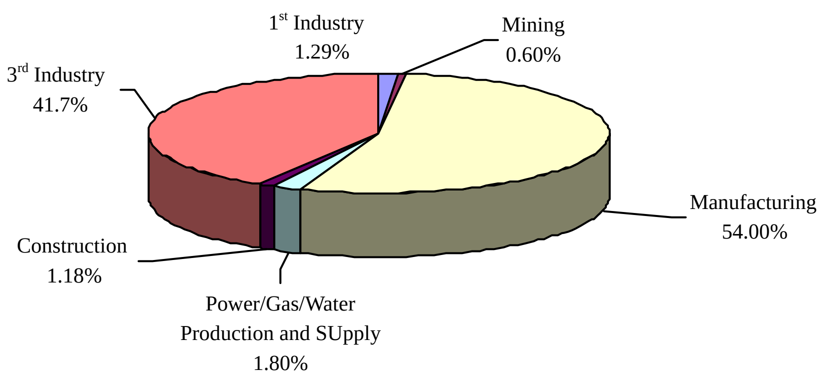

Figure 5-3 FDI by sector, 2008

Source: China's National Yearbook 2009, National Statistical Bureau.

(2) FDI in China is diversified in method of investment. The proportion of joint-ventures is 40%; the proportion of wholly-owned foreign enterprises is 40%. Sino-foreign cooperative enterprises represent 17% of FDI and the rest is composed of

cooperative developments, shareholding arrangements, etc.

(3) The geographical distribution of FDI in China is very unbalanced. FDI scale and benefits in the eastern costal area are much larger than those in other areas in China. The investment environment in the eastern coastal area—Bohai Economic Rim (including Shandong Peninsula, Liaodong Peninsula, Tianjin, and Beijing) centered around the Jingjintang Region; the Yangtze River Delta (including Zhejiang, Shanghai, Jiansu, etc.) centered around Shanghai; and the Pearl River Delta (including Guangdong) centered by Guangzhou—is comparatively sound due to policies of reform. These areas have attracted more than 80% of FDI in China. FDI is gradually moving into middle and western areas with an improving investment environment and market-driven forces attracting FDI to the areas.

5.2.2 Social and environmental impacts of China's FDI

Depending on the period, China's FDI acceptance policies, and the nature of foreign investment, the growth of FDI in the country can be divided into four stages:

(1) Initial Stage (1979—1985)

1) *Development features*

① The Law of the People's Republic of China on Chinese-Foreign Equity Joint Ventures marks the legalization of foreign investment;

② Foreign investments in China are mainly exploratory;

③ Investment is mainly concentrated on four special economic zones (Shenzhen, Zhuhai, Shantou, and Xiamen), and national foreign investment has not yet expanded broadly.

2) *Environmental impacts*

Foreign investment in China had not expanded into full swing. Total investment was on a small scale, thus the impacts on the environment were limited.

(2) Rapid Development Stage (1986—1995)

1) *Development features*

① Accelerated the legislative work related to foreign investment, and improved the climate for foreign investment;

② Under the multiple super-national treatment stimulation, foreign investment grew rapidly.

2) *Environmental impacts*

Guided by a series of preferential policies, such as "market for technology," a large number of foreign investments entered manufacturing, chemical, and other pollution-intensive industries. Because the investment structure presented no limits and foreign investment continued to increase, it led to large transfers of pollution-intensive industries to China, with varying degrees of impact on the environment.

(3) Adjustment and Improvement Stage (1996—2005)

1) *Development features*

① Guiding policies on foreign investment emerged: Interim Provisions on Guiding Foreign Investment Direction; the twice amended Catalogue for the Guidance of Foreign Investment Industries; and the amended Catalogue of Priority Industries for Foreign Investment in the Central-Western Region;

② The average scale of foreign investment continued to expand;

③ The industrial structure of foreign investment was further adjusted with foreign investment in high-tech, infrastructure, and other sectors increasing substantially.

2) *Environmental impacts*

The environmental impacts of foreign investment attracted more and more attention, and some large multinational corporations began to pay attention to internal environmental management, but the demonstration effect to domestic enterprises was limited. Due to the continuous expansion of foreign investment, the effects were still primarily negative.

(4) Sustainable, Coordinated, and Stable Development Stage (2006–present)

1) *Development features*

① In 2007 the *"Enterprise Income Tax Law of the People's Republic of China"* was formally enacted, merging the two income tax regimes for domestic and foreign enterprise, thereby leveling the playing field for foreign investors;

② There is stronger policy guidance regarding what industries and regions will be promoted for more foreign investment;

③ There are initiatives to promote various forms of domestic and foreign technical cooperation and joint innovation;

④ There is improvement in foreign investment projects vis-à-vis energy and water consumption; occupation of land; and other access standards, demonstrating an evolving focus on the sustainability of foreign investment.

2) *Environmental impacts*

With sustainability becoming a mainstream focus of development, and with China's strict restrictions on the entry of low-level, high-consumption, and pollution-intensive foreign investment projects, the

Recommendation: Ensure, as a matter of principle and legal framework, that FDI into China and China's ODI should be held to a high standard on corporate social responsibility.

See 5.6 for more discussion about this recommendation.

environmental impacts of foreign investment are gradually demonstrating a positive side [13].

5.2.3 International comparisons

FDI in Brazil, India, China, and the United States

Brazil's welcoming of FDI occurred several decades before China's, and therefore Brazil faced sustainable development challenges much earlier. Under the guidance of the government, the structural transformation of FDI in Brazil is basically complete. FDI in Brazil is mainly concentrated in low-polluting industries such as service, energy, communication, finance, and transportation.

India's national conditions are similar to those of China, and its national development strategy is also very much like China's. However, compared with India, China features greater government intervention in the economy, therefore, the Chinese government has an advantage over India's in terms of creating the conditions to attract foreign investment in the manufacturing sector. Meanwhile, the service industry, which is also labor-intensive, sees strong growth in India. The different policy orientations of these three developing countries have led to different distributions of FDI throughout their respective economies, and different degrees of environmental impact.

By comparison, the investment policies of the United States place more emphasis on establishing a long-term stable investment environment. The government aims to provide foreign investors with a fair, transparent, and liberal investment environment and excellent infrastructure, featuring a limited and predictable policy system and efficient and high-quality government services. Investors must observe various legal provisions in the United States, including its environmental standards and environment-related legal provisions. The high degree of market orientation also forces enterprises to attach importance to the sustainability of investment; otherwise they will be eliminated by the market. In contrast, China's investment-attracting policies are mainly aimed at gaining significant short-term benefits against the backdrop of local governments' blind pursuit of GDP. Some of the policies were even launched at the cost of national assets and environmental destruction. The relative disconnect between investment laws and the environment, lack of relevant and up-to-date project management expertise, and weak regulation over foreign-funded enterprises are important causes of unreasonable FDI structure and serious environmental destruction in China.

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5.2.4 Opportunities and challenges facing foreign investment

Since the outbreak of the financial crisis, China has succeeded in maintaining a stable investment climate, providing a relatively safe harbor for FDI. As the government encourages further FDI, specifically towards the central and western regions of China, it can use environmentally-based incentives to better distribute these new investments. This approach can help China address its continuous need for new FDI, related technologies, and ecologically sound initiatives.

While China remains a most attractive host country destination for FDI, foreign investment is also increasingly confronted with a series of new and changing concerns. The various challenges faced by the Chinese economy are compounded by external environmental and economic changing conditions. Operating costs in China are rising. With industrial structural adjustment in China, the international competition for FDI will be further intensified. With the further improvements and the maturing of China's market mechanisms, various "super-national treatments" that foreign-funded enterprises currently enjoy will end (some have already ended), thereby placing higher demands on foreign-funded enterprises.

Case Study: Royal Dutch Shell

Shell's sustainable development report is an important channel for its active disclosure of environmental information. Compared with the environmental information disclosed by Shell China, the reports of Shell's American and Dutch subsidiaries, though imperfect, cover a wider range of issues, and provide much more in-depth information, including Shell's efforts in air and water preservation and energy utility; the environmental impact of Shell's operation; safe production, etc. The reports also articulate the company's social responsibility initiatives. The contents of the Shell China report, on the other hand, are simpler, without global considerations or descriptions of technological innovation and applications from the perspective of global energy use. As specific data are not required by China—the host country in this case—the Shell China report lacks detailed information in terms of environmental performance and therefore, on a comparative basis, its environmental performance measures are superficial.

5.2.5 Conclusion

Since China started to accept FDI three decades ago, the flow of foreign capital, all-in-all, has had positive and negative impacts on China’s environment and development. It is hard to say on balance whether the net contribution of FDI is positive in relation to the environment. In any case, rapidly absorbing large amounts of new investment in pollution intensive industries has made China the “world’s factory” confronting it with very serious environmental challenges. As China has become an important destination for transnational corporations, it has been increasingly exposed to some of their new thinking, raising awareness about the importance of environmental protection; stimulating concern among the public; and introducing corporate social/environmental responsibility policies into the investment deployment process.

The uneven distribution of foreign investment in industries and regions has increased the difficulty in regulating pollution. The environmental advantage of foreign investment in sensitive industries is weakened. Take the chemical industry, for example. In the last five years, the pollution associated with investment from FDI in this sector has been increasing, and the continuous increase of foreign investment in the chemical industry, to some extent, does not meet China’s environment and development policy orientation of “energy conservation, emissions reduction, and green development.”[14]

Foreign investment will continue to be an important driving force in the Chinese economy, but we should not blindly overestimate the influence of foreign investment on Chinese enterprises. In fact, FDI cannot truly foster domestic enterprises, and the re-invigoration of national industries in China must rely on longer-term, domestic efforts. Foreign investment should provide important support for preventing the constant inflow of old, inefficient technology while optimizing the economic growth structure. Voluntary environmental measures, as a new approach to environmental management, are still in their very early days in China. Foreign investment’s “spillover effect” can be used to effectively promote the development and progress of voluntary environmental measures in China.

5.3 Environmental and Social Impacts of Chinese ODI on Host Countries

With the rapid growth of China’s outward direct investment (ODI), the country’s enterprises have become more visible on the world stage, but so have their considerable environmental and social impacts on host countries. With the increased awareness of environmental protection in host countries, governance of natural resources, and increased

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attention to corporate social responsibility by the international community, China's ODI needs to concern itself with environmental issues and the potential social benefits to host countries.

This chapter analyzes and discusses how to treat China's image, including perceptions of its ODI by media and other parties; whether Chinese overseas enterprises only comply with lower environmental standards in host countries; whether a large number of medium-sized and small Chinese overseas enterprises pollute the local environment of the host countries; and how well Chinese overseas enterprises have performed vis-à-vis minimum wage standards, medical care, welfare measures, and local employment.

5.3.1 The current state of China's ODI and future trends

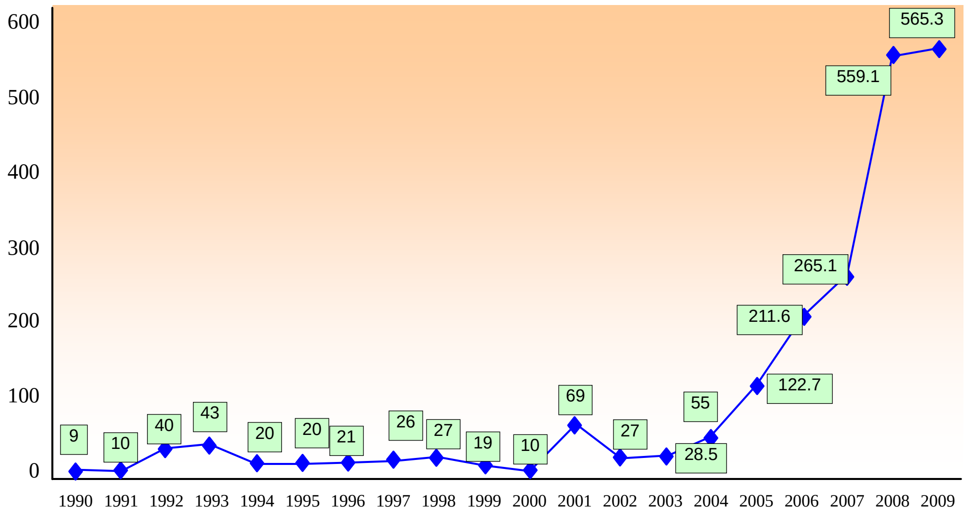
5.3.1.1 Current state of China's ODI

With a diverse and growing economy, the volume of China's ODI has been increasing rapidly since the 1990s. The "going global" strategy of 2002 has been a major driving force for the increase in ODI.

China's volume of ODI increased from USD 33 to 230 billion during 2003–2009, approximately a seven-fold increase. By the end of 2009, 12,000 domestic Chinese investors had created 13,000 directly-invested enterprises in 177 countries around the world, totaling USD 245.75 billion in investments. These were broken down into USD 76.92 billion in equity investment (31.3% of the total), USD 81.62 billion in reinvested earnings (33.2% of the total), and USD 87.21 billion in other types of investment (35.5% of the total). The total assets of Chinese enterprises operating overseas exceeded USD 1 trillion by the end of 2009 (see Figure 5-4).

Recommendation: China should focus its ODI not only to play a significant role in meeting China's "12th Five- Year Plan" targets, but also to promote host country green development and transformation, in line with objectives defined by the host nations, the Millennium Development Goals, and other relevant international sustainable development objectives. China should articulate and expand its policy guidance for enterprises that are "Going Global", so that its ODI is consistent with China's green development vision.

See 5.6 for more discussion about this recommendation.



Note: Figures of China's ODI from 1990 to 2001 are from UNCTAD's World Investment Report; figures from 2002 to 2009 are from MOFCOM.

Figure 5-4 Rapid growth of China's ODI

Source: UNCTAD and MOFCOM.

Despite the recent rapid growth of China's ODI and the fact that it ranked fifth in the world (first among developing countries) in 2009, the flow and volume of ODI of China respectively accounted for merely 5.1% and 1.3%[15] of the 2009 world's total.

5.3.1.2 China's ODI structure

Contrary to many assumptions about China's ODI being concentrated on energy and mining, the sectoral distribution of China's ODI is actually reasonably balanced (see Figure 5-5). Leasing and commercial services, and the finance sector each represent a higher percentage of Chinese ODI than mining, which accounts for a mere 16.5%. The manufacturing sector ranks even lower at 5.5%. This is in clear contrast with the characteristics of China's domestic economic structure.

15 UNCTAD World Investment Report 2010.

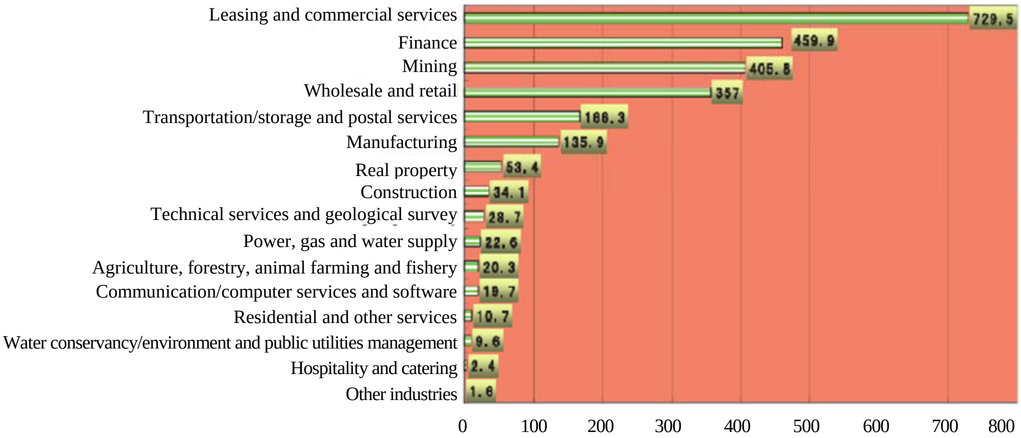


Figure 5-5 Industrial distribution of ODI volume of China by the end of 2009

Source: 2009 Statistical Bulletin of China's Outward Foreign Direct Investment, MOFCOM.

Heavily concentrated in Asia, followed by Latin America and Africa, the geographic distribution of Chinese ODI is highly uneven. By the end of 2009, the investment volume in Asia registered at USD 185.5 billion, accounting for 75.5% of the total volume and mainly concentrated in Hong Kong, Macao, Japan, South Korea, and Southeast Asian countries; the investment volume in Latin America was USD 30.6 billion, accounting for 12.5% of the total and mainly concentrated in the British Virgin Islands, the Cayman Islands, Brazil, and Peru; the investment volume in Africa was USD 9.33 billion, accounting for 3.8% of the total and mainly concentrated in South Africa, Nigeria, and Zambia (see Figure 5-6).

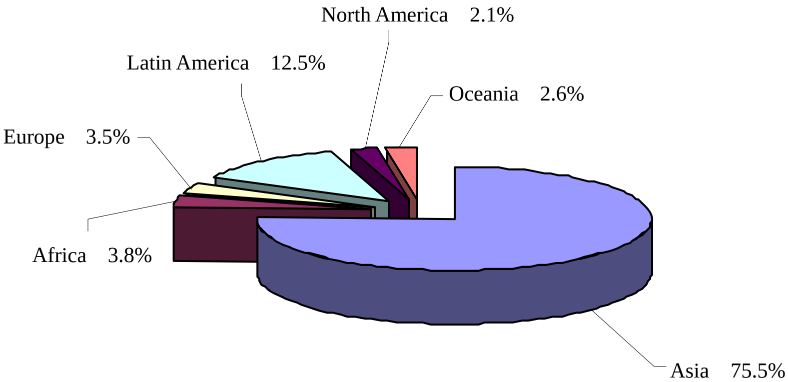


Figure 5-6 Regional distribution of China's ODI

Source: 2009 Statistical Bulletin of China's Outward Foreign Direct Investment, MOFCOM.

From an ownership perspective, state-owned enterprises (SOEs) account for the largest proportion at 69.2% of China's total ODI, followed by limited liability companies and shareholding limited companies, accounting for 22.0% and 5.5% respectively; while privately-owned enterprises account for a mere 1.0% (see Figure 5-7).

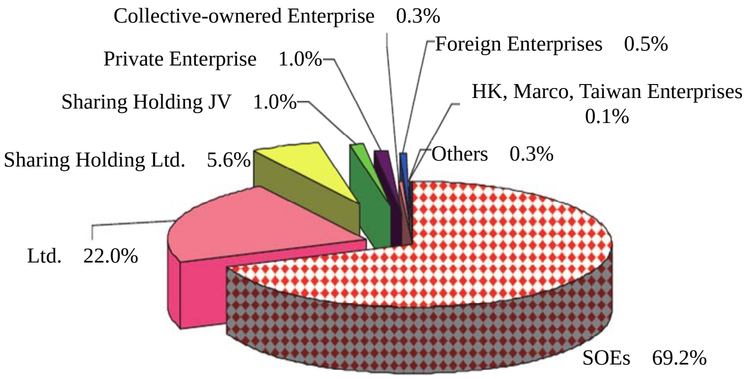


Figure 5-7 Non-financial volume of China's ODI at the end of 2009, by registration type of domestic investors

Source: 2009 Statistical Bulletin of China's Outward Foreign Direct Investment, MOFCOM.

5.3.1.3 Future trends in Chinese ODI

China's ODI is gradually becoming more diversified as the number of technology-intensive projects continues to increase. China's ODI facilitates the export of merchandise related to its domestic production, while trade related to ODI plays a significant role in the growth of foreign trade. According to a UN survey in 2010, China ranks second in the world in global investment potential (UNCTAD, 2010a).[16] China's confidence in ODI was not dampened by the global economic crisis. In 2009, its non-financial ODI reached USD 43.3 billion with significant annual growth. The Ministry of Commerce predicts that China's ODI for 2010 will have totaled USD 60 billion. Most of the ODI flows to Asia, Latin America, and Africa and is focused on design and manufacturing, sales, and the retail and trade sectors. Mining and resource-related sectors are becoming the new focus of investment by Chinese enterprises.

As growth in ODI increases, so too do complaints of environmental and social impacts.

16 Yin-Wong Cheung, XingWang Qian, Shu Yu, China's Outward Direct Investment in Africa.

5.3.2 Social and environmental impacts of China's ODI

5.3.2.1 Social impacts and challenges of China's ODI

China's ODI has created a large number of job opportunities for host countries, but there is still room for improvement in the employment structure it provides. In Cambodia and Vietnam, investment by Chinese investors in manufacturing is concentrated on labor-intensive manufacturing. In Cambodia, the 27 Chinese manufacturers surveyed have a total of 26,439 employees, 98% of whom are Cambodian. In Vietnam, the 33 Chinese enterprises surveyed have provided a total of 10,020 jobs, 95% of which are held by Vietnamese[17]. The labor structure within an enterprise may vary according to the level of technical intensity. In Cambodia, local employees account for less than 30% of the intermediate and senior positions as most of the senior executives are Chinese. This situation can be attributed to Chinese investors' belief that local candidates are lacking in skills and experience. Therefore, the clothing industry and Asian enterprises have come to a consensus that Chinese nationals should constitute a large proportion of supervisors. However, communication difficulties and cultural differences between these Chinese nationals and local Cambodian workers sometimes lead to labor unrest and strikes, and Chinese supervisors cannot easily solve these problems. The case in Vietnam is the opposite, as 63% of supervisory positions are held by Vietnamese. The major difference between Chinese enterprises operating in Cambodia and Vietnam is the gap of education level between these two countries. In Vietnam, Chinese enterprises would rather employ Vietnamese than expensive overseas Chinese as executives as it costs less for to train their Vietnamese employees for these executive positions.

Governments of many countries require Chinese enterprises to provide a certain proportion of employment opportunities for local workers. For example, the host country of the national stadium project in Costa Rica demanded that the project be completed within one year and that no Chinese workers should be involved. (In the end, only Chinese workers were employed and the stadium was finished in two years).[18]

The cultural challenges faced by Chinese enterprises pose a major barrier to their development. Chinese enterprises investing overseas are faced with an unknown environment featuring totally different commercial practices, not to mention management,

17 EU-China Civil Society Forum, *The Impact of Chinese Outward Investment*, Published on 2 March, 2011, Viewed on. 13 Oct., 2011： http://www.eu-china.net/.../11-03-02_Impact%20of%20chinese%20outward%20investment.pdf.

18 Older Entry, *Costa Rica Insight*, viewed on 13 Oct., 2011, http:// costaricainsights.wordpress.com/page/2/.

financial, and cultural rules that differ from those on China's mainland in green field investment as well as mergers and acquisitions (M&A). For example, studies of M&A of Chinese enterprises in Germany show that the most important factors in managing overseas acquisitions are staff integration and narrowing the cultural gap between Chinese investors and the corporate protocols in Germany[19].

In Zambia, many of the local complaints from community and labor representatives centered around misunderstandings and social clashes occurring between Chinese and local people due to a lack of dialogue and cultural exchange. These seemingly superficial crises often led to deep resentment, xenophobia and hysterical media accounts that were based it would appear on misperception and a lack of communication. In order to improve the performance of an acquisition, Chinese enterprises must make a special effort to better integrate with their host community in order to prevent and resolve cultural differences; and create links with the local society, its stakeholders, its government and NGO representatives, as well as the environment, labor, and regulatory officials of host countries.

The performance of ODI may vary greatly depending on circumstances, and even well-planned direct investment projects may be confronted with unexpected difficulties due to differences in culture and management practices. For example, TCL found itself in a very difficult situation after its acquisition of Alcatel in France due to difficulties in managing local staff; Shougang Group was challenged by strikes and conflicts between investors and labor in South America; Shanghai Automobile Industrial Corporation (SAIC) also had similar experiences after its acquisition of Ssangyong Automobile in South Korea in 2004 and failed in its negotiation with the labor union on wages.

Likewise, during the TF field trip to Indonesia, the team visited the Pertamina-Petrochina joint oil desulfurization unit in Bojonegoro, East Java. While the company had serious accidents in the past, management was proud to show that it had reduced its accident rate to zero since the arrival of the Chinese partner. Nevertheless, they had suffered a lot of complaints from the field as Chinese drilling rig equipment had no safety notices in either English or Bahasa Indonesia (Indonesia's official language). A small detail considering the size of the investment, but it led to false allegations that the equipment was not safe and performed below par. The local media amplified these issues creating the false image that Chinese drilling rigs were of low quality and Petrochina's drilling teams were not concerned with worker safety.

China's ODI enterprises suffer from a lack of expertise, experience and

19 Kay, Li Kuen Andrew, *International Exhibition Organizers in China and Their Performance*, The Hong Kong Polytechnic University, Published in June 2007, http://www.cpexhibition.com/introd/Kay%20DBA.pdf.

preparation. Poor confidence and inadequate experience in cross-border investment in a strictly regulated environment with complicated market administration have proven the lack of necessary expertise of Chinese enterprises. Examples include the joint-venture of SAIC and Ssangyong Automobile in South Korea and the recycled steel plate project operated by Baosteel in Brazil. However, although increasing globalization has exposed the limited expertise of Chinese enterprises in large-scale Western-style acquisitions, many destinations of Chinese ODI—especially Africa and Asia—still feature weak organizational structures, flawed intellectual property rights protection, government intervention, and different corporate management systems. Western multinationals are comfortable operating in stable markets with transparent regulations, while their Chinese counterparts are better equipped to operate in more complicated and unclear regulatory frameworks. This could be considered one of the unique advantage's that have helped China develop innovative and country specific relationships with African countries. Its business expansion in that continent has become a strong example of its "going global" strategy.

China is still suffering from the negative effects of its ambiguous definition of property rights, a lack of a clearly defined regulatory mechanism for the private sector, flawed corporate governance, and inadequate experience in international business. Private enterprises in China are relatively weak in seizing ODI opportunities. Their senior management need to be trained to enhance corporate governance in line with international practices. In countries with mature institutional systems, the costs of contracts and other legal supports are relatively low, making them effective in building relationships, yet Chinese enterprises need more time to be adopting them.

Their global presence will inspire changes in Chinese enterprises, especially those who have entered developed countries and compete in high-end product markets. How should Chinese enterprises establish their own identity on a global scale, designing suitable business models adapted to the realities of different countries while enhancing corporate governance both at home and abroad? How should Chinese enterprises improve the quality of their products and services as well as corporate governance while competing for market share and developing an institutional system in China? What modern governance system is suitable for the trajectory of development in China? These questions will exert profound influence on the development of Chinese enterprises for the foreseeable future.

5.3.2.2 Environmental impacts and major challenges of China's ODI

(1) Environmental impact on forest and biodiversity

Research into the environmental impacts of China's ODI considers the exploitation of natural resources and the degradation of biodiversity. For example, China's investments in Southeast Asia and Africa are concentrated in environmentally sensitive sectors (e.g., petroleum and gas extraction, mining, hydropower, and forestry) and infrastructure projects (e.g., highways, railways, electric-power and transmission lines). The Kunming-Bangkok Highway, an important corridor for trade and investment and a facilitator of interaction between China and Southeast Asian countries, is significant for economic prosperity and development. However, environmentalists believe the highway has damaged local biodiversity. A Chinese enterprise built a rubber plantation in the "Golden Triangle", to help Burma and Laos replace the cultivation of cash crops and illegal logging in an opium-based economy, as the governments try to eradicate drug abuse and poverty. However, similar allegations of local biodiversity damage have also been leveled against the Chinese. There is clearly a need to study how to better assess those projects.

China is the second largest importer of wood products in the world. Chinese logging companies have expanded around Southeast Asia, West Africa, and in the Amazon region. Approximately one third of such imports is intended for processing and re-export to G8 countries. Exports from Africa to China have been rising quickly, and it is estimated that 70% of these exports are from Gabon and Equatorial Guinea. Russia has also become an increasingly important source of timber to China. Illegal logging and certification are of great concern to the international community[20].

During the TF visit to the East Kalimantan region of Indonesia, the team assessed the impacts of China's growing trade in coal and palm oil; China is Indonesia's second buyer of palm oil. Increasing demand for the oil, coal and the lucrative nature of the international market, combined with weak public governance at the domestic level promote illegal logging, deforestation, and the rapid conversion of forest land into coal mining and palm oil plantations in Indonesia. This type of coal and palm-oil operation has caused massive ecological damage and adverse social-economic impacts to the region and to local communities. Yet, China is more interested in importing the raw natural resources for domestic processing, while leaving the responsibility of the upstream impacts of this business, such as illegal logging and degraded forests, entirely in the hands of the host country.

(2) Challenges in environmental standards compliance

A pre-project evaluation of environmental impact; the implementation of environmental measures during a project; and environmental assessment after completion are required for

20 Prof. Sun Siheng, State Forestry Administration, A Guide on Sustainable Management and Utilization of Oversea Forest by Chinese Enterprises, Published on 8 September, 2010.

all projects funded or financed by the China Export-Import Bank[21]. China's environmental standards are compared with those of the host country, and the higher standards are adopted.

Research conducted by the CCICED team in Zambia found that the energy consumption of copper production per Mt in Luanshaya Copper Mines—in which China Nonferrous Metal Mining (Group) Co. is investing—is 186 Mtce with the application of the most advanced technology and equipment from Australia. At the same time, the energy consumption of copper production per Mtce is 260 Mt of standard coal equivalent at China-Yunnan Copper Co., Ltd. and Jiangxi Copper Co., Ltd. This case shows that environmental standards adopted by the enterprise in Africa appear superior to the standards applied in China.

Many well-known Chinese enterprises, managing environmental concerns, have taken the initiative to adopt ISO14000 environmental standards and the ISO26000 guiding principles of social responsibility. However, problems in compliance with environmental standards may exist with some medium-sized and smaller enterprises (SMEs) due to their limited environmental awareness, economic strength or other reasons. While some developing countries in Asia, Africa, and Latin America are developing stronger environmental awareness, with environmental standards that are increasingly aligned with the international mainstream, the environmental behavior of Chinese SMEs still often lags behind such mainstream levels. Whether the companies are large, medium, or small-sized, they are representing Chinese interests and respect for the environment should be part of their way of doing business. This should be the case regardless of whether or not the Chinese government provides foreign aid, capacity development, or other assistance to the developing host country.

5.3.3 Related roles played by major stakeholders in reducing the social and environmental impacts of ODI

5.3.3.1 China's ODI enterprises

When it comes to the adoption of modern social and environmental approaches to their ODI activities, Chinese enterprises still appear to be 15–20 years behind their western counterparts. This is perhaps due to the more active role of influential NGOs in the west. At present, some Chinese enterprises are making a considerable effort to invest in

21 China Intelligent Online, *China Environmental Protection Industry Overview,* Published on 2008, Viewed on 13 Oct., 2011, http://www.slideshare.net/chinaintel/china-environmental-protection-industry-report-2008.

environmental enhancement and projects to advance social well-being, yet there is a major gap in capacity and roles between state-owned and private enterprises. Generally speaking, the social and environmental performance of large state-owned enterprises is somewhat better. Considering that over 70% of Chinese ODI comes from large state-owned enterprises and only 1% from medium- and small-sized enterprises, it is easy to conclude that the overall environmental and social impact of Chinese ODI is largely in the hands of the government.

In recent years, China has actively promoted policies that stress the adoption of social and environmental commitments by FDI and ODI enterprises. For example, in 2007, China's import and export bank (EXIMBANK) promulgated the "Guiding opinions on the environment and social evaluations of EXIMBANK loan projects." That same year, the China Banking Regulatory Commission printed and distributed "Opinions on consolidating the corporate social responsibilities of the banking industry and financial institutions," requiring that large-scale banks abide by the 10 basic principles of CSR advanced by the UN Global Compact. The Commission also asked these banks to prepare CSR reports to articulate their activities. In 2007, the Ministry of Environmental Protection, together with the People's Bank of China and the China Banking Regulatory Commission issued documents that established China's Green Credit Policy. The International Finance Corporation (IFC) Performance Standards and the Equator Principles were identified as international guidance documents that Chinese banks can refer to in their implementation of the Green Credit Policy.

In addition，in order to encourage the enterprises to engage in CSR activities, in December 2007, the state-owned Assets Supervision and Administration Commission of the State Council distributed the "Guiding opinions on the exercising of corporate social responsibilities by state-owned enterprises", and proposed that as Chinese enterprises "go global", they should help host countries modernize and implement their environmental regulations. The international trend towards more environmental considerations in international agreements is quite clear and China should be fully engaged in contributing to its development.

5.3.3.2 Central and local governments of host countries: sharing responsibility for regulation and enforcement

Chinese enterprises generally abide by the laws and regulations of the host countries in which they invest, hence it is the central and local governments of the host countries that should play the major role in regulation. A Canadian governmental official, while analyzing the positive and negative impacts of China's investment in the mining sector of Canada, said that China-based overseas investors are beginning to learn to abide by local laws and regulations with no apparent difference from other industrialized countries[22]. In the bidding efforts for investment in Rio Tinto in February 2009, the president of Chinalco endorsed the sustainable development pledge of Rio Tinto[23]. In Indonesia, the local Regent of Bojonegoro, East Java, told the TF team visiting Petrochina's oil exploration operations that they were taking voluntary actions in relocating schools and communities as well as financing mobile libraries for the local populations (together with EXXON-Mobil) in order to spare them from the pollution and dangers of living in close proximity to oil desulfurization plants and crude oil production wells. These actions were very much appreciated and widely recognized by the local communities.

On the other hand, there are reports of Chinese enterprises, especially small private enterprises, turning a blind eye to environmental requirements or bribing local officials. An increasing number of NGOs and civil society organizations criticize Chinese enterprises for failing to comply with local laws and regulations. The solution requires, in part, the application of a transparent and accountable system to the public in the host country and improvement in the administrative capacity of host governments to enforce their laws and regulations.

5.3.3.3 Central and local governments of China: sharing responsibility for the environment

As China positions itself to become a major global player, central and local governments are beginning to require Chinese enterprises to improve their environmental performance and enhance their social contribution in an effort to safeguard China's image and promote sustainable global investment and business. Progress in policy-making, legislation, and standardization in China is an important driving force for Chinese enterprises to meet environmental and social goals. In particular, the Chinese government requires enterprises to conduct clean production auditing on a regular basis, which effectively improves their environmental performance. And Chinese enterprises, state-owned and private, are actively engaged in improving their governance and ameliorating their environmental and social impacts at the urging of government. A positive example is that China's Forestry Administration issued A Guide on Sustainable Overseas Forests

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22 Prof. Sun Siheng, State Forestry Administration, *A Guide on Sustainable Management and Utilization of Oversea Forest by Chinese Enterprises*, Published on 8 September, 2010.

23 UNCTAD, *World Investment Report 2009*，Published in 2009, United Nation Publication, ISBN 978-92-1-112775-1, http://www.unctad.org/en/docs/wir2009_en.pdf.

Management and Utilization by Chinese Enterprises to provide guidance on investment and operations of China's ODI in host countries in consideration of sustainable development, environmental protection, and CSR.

5.3.3.4 Non-governmental organizations

Non-governmental organizations may monitor ODI and ensure that these investments will not exert negative impact on local environment and society. Of all Chinese ODI activities, two major areas are of particular concern: natural resources, such as coal, wood, petroleum, natural gas, etc.; and construction projects, such as building highways, hydro-dams, water supply reservoirs, electric-power and distribution systems, public housing, etc. Both types of investment have important social and environmental impacts. Therefore, enterprises must exert the utmost diligence in avoiding such impacts, compensate for any damage by restoring and rehabilitating damaged sites, and offer additional compensatory facilities such as new schools and hospitals that can somewhat mitigate impacts. These proactive steps in a "going global" project are likely to be acknowledged by the beneficiaries of such investments and lead to a more positive perception of China by the residents of the host country. Local stakeholder organizations and international NGOs may play a role monitoring such actions and controlling malevolent or corrupt and defamatory media campaigns against Chinese interests.

5.3.3.5 Media

The strong and committed environmental governance efforts of some Chinese enterprises involved in ODI projects have produced quite visible positive results as Chinese enterprises assume greater CSR initiatives. For example, the China International Marine Containers (Group) Ltd. has adopted the UN Global Compact Environment Statement; China National Petroleum, Sinopec, and CNOOC have adopted a series of rigorous environmental protection standards; and the Industrial Bank of China has become the first Chinese bank to adopt the Equator Principles. Yet international media tend to focus mostly on criticizing the environmental performance of China's outward investments, which raises suspicions about the country's strategy of "going global". Furthermore, there is little coverage about Chinese ODI in the Chinese media, and even less coverage about the environmental and social impacts of such investments. An improved Chinese media focus on the efforts made by Chinese enterprises to minimize their negative environmental impacts will help create a more accurate image of Chinese ODI and help reduce the negative perceptions transmitted by the international media.

5.3.4 Examples of the positive contributions of Chinese ODI

5.3.4.1 China's ODI in the natural resource sector

The investment by Chinese state-owned enterprises in the natural resource mining and petroleum sectors of some South American countries has had significant impacts on local societies, economies, and their environment. At first, those impacts tended to be negative, but as the firms adjusted their CSR strategies and policies, positive impacts began to gradually manifest themselves. Andes Petroleum Ecuador Ltd., a joint venture of CNPC and SINOPEC, for instance, is a symbol of China's cooperation with the central government of Ecuador. The company plays an active role in the alleviation of tensions between the local government and its residents. Shougang Hierro Peru S.A.A. has also reversed its early negative impact on the social development of the Peruvian community where it operates by deciding to adopt a proactive approach to addressing local social issues it used to ignore.[24] In Indonesia, on the other hand, the TF team witnessed considerable environmental degradation related to surface coal mining activities in East Kalimantan intended to supply Chinese trade. Over 24% of imported coal in China in 2009 was from Indonesia, and Kalimantan accounts for a majority of coal production in Indonesia. In 2005, East Kalimantan's share was 51.7% and South Kalimantan was 41.2%. Significant production increases in recent years have occurred to supply the export market at more than 75% of national coal production. Most of that goes to China, which is blamed for the resulting environment damage to Indonesia.

5.3.4.2 China's ODI in the new energy sector

China's ODI enjoys great opportunity in the new energy sector. In Africa and developing countries elsewhere, Chinese low-carbon technologies and products are particularly competitive with advantages ranging from low costs, limited infrastructure requirements, low emissions, and high economic returns. Compared with advanced technologies and products in western countries, Chinese companies are better equipped to facilitate green development and the required economic shift in developing countries. Installing a Chinese low-carbon solar water heater is one-third the cost of installing an average water heater. Likewise the extensive palm oil plantations being stimulated by China's appetite for vegetable oils could also provide a unique resource for renewable

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24 Julie Jiang & Jonathan Sinton, *Oversea Investments by Chinese Oil Company*, International Energy Agency, Published in February, 2011, http://www.iea.org.

energy through biodiesel applications. The TF team visited a small, privately-owned Chinese steam boiler and electric turbine producer on the outskirts of Jakarta (ZUG POWER GROUP, PT. ZUG Industry Indonesia). The firm was anxious to receive some form of incentive to produce small off-grid power plants that would use their equipment and supply renewable energy to isolated communities. The new energy resource sector will become an increasingly important target for Chinese ODI.

5.3.4.3 China's ODI in the infrastructure sector

The cost for Chinese enterprises to invest in the infrastructure sector is up to 50% less than it is for their European and American competitors. At present, Chinese investors are interested in water storage projects, especially hydro-dam construction projects in Southeast Asia and the Middle East, including the Stung Cheay Areng Dam on Cheay Areng River in Cambodia, the Shweili Dam Project in Myanmar, the Aswan Dam Project in Egypt, and others. Although dams and water reservoirs will generate agricultural benefits, they also create an impact on the local environment and society. It should be noted that the investor and property owner of dam projects are usually the host country governments rather than Chinese enterprises, which are mainly involved in construction and finance. For those mid- and small-scale hydropower projects with a capacity below 60 MW, Chinese investors are the key players as developed countries have decided not to explore this market. As a result, Chinese project builders are often the target of media and NGO criticism when in fact the responsibility for the project is mostly in the hands of the host countries, and only very rarely in those of the Chinese investors and contractors.

5.3.4.4 China's ODI in the forestry and agriculture sector

Old growth forest exploration causes loss of native forest-related biodiversity and promotes the disappearance of local culture. A Chinese enterprise built agro-forestry projects in the “Golden Triangle”, an area on the boundary between Thailand, Burma, and Laos, to help replace the opium-based economy with cash crops and commercial timber. This ODI project is killing two birds with one stone, as it aims to control the drug flow into China while cracking down on drug abuse in the host country. There are approximately 40 Chinese enterprises (including eight major rubber companies) operating in Northern Laos under the guidance of anti-drug policies.

A positive management model in forestry will also promote the healthy development of the forest ecological system. For instance, a Chinese enterprise in British Columbia, Canada, has harvested mature and post-mature forests in compliance with the law regarding reforestation, thereby meeting governmental standards[25]. Managers of Chinese enterprises have gradually grasped the complex nature of the forest ecological system, and the activities of Chinese enterprises have also triggered extensive interest among local residents in the forestry sector. Take another Chinese enterprise in Russia for example. After purchasing the Far East Forest company in Russia, it managed the firm's logging activities through sustainable harvesting methods which reduced the amount of waste wood logged annually; and recycled low-value wood for sawdust and chips for pulp/paper making, thereby enhancing the efficiency rate of the resources. Similarly, two Chinese enterprises have located their headquarters respectively in Indonesia and Brazil and built overseas factories to process wood into pulp. Lands for cultivation of the timber supplies are secondary, low-return, and infertile forestlands where the wood coverage is below 20 m^3 per acre. These enterprises conscientiously fulfill their pledge to protect biodiversity in high conservation value forests as in all typical forest ecosystems.

5.3.4.5 Field trip research in Indonesia, South Africa, and Zambia

In order to get first-hand information, the Task Force carried out field trips to Indonesia, South Africa, and Zambia. In general, China's ODI seemed to be greatly appreciated by local governments. It is also welcomed as China's ODI is also seen as an opportunity to help achieve local sustainable development targets. Both the scope of trade and investment as well as its rapid pace of development have accelerated greatly in recent years, placing new challenges before China's ambitions.

In Indonesia, China's ODI enterprises have demonstrated some very good practices, which have led to the construction of new schools, new housing developments, hospitals, and road infrastructure. However, when compared with other ODI, China's investments are generally less well accepted than western investments. They often rank lower than even Indian and Japanese investments. One of the reasons seemed to be that Chinese investors rarely invest downstream into the markets when they are exploring for minerals or oil, for instance. They will extract the resources and ship them away. Indian investors, for instance, are more inclined to build fertilizer plants or LNG bottled gas distribution networks downstream from a natural gas plant or refinery. Indian investors integrate more into the economy and society. SMEs' improper practices are generally responsible for damaging the reputation of China's ODI, although certainly problems are not restricted to SMEs. The lack of communication by some Chinese ODI enterprises, large and small, and their tendency to live in an isolated way inside

25 Prof. Sun Siheng, State Forestry Administration, *A Guide on Sustainable Management and Utilization of Oversea Forest by Chinese Enterprises*, Published on 8 September, 2010.

the host communities are further reasons why some have difficulty in gaining acceptance and admiration. The case of Indonesia was somewhat different as the team observed many instances where Indonesians, Indonesian-Chinese and Chinese overseas entrepreneurs share common cultural roots, cuisine, and living habits, which did, in fact, facilitate dialogue.

In South Africa and Zambia, the image of China's ODI also aroused a lot of concerns. The Task Force team visiting South Africa read about media stories denouncing the behavior of bad "Chinese" investors. Indeed, it was later discovered that they were Asians, but not Chinese. China is far away from Africa and so the lack of cultural communication led to many misperceptions and caused needless stress. Most of China's ODI enterprises are state-owned enterprises running under a top-down management system. While they do not develop sufficient connections with other local powerful organizations, such as the labor unions, other stakeholder groups, or NGOs, they pay greater attention to maintaining good and strong relations with local government representatives. The lack of communication with these local community and social organizations is one of the great hurdles faced by China's ODI enterprises. China's ODI enterprises should be better equipped to overcome such hurdles before going global.

5.3.5 Conclusion

China's investment process should not be purely profit-driven; it should also aim to improve local employment rates, promote local sustainable development, and protect the local environment while still respecting the host country's cultural traditions and social norms. Besides improving the quality of products and services exported, China should pay more attention to job creation, enhancement of local benefits and protection of the local environment, community, and wildlife. Some major Chinese enterprises are very much aware of the environmental and social impacts on investment destinations while some medium- and small-sized enterprises still fail to address such issues due to lack of attention, limited resources, and poor capacity.

Thus based on case studies and on the literature available on China's ODI, we see that good environmental and social performance as well as environmentally damaging behaviors indeed co-exist in China's ODI. The reduction of negative environmental and social impacts of China's trade and investment must rely upon joint efforts of China and host countries. It is therefore important to enhance the sense of social responsibility of overseas enterprises through education and training, and to design with the appropriate authorities legitimate guiding principles for overseas environmental protection and social responsibility so that sustainable development would be ensured in the communities where Chinese ODI is absorbed.

5.4 International Trade and the Green Shift

5.4.1 International trade: current conditions and future trends

5.4.1.1 The current state of international trade

China has performed very well in international trade since the process of reform began over 30 years ago. Total trade volume has risen to number one in the world, increasing from USD 20.64 billion in 1978 to USD 2.97 trillion in 2010[26], representing an average annual growth rate of 16.8% The export volume increased from USD 9.75 billion in 1978 to USD 1.58 trillion in 2010, at an average annual growth rate of 17.23%; the import volume increased from USD 10.89 billion in 1978 to USD 1.39 trillion in 2010, at an average annual growth rate of 16.37%. The gap between imports and exports was USD -1.14 billion in 1978 and USD 183.1 billion in 2010 (see Figure 5-8). Nearly half of China's economic activity is related directly to international trade (49.45% in 2010).[27]

The nature of China's international trade is fluid as it moves continually toward optimal performance. Chinese foreign trade has shifted from primary product exports to the export of light industry and textile products, to the export of mechanical and electrical products, and is currently shifting towards high-tech products. In 2010, the export of mechanical and electrical products by China accounted for 58.9% of the country's total export volume, 3.1 percentage points higher than in 2005.[28]

> **Recommendation:**
> China should align its trade, energy, and environmental policies in order to send consistent signals about its use of market mechanisms and economic policies to promote energy savings and emission reductions.
>
> *See 5.6 for more discussion about this recommendation.*

The proportion of primary products exported relative to other types of products has been dropping, from 50% in 1980 to 5.18% in 2010. Since 2002, the proportion of primary products in total imports has been rising, from 16.7% in 2002 to 31% in 2010 (see Figure 5-9).

The nature of international trade in China has also changed. In the early years of reform, China's imports and exports mainly comprised general trade. Processing trade (the trade of

26 Source of data: *Statistical Abstract of China in 2011*.
27 Source of data: *Statistical Abstract of China in 2011*.
28 Source of data: *Statistical Abstract of China in 2011*.

raw materials and components that will be used in the production of finished goods) has been rapidly expanding since then, exceeding the growth of general trade (see Figure 5-10). For example, general trade exports accounted for 94.5% of total exports in 1981, and general trade imports accounted for 92.5% of total imports. After 1981, the proportion of general trade in total trade gradually declined and by 1993, general trade accounted for 47% of total exports, and 36.6% of total imports.

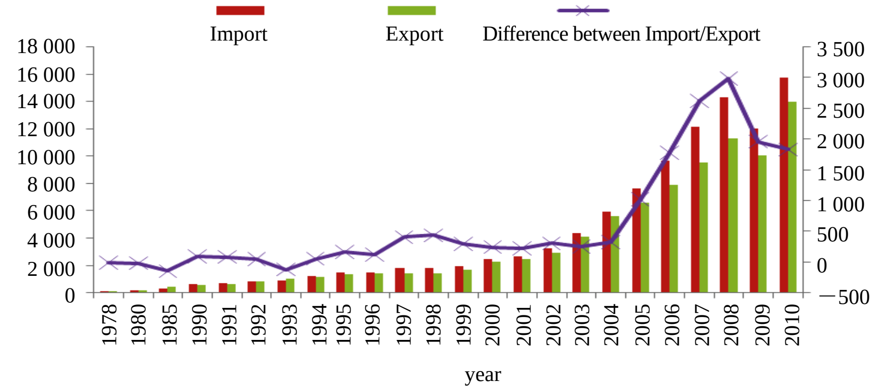

Figure 5-8 China's exports, imports, and trade surplus (USD 100 million)

Source: China Statistical Yearbook 2010 and Statistical Abstract of China in 2011.

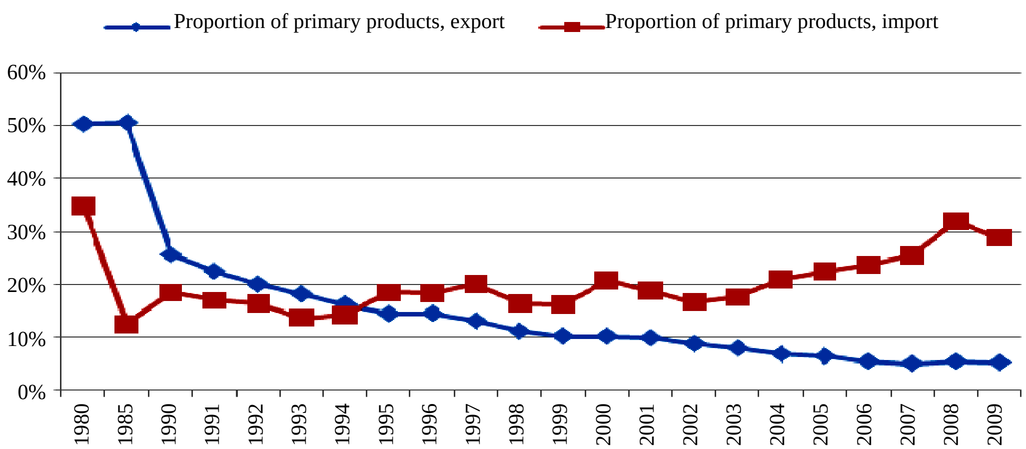

Figure 5-9 Proportion of primary products in import and export

Source: Statistical Yearbooks.

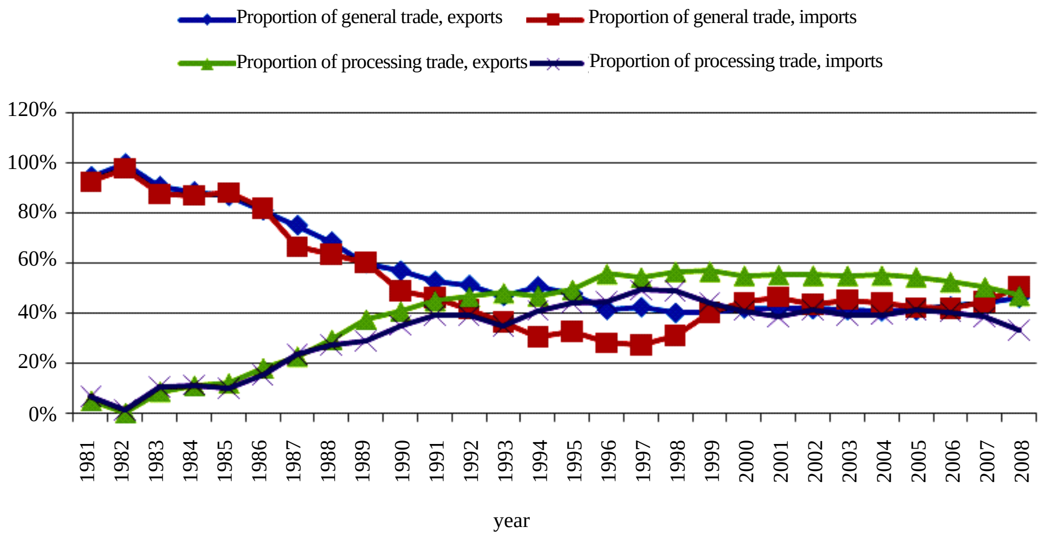

Figure 5-10 Proportion of general and processing trade

Source: China Statistical Yearbooks.

5.4.1.2 Environmental implications for Chinese foreign trade during the "12th Five-Year Plan"

During the period of the "12th Five-Year Plan" (2011—2015), China's foreign relations will become increasingly complicated and will be confronted with multiple and changing challenges. Environmental matters will be an important element, but by no means the only issue. Climate change poses new challenges for economic development and trade expansion in China. On one hand, a commitment to energy conservation and emission reductions must take into account China's ability to develop; on the other hand, border measures such as carbon tariffs that developed countries may adopt could directly affect China's export competitiveness, which, in turn, would affect China's attractiveness for export-oriented foreign investment.

During the period of the "12th Five-Year Plan", China will enjoy obvious advantages in terms of production scale and large domestic market and it should remain as a global manufacturing center even with rising labor costs, environmental pressures, and the rise of other developing economies. It can be presumed that China will seek various ways to sustain its strong foreign trade and economic performance. Some of the more significant ways are to:

(1) Maintain a reasonable rhythm and scale of foreign trade development, aiming to keep the growth rate higher than the average growth rate of GDP.

(2) Enhance the international competitiveness of its service sector to realize the benefits of coordinating the development of manufacturing exports and service exports.

(3) Develop emerging markets and achieve export diversity within them, while maintaining a foothold in developed markets.

(4) Address trade frictions as one way to create an excellent trading environment.

(5) Upgrade its position in the global supply chain and improve its import and export product structure.

(6) Enhance its competitiveness in the trade-related service industry to extend its presence in the value chain.

(7) Rationalize the foreign trade system, by further improving policy measures such as tariffs, export rebates, and policy finance.

(8) Advance the sustainability of foreign trade through environmental protection.

There are a number of ways to bring trade and environmental matters into the "12th Five-Year Plan" period. China could:

(1) Continue to restrict the export of goods that consume too much energy, create high levels of pollution, or consume too many resources.

(2) Address the challenges created by climate change problems and transcend technical trade barriers. China's import and export activities are better than domestic production activities on the whole in terms of energy consumption and carbon dioxide emissions.

(3) Step up efforts to import, where necessary, and to export, greater quantities of environmentally-friendly technologies, equipment, and services.

(4) Promote and strengthen international cooperation in developing environmental technologies.

(5) Rationalize resource and energy prices, strengthen environmental protection and ensure that the prices of exported products fully reflect the costs of resources and energy, and fully account for environmental impacts.

Of course many of these ideas have been either introduced or thought about in previous years. The point now is that the challenges are very likely to be more significant in the years ahead and the need for addressing trade-related environmental matters more urgent.

5.4.2 Changes to the trade structure: an environmental perspective

The relationship between trade and environment is multi-dimensional and complicated. It is generally thought that the environmental impact of international trade on the environment and on society is comprehensively reflected through scale effects, structure effects, and technology effects. These effects could result either in improvement or deterioration of the environment. However, the important factor is whether a sound market and effective management are present. To analyze the impact of foreign trade on China's environment, this report refers to the input and output tables of 34 departments in 2002 and 2007 and energy consumption data of relevant departments. According to their energy consumption intensity, industries were classified into high-energy consuming industries, medium-energy consuming industries, and low-energy consuming industries, and we further analyze import and export structures and their changes according to the intensity of energy consumption.

From Table 5-2, it can be see that in 2007 the export volume of products of high-energy consumption was USD 197.2 billion, accounting for 16.21%; the export volume of products of medium-energy consuming industries was USD 275.6 billion, accounting for 22.66%; the export volume of products of low-energy consuming industries was USD 743.9 billion, accounting for 61.14%. Relative to 2002, the proportion of products of high-energy and low-energy consuming industries in total exports increased, while the proportion of products of medium-energy consuming industries in total exports decreased.

Table 5-2 Distribution of exports and energy consumption in 2002 and 2007 (USD 100 million)

Sector	2002		2007	
	Export volume	Proportion (%)	Export volume	Proportion (%)
High-energy consuming industries	487.65	15.05	1,971.68	16.21
Medium-energy consuming industries	908.42	28.03	2,756.50	22.66
Low-energy consuming industries	1,844.70	56.92	7,438.70	61.14
Total	3,240.78	100.00	12,166.88	100.00

Source: Input-Output Tables of China in 2002 and 2007, calculated by Li Shantong and the team for topic 1 of the Task Force.

From Table 5-3, we can see that in 2007, the import volume of products of high- energy consuming industries was USD 283.2 billion, accounting for 29.70%; the import volume of products of medium-energy consuming industries was USD 171.4 billion, accounting for 17.97%; and the import volume of products of low-energy consuming industries was USD 499.1 billion, accounting for 52.33%. Relative to 2002, the proportion of imports of products of high- and medium-energy consuming industries both rose to some extent while the proportion of products of low-energy consuming industries decreased.

Table 5-3 Distribution of imports and energy consumption in 2002 and 2007 (USD 100 million)

	2002		2007	
	Import volume	Proportion (%)	Import volume	Proportion (%)
High-energy consuming industries	811.50	27.81	2,831.71	29.69
Medium-energy consuming industries	512.05	17.55	1,714.08	17.97
Low-energy consuming industries	1,594.77	54.65	4,990.28	52.33
Total	2,918.33	100.00	9,536.08	100.00

Source: Input-Output Tables of China in 2002 and 2007, calculated by Li Shantong and the team for topic 1 of the Task Force.

Over the period from 2002 to 2007, one can observe a clear shift in the export mix from low-tech to high-tech products. While low tech products have grown in absolute terms, they have decreased in relative terms. The proportion of natural resources (coal, oil and gas) in total exports has fallen from 0.8% to 0.3% of exports, from 2002 to 2007, respectively. The same applies to traditional industries such as textiles, which fell from a 10% share of exports to 9% during the same period. Meanwhile the share of high-tech equipment (communication and computers) has gone from 19% to 25% (2002—2007).

On the imports side we see a slower shift. During the same period, coal related products and Oil & Gas have increased their share of imports from 0.12% to 0.26% and 4.3% to 8.4% respectively. At the same time textile products decreased their share of imports from 4.6% to 1.7%. The import share of communications, computer, and other electronic equipment increased, meanwhile, from 21% in 2002 to 23.4% in 2007. From the above, we can see that the import shares of resources and high-tech products are rising, while the import proportion of traditional products is falling.

5.4.3 Analysis of embedded pollutants in international trade

International trade has opened up global markets for China, allowing for a more extensive and effective allocation of resources and promoting the development of the domestic economy. At the same time, all stages of the export process can consume resources (energy) and emit pollutants, causing a huge impact on energy and environment of different countries, a matter that has increasingly drawn people’s attention. The pollutants discharged during the processing, manufacturing, and transportation of goods are termed “embedded pollutants”. Obviously, embedded pollutants are more significant than the pollutants emitted in the final consumption of a product. For example, the emission of embedded sulfur dioxide (SO_2) refers to all SO_2 emitted during the whole process of upstream processing, manufacturing, and transportation of a product, and the embedded SO_2 is larger than the SO_2

emitted in the final consumption of a product. In this report, an input-output model of multiple countries (regions) is used to estimate embedded CO_2 and SO_2.

5.4.3.1 Analysis of embedded CO_2 in international trade

(1) Embedded CO_2 in Chinese trade in 2007 and 2002

International trade numbers hold large embedded CO_2 volumes. In 2007 the total embedded CO_2 in the trade surplus was 1.4 billion Mt or the equivalent of 23% of China's total CO_2 emissions. This corresponds to an increase of 200% over the 2002 embedded surplus number. Taking the export numbers, the situation is even more alarming as CO_2 emissions embedded in 2007 exports accounted for 33.26% of the same year's CO_2 emissions. Looked at it from another angle, embedded CO_2 in exports is equivalent to 3.29 times that of embedded CO_2 in imports.

The situation is just as acute if looked at from the standpoint of CO_2 intensity measures. The embedded CO_2 intensity in exports is 18.10 times greater than the CO_2 intensity embedded in imports. From an emission intensity measure, the embedded CO_2 emissions intensity per USD 10,000 in exports is 16.31 Mt, and the embedded CO_2 emissions of every USD 10,000 in imports is only 6.33 Mt. That is to say, embedded CO_2 emissions intensity in exports is 2.58 times more than the embedded CO_2 emissions intensity in imports.

Table 5-4 Embedded CO_2 in Chinese trade in 2007 and 2002 (million Mt)

Year	Embedded CO_2 in exports	Embedded CO_2 in imports	Surplus
2007	1,984.3	603.2	1,381.1
2002	770.5	149.4	621

Source: Input-Output Tables of China in 2002 and 2007, calculated by Li Shantong and the team for topic 1 of the Task Force.

(2) Sectoral analysis of China's exported embedded CO_2

We calculated the exported embedded CO_2 emissions of various sectors and arrived at the embedded CO_2 contribution of China's total exports. In terms of exports in 2007, the top four sectors in terms of volume were: communications, computer, and other electronic equipment (25.32%); machinery equipment and instrument manufacturing (22.08%); the textile and garment industry (15.58%); and the chemical industry (8.5%). These are also the top four sectors in embedded CO_2, accounting for 63.18% of the embedded CO_2 for all exports in 2007: machinery equipment and instrument manufacturing (24.73%); communications, computer, and other electronic equipment (16.10%); the textile and garment industry (11.34%); and the chemical industry (11%).

The sectors for which there was a rise between 2002 and 2007 in their proportion of total embedded CO_2 included: metal smelting and calendaring processing; metal products; machinery equipment and instrument manufacturing; communication, computer, and other electronic equipment; and transportation equipment manufacturing. The proportions of other sectors all drop to some extent from 2002 to 2007, mainly because of the increased export volume of the above-mentioned sectors. The same applies to the levels of embedded SO_2 in trade.

5.4.3.2 Analysis of embedded SO_2 in international trade

(1) China's imported and exported embedded SO_2 in 2007 and 2002

The embedded SO_2 emission in China's 2007 trade surplus was 674.5 million Mt, equivalent to 31.52% of total SO_2 emissions in the same year. If one looks only at exports, SO_2 emissions embedded in exports accounted for 33.36% of total SO_2 emissions in 2007.

In terms of SO_2 intensity measures, the situation is just as serious. The emission intensity of embedded SO_2 for every USD 10,000 in exports is 0.0587 Mt, and the embedded SO_2 emission intensity for every USD 10,000 thousand in imports is only 0.0041 Mt. That is to say that embedded SO_2 emissions intensity in exports is 14.19 times greater than the embedded SO_2 intensity in imports.

Table 5-5 Embedded SO_2 in Chinese Trade in 2007 and 2002 (million Mt)

Year	Exported embedded SO_2	Imported embedded SO_2	Surplus
2007	713.98	39.44	674.54
2002	334.95	10.96	323.99

Source: Input-Output Tables of China in 2002 and 2007, calculated by LI Shantong and the team for topic 1 of the Task Force.

(2) A Sectoral analysis of China's exported embedded SO_2

Using the calculation formula of embedded SO_2, we can calculate the embedded SO_2 emissions of exports in various sectors in order to arrive at the embedded SO_2 contribution of China's total exports.

The top five sectors in terms of export volume in 2007 were: communications, computer, and other electronic equipment (25.32%); machinery equipment and instrument manufacturing (22.08%); the textile and garment industry (15.58%); the chemical industry (8.5%); and the metal products industry (5.5%), which were also the five leading exporters of embedded SO_2, accounting for 71.66% of the embedded SO_2 in all 2007 exports of 2007. Proportion of embedded SO_2 breaks down as follows: machinery equipment and instrument manufacturing (22.23%); communications, computer, and other electronic equipment (16.17%); the textile and garment industry (12.89%); the chemical industry (12.69%); and the metal products industry (7.68%).

The sectors for which the proportion of embedded SO_2 in total embedded SO_2 rose from 2002 to 2007 were: metal smelting and calendaring processing; metal products; machinery equipment and instrument manufacturing; communication, computer, and other electronic equipment; and transportation equipment manufacturing. The proportions of other sectors all drop to some extent from 2002 to 2007, mainly because the of the increased export volume of the above-mentioned sectors.

5.4.4 Conclusion

In recent years, China's import and export volumes have been increasing substantially, reaching USD 2.97 trillion in 2010, and the total volume of imports and exports has soared to number one in the world. International market share has obviously improved, the market space for foreign trade will be more extensive, and product structure will continue to be optimized. In 2010, the export of mechanical and electrical products in China accounted for 58.9% of total Chinese exports, equivalent to a rise of 3.1 percentage points over 2005; in 2009, high-tech products accounted for 31.36% of the China's total exports, equivalent to a rise of 2.7 percentage points over 2005. A major shift has occurred in import and export trade patterns, with processing trade expanding rapidly, exceeding the growth of general trade.

Up until 2007, the proportion of high-energy consuming industries increased to some extent. The export volumes of products of high-energy consuming industries and medium-energy consuming industries accounted for 16.21% and 22.66% respectively. Relative to 2002, not only did the export volume of high-energy consuming industries increase, but so did the proportion of high-energy consuming industries against total exports, from 15.95% to 16.21%. The import volume of products of high-energy consuming industries and medium-energy consuming industries accounted for 29.70% and 17.97% respectively. Relative to 2002, not only did the import volume of high-energy consuming industries increase but so did the proportion of high-energy consuming industries against total imports, from 27.81% to 29.69%.

Though there is a large surplus in China's foreign trade; it is often based on high-energy inputs and high-pollution products, which account for a substantial proportion of embedded energy and emissions in the exported products. Energy efficiency in China is low, so a large amount of energy is embedded in exported products and a large amount of pollutants remain in China, thereby increasing pressure on China to address energy conservation and environmental protection.

This research adopted the computational general equilibrium (CGE) model to analyze how environmental policy is used to optimize industrial structure, investment and trade structure, as well as the impact on the environment. The simulation results show that environmentally-friendly economic policies will cause some reduction of trade, but the impact on exports will be greater than the impact on imports. Mainly the energy sector and energy-intensive manufacturing industries will be negatively affected by such policies, thus shifting trade to a lower-carbon reality.

5.5 China's Participation in International Rule-Making to Promote Environmental Protection

5.5.1 The development of relevant international rules

Domestic policies and international rules regulating trade and investment generally complement each other. In the international arena there are a number of bilateral and multilateral agreements that regulate international investments activities, as well as international trade agreements negotiated under the WTO or free trade agreements (FTAs) that govern the international exchange of goods and services. On the environmental side, international relations are governed by specific environmental protocols, conventions, and agreements.

China is no longer just a passive member of the international rule-making process; it is gradually adopting a major position in these processes, whether or not it wishes to be. This is a reality of being such an important player. As it takes part, China faces the challenge of safeguarding its own interests while contributing to the improvement of global governance in general.

China also faces a growing number of trade disputes, with a substantial number related to environmental protection. For example, the export of Chinese energy-saving rights generated high anti-dumping duties levied by the EU[29], and subsidies directed towards alternative energy development were subject to the anti-subsidy investigations of the US[30]. Likewise, China's heavy restrictions on the exports of coke resources were opposed through EU and US lawsuits[31], despite the self-sacrificing nature of these restrictions.

29 Xinhua News: The Case of Chinese Exported Energy-saving Bulbs Reflects Conflicts of anti-dunmping policy inside of EU.31 Aug. 2007.

30 New York Times: "US to Investigate China's Clean Energy Subsidies", 15 Oct. 2010. http://www.nytimes.com/.

31 Financial Times："US lodges WTO case against China"，June 23 2009. http://www.ft.com/.

5.5.2 Environment provisions in international investment agreements

5.5.2.1 An overview of global investment governance

While transnational investments are developing rapidly, the global governance framework of agreements and regulations to govern them is lacking in general. The total annual amount of FDI should reach USD 1.3 to 1.5 trillion in 2011.[32] However, currently in the field of international investments, there exists no single multilateral legal framework. The current transnational investment governance system is based on a multitude of bilateral and regional international investment agreements (IIAs). The number of IIAs has increased rapidly during the past 20 years, especially during the 1990s China has endorsed 230 international investment agreements of which 125 are bilateral trade agreements.[33]

5.5.2.2 Environmental provisions in international investments rules

The incorporation of environmental issues into intergovernmental investment agreements is a new trend. Article 3 of the WTO's Trade-Related Investment Measures (TRIMs) requires that all the exemption articles in the text of 1994 of the General Agreement on Tariffs and Trade (GATT) shall apply to TRIMs. This means that the general exemptions of Article 20 of GATT are also binding on the environmental issues in international investment. [34]

The most important agreement-based environmental initiatives took place under the North American Free Trade Agreement (NAFTA) framework, launched in 1993. Since then, despite disagreements on allocation of funding resources and the use of the CEC (NAFTA Commission on Environmental Cooperation), the three main NAFTA member countries—the US, Canada, and Mexico—have all generally become active advocates for the incorporation of environmental provisions into bilateral trade agreements. Some European

32 UNCTAD. (2010). *World Investment Report 2010: Investing in a low-carbon economy*. New York and Geneva: United Nations. July, 2010.
33 UNCTAD. (2010). *World Investment Report 2010: Investing in a low-carbon economy*. New York and Geneva: United Nations. July, 2010.
34 The articles relevant to WTO rules and environmental protection are mainly concentrated in the paragraphs (b) and (g), Article 20 of GATT. Based on the provisions of the General Exception of GATT, 1994: "Subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade, nothing in this agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures: (b) necessary to protect human, animal or plant life or health; (g) relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption."

countries, such as Finland, Sweden, Luxembourg and Belgium, are now also participating in this trend.

The major modes of incorporating environmental provisions into FTAs and bilateral trade agreements include: preamble clause; special environmental provisions; environmental exceptions and exemption articles; articles of dispute resolution procedures; and articles addressing the relationship between investment agreements and environmental agreements. In general, the environmental provisions revolve around disclaimer articles allowing members to make exceptions for environmental and health reasons; articles prohibiting members from loosening environment standards in order to stimulate FDI; articles demanding that members respect host country environmental rules and regulations, and so forth.

5.5.2.3 Environmentally-relevant international investment rules: China's participation

The incorporation of bilateral environmental provisions into trade agreements is a practice that has been actively promoted over the past decade by the US and other developed countries. This may become an important trend that China should follow as it negotiates its own new agreements. Many older IIAs do not include articles that coordinate the relationship between international investment and the environment. By comparison, the China-New Zealand, China-Chile, China-Pakistan FTAs already include environmental protection as an integral part of the agreements.

5.5.3 Environmental provisions in international trade rules

5.5.3.1 Overview of international trade rules and international environmental rules

The goal of international trade rules is to enhance the liberalization of economic activities. In contrast, the goal of environmental management rules often seems to be to restrict aspects of economic activities. While the two are fundamentally different they can influence each other significantly. Special effort is required to reconcile and combine the objectives within common agreements.

Recommendation: China should play a more active role in rule-making in relation to international, regional, and bilateral trade and investment arrange- ments in order to help promote green transformation. In addition to various legally-binding standards and agreements, this might include creation of a *Green China Consensus* on various voluntary standards where indu- strial and service industries and associations need to reconcile international and Chinese interests in establi- shing green certification systems.

See 5.6 for more discussion about this recom- mendation.

The environmental provisions in the existing international trade rules are basically those of the WTO. Most of the other regional trade agreements (RTAs) and FTAs—with a few exceptions, such as NAFTA—generally have no independent environmental provisions. Except for the 3 FTAs mentioned above (NZ, Chile and Pakistan), China has already endorsed bilateral and multilateral FTAs with more than 30 countries, in which trade has not been linked with environmental issues. In most cases environmental cooperation usually appears as the appendices of FTA protocols.

At the same time, the multitude of international environmental conventions does not completely exclude trade development, and some of them have actually established "trade and environment commissions," specified by Specific Trade Obligations (STOs). They regard trade as an important means of implementing environmental conventions. For example, in the CITES Conventions, such trade measures as the banning of trade of elephant tusks have been adopted.

5.5.3.2 Environmental provisions in GATT and other trade agreements

Environment-related agreements made outside GATT include: ① the Agreement on Technical Barriers to Trade (TBT); ② the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS); ③ the Agreement on Subsidies and Countervailing Measures (ASCM); ④ the Agreement on Agriculture (URAA); ⑤ the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS); and ⑥ the General Agreement on Trade in Services (GATS).

5.5.3.3 Possible environmental provisions in future WTO agreements

In 1995, at the beginning of WTO's existence, the Committee on Trade and Environment (CTE) was established under the General Council and discussions were conducted on environmental issues. Today, environment remains a major topic in the WTO's Doha Round. It includes (sections 31 and 32 of the "The Doha Ministerial Declaration"): the relationship between the WTO multilateral trade rules and Multilateral Environmental Agreement (MEAs); reducing or abolishing the tariff and non-tariff barriers of trade in environmental goods and services; the impacts of environmental measures on market access; trade and environmental issues in the negotiations of intellectual property agreements; and eco-labelling.

5.5.3.4 WTO rules on environmental products: China's active role

China should play an active role in making international rules in terms of its WTO based environmental interests. The current WTO-CTE's environmental goods and services (EGS) negotiations are driven by trade interests rather than environmental ones. They are based on national agendas, and therefore lack a global perspective and are quite poor in terms of any coordination with Multilateral Environmental Agreements (MEAs). They lack an integral awareness of China's national and departmental interests, suggesting that the country's environmental interests have not been sufficiently considered. Hence, it is suggested that China should better prepare its international negotiations strategies to gain environmental benefits alongside its trade and industrial development interests.

In light of the diversity and complexity of China's economic development and the urgency of environmental needs, it is necessary to discard the too simplified dichotomy of international trade for developing countries and developed countries. The environmental goods and services listed by this study reflect China's economic benefits (industrial benefits and trade benefits); environmental benefits; and social benefits. China is especially competitive in all three categories of environmental products, and will become more competitive over time. There are also interesting alignments of interests to be explored with other developing countries.

5.5.4 Climate change, international investment, trade, and China's involvement

5.5.4.1 International climate process and system

Global climate change has been a fixture in international headlines in recent years, but still the challenge of construing of a fair and effective international climate change response after 2012—the end of the Kyoto Protocol commitment period—is still far from resolved. The international climate system involves a wide range of processes, frameworks, and mechanisms characterized by statements, laws, agreements, decisions, and standards. Some are legally binding; others are voluntary. Some countries have attached great importance to the commitments made at various international climate meetings, and have indeed changed domestic policy to reflect them.

It is obvious that climate change would have implications for international investment, trade, and indeed the global economy. Climate change could alter the comparative advantages of some countries, and climate policies adopted by some countries could potentially alter the scale, flow, and direction of international investment and trade. On the other hand, certain international investment and trade policies could enhance international climate actions, but might also impede them. During the course of the global shift to green economy, there will certainly be unavoidable friction surrounding the relationship between climate change and investment policy. This calls for the thoughtful coordination of the international climate system with international investment and trade rules.

5.5.4.2 Climate change and international investments

The climate change system depends on financial resources that it doesn't have to be properly implemented. This chronic lack of funding has deepened the distance between developed nations—which promote market-based mechanisms—and developing nations, which typically promote public funding sources. More recently, developed countries have pledged to provide USD 30 billion during the start-up phase (2010—2012) as well as a long-term goal of raising annually USD 100 billion by 2020 and the establishment of a "world green fund". So far, none of these pledges have been honored and the international carbon markets have also not yet been formed. So climate-related investments are still being implemented more on a voluntary basis than on a mandatory basis. Currently, there are no direct provisions to standardize international low-carbon investment. The incorporation of such international investment policies into the international climate system presents an opportunity for future development.

5.5.4.3 Climate change and international trade

The impacts of climate policies on international trade are of great concern to the international community as they can lead to serious competitiveness issues and trade frictions around, subsidies, carbon tariffs, the liberalization of low-carbon products, and other contentious issues.

Based on the United Nations Framework Convention on Climate Change's (UNFCCC) principle of "common but differentiated responsibilities", developed countries and developing countries should assume different emissions reduction obligations. In terms of carbon leakage and competitiveness, developed countries in Europe and America have proposed to address the developing countries' competitive advantages in international trade and increased emissions to be compensated through carbon tariffs and other offsetting measures. These include the EU's decision to incorporate aviation emissions into the EU's trading system (EU–ETS) in 2012, a unilateral action that has caused great dispute in the international community and which will seriously affect China's aviation industry. The legitimacy of carbon tariffs under the WTO remains undetermined. Developed and developing countries have different positions, and there exist different opinions even within the EU. This could all lead to potential conflict at the intersection of the international climate system and international trade rules.

5.5.4.4 China's status, role, and strategic choices

As it evolves from being a recipient to a contributing country in the climate regime, China is the largest stakeholder in the debate. China has considered enhancing South-South cooperation on climate change by providing funds through bilateral channels. China's FDI is increasing rapidly while the state vigorously strengthens energy-saving programs, emissions reduction measures, and policies to promote low-carbon development and investment.

China's image as the "world's factory" cannot be altered overnight. The net export of embedded carbon emissions in Chinese trade still accounts for about one-fifth of China's total carbon emissions. Internationally, most of the comments about carbon tariffs are directed at China as many believe that China has been reluctant to adopt "effective" climate policies. To strengthen its economy, bolster its image, and advance a global green shift, China must participate actively in the development of a viable international climate system and should attach great importance to the interaction of international rules on climate change, international investment, and trade.

5.6 Policy Recommendations: Ideas for a Greener Future

5.6.1 Overview

China now has the second largest GDP in the world but still faces many social and environmental hurdles typical of emerging economies, both domestically and internationally. Its economic transition offers many opportunities for growth and positive transformation. China has chosen to address its environment and development challenges head-on, thus opening the potential to secure its own sustainable future and to contribute to global sustainability. Investment and trade need to be at the forefront in meeting these challenges.

China is the world's largest buyer of many internationally traded commodities as well as the main exporter of a number of manufactured essential goods. China's integration with the global economy is demonstrated by the increase in its investments abroad, in Latin America, Africa, and the ASEAN Region, among others. China is thus exposed to growing public scrutiny and constant examination about its actions and policies affecting its business interests both at home and abroad. As a global player, it is also tied to its international commitments, general engagements, alliances, and integrated domestic development plans.

Domestically, China is adopting policies and encouraging voluntary measures that will drive it towards a green economy and lowering its carbon emissions. The Government of

China is imposing stricter environmental conditions on industrial and other sectors during the "12th Five-Year Plan" (2011—2015). There are implications for the activities funded via foreign direct investment (FDI). And since Chinese outward direct investment (ODI) is expanding rapidly, some structural adjustments in its trade and foreign investments policies will be needed to address environment and development matters related to topics such as accessing, processing, and transporting natural resources; infrastructure development in other countries; and manufacturing or other industrial activities carried out abroad.

Environment and trade continues to be a difficult subject with a constant need to monitor and address impacts of trade agreements on the environment; and to ensure international environmental agreements do not create competitiveness or other barriers to trade. With the rise of bilateral and regional trading agreements signed by China, there are additional opportunities to ensure its trade is carried out with due regard for environment and development within China and with its trading partners.

The Investment, Trade, and Environment Task Force (TF) has examined various aspects of China's FDI and ODI; considered corporate social responsibility (CSR) on the part of Chinese firms operating domestically and abroad; and examined some current aspects of trade and environment policies. The TF members carried out interviews and observed relationships involving Chinese investments in two regions: Southern Africa and Southeast Asia (Indonesia). The resulting recommendations are intended to be pragmatic measures that could help China to fulfill its commitment towards achieving healthy and sustainable development within China and to provide sustainable benefits for other countries in the process.

In addition to the specific topics covered below, the TF wishes to make an overarching policy recommendation (Section 5.6.2) concerning the shift in trade and investment circumstances in which China finds itself.

5.6.2 Environment and development policy for China during its investment and trade transition

China's actions on trade, FDI, and ODI affect the economy and ecology globally and within other countries in an ever-increasing fashion. China can ill-afford a passive attitude in dealing with other countries and the global community if it is to achieve optimal and sustainable patterns of development, including mitigation of the current problems of excessive damage to its own environment. The future of China's "international brand" will have to be green for the country to thrive.

Therefore:

China needs to take proactive positions regarding environment and development that will: ① ensure that those investing within China operate at the highest standards of CSR; ② secure goodwill and the right to operate in countries abroad for Chinese ventures, based on the quality and style of investment and benefits for local people; and ③ seek bilateral, regional, and international trade, environment, and other agreements that take into account Chinese interests and concerns for a green economy, and indeed, for the transition to ecological civilization. China should aim to be an open and declared advocate in developing and promoting international green transformation.

The positive attitudes and action China has shown towards the environment, especially during the 11^{th} and now the "12^{th} Five-Year Plan", position the country and its businesses very well. However, it will require a concerted effort to capitalize fully on the opportunities, including addressing significant perception issues—and the stakes are high. China should hold both its FDI and its ODI to consistent, high standards of performance. It is essential not to behave one way at home and another abroad.

5.6.3 Policy recommendations on investment and environment relationships

The approach suggested here aims to upgrade the quality of China's FDI Section 5.6.3.1 and ODI Section 5.6.3.2 and to create symmetry between them where possible so that China's aspirations and requirements for inclusive growth are met while its international brand is enhanced. Since much of the effort will be undertaken by enterprises operating domestically and/or internationally, voluntary efforts need to be fostered and enabled. Thus Section 5.6.3.3 deals with CSR policy needs.

5.6.3.1 Foreign direct investments (FDI) into China

China should use FDI to help promote China's green transformation and sustainable development by ensuring a more balanced sector and regional distribution of FDI, with environmental concerns dealt with in a consistent manner.

More specifically, China should:

(1) Update and modernize its investment policies to attract desirable FDI into key sectors, such as high-tech, environmentally friendly, and other strategic emerging industries, thus helping China meet its "12^{th} Five-Year Plan" environmental targets.

This means shifting from the current emphasis on scale and speed of foreign investments towards quality. To hasten this shift, China should adopt fiscal, taxation, and financial incentive policies, consistent with the Decision on Accelerating the Fostering and Development of Strategic Emerging Industries of the State Council, October 2010. Such incentives can also be introduced to attract FDI to the western region and inland cities away from the coastal areas as long as they lead to appropriate environmental safeguards in these other areas.

(2) Draw on the environmental experience of FDI source countries, especially those countries requiring compliance with high environmental standards of their own, to modernize and further upgrade China's legal framework on FDI.

Under such a legal framework, both foreign and domestic industries operating in China should minimally be subject to identical Chinese environmental protection and enforcement rules, regardless of whether the investors are foreign or domestic.

(3) Encourage all enterprises to invest in green products and services where possible, and to promote the greening of market supply chains across sectors.

The existing Catalogue for Guidance of Foreign Investment Industries should be revised to create incentives for greener investments. The Chinese environmental impact assessment requirements should be applied equally to, and be enforced for all investment activities in China, whether carried out by foreign or domestic companies.

(4) Evaluate local government performance by using indicators that place greater emphasis on the quality of FDI, particularly with regard to environmental performance and technological progress.

5.6.3.2 China's outward direct investment (ODI)

China should focus its ODI not only to play a significant role in meeting China's "12th Five-Year Plan" targets, but also to promote host country green development and transformation, in line with objectives defined by the host nations, the Millennium Development Goals, and other relevant international sustainable development objectives. China should articulate and expand its policy guidance for enterprises that are "going global", so that its ODI is consistent with China's green development vision.

China's ODI is generally welcome worldwide. Yet this ODI is often subject to criticism especially if it is perceived to be ill prepared and badly introduced. An ODI approach based on green development can be designed to allow China to maintain its economic growth path, while ensuring that its overseas commercial activities are socially responsible and environmentally sustainable, with strong benefits for the local population and economy in the host country. China's SOEs (state-owned enterprises) can lead the way in demonstrating this positive behavior.

More specifically, China should:

(1) Prepare Chinese enterprises engaged in "going global" to take a proactive role in green development of host countries and in properly addressing environmental and social impacts.

There is always scope for improving the sustainability performance of business, and China should encourage its ODI along this path, while systematically improving its communication of good practice to overcome stereotypes and prejudices. China's ODI is likely to play a major positive role in the green transformation of host countries, especially other developing nations.

China's ODI should work towards a better integration with host country societies and should seek alignment of interests with local stakeholders, improving the products and services offered to host countries, and placing greater emphasis on environmental stewardship and sustainable development. Such actions will require better investor preparedness, implementation on the ground, and communication. Transparency will help protect Chinese investment interests through better relationships with local stakeholders, their business community, and citizen representatives. These steps will support the broader imperative of securing host countries' trust, if done properly.

(2) Establish new platforms for ongoing dialogue on implementation issues between China and countries with which it is creating trade and investment relationships.

This need, articulated by various representatives of each of the three countries visited by the Task Force, should facilitate communication and mutual understanding of needs, objectives, and concerns around the impacts of Chinese trading and investment activities abroad. Preferably, these platforms should be agile and flexible, created alongside or outside the traditional and more formal international venues, such as the Forum on China-Africa Cooperation (FOCAC) and the ASEAN Plus One Forum. The dialogue platforms should facilitate unencumbered two-way communication on a broad range of topics of interest to the countries. The dialogue channels should help build understanding, enhance business exchanges, and facilitate resolution of environmental, educational, social, and other concerns related to ties with China. They should be accessible to citizens in the ODI host countries. They are urgently needed to address the various development hurdles around the adoption of new environmental standards that could be seen as trade and investment barriers if not disclosed and discussed in advance.

(3) Address the negative perceptions sometimes associated with China's ODI and trading activities abroad.

There are many possible reasons for such perceptions, including some rooted in substance and others in a variety of motivations. Certainly improving the existing situation is important. However the TF found that even where good examples of initiatives undertaken by Chinese enterprises exist, the host country general public is totally unaware of these cases. All they knew and spoke of were the cheap and low quality products made in China, which were unfairly flooding their domestic markets, among other issues. While some of this negative image and perception of Chinese products in those countries can be countered by better information and communication campaigns, true success will require integrated strategies on the part of government working with Chinese enterprises.

These strategies should change some aspects of Chinese corporate behaviour, provide incentives for marketing and exporting better quality products and services to developing countries, and other changes noted in the previous recommendations. It will be necessary to involve governmental agencies as well as China's embassies, educational institutions, business associations, and non-governmental organizations. China can learn from precedents set by other countries and from the experience of some multinational enterprises that have satisfactory sustainable development records.

(4) Create an evaluation methodology that enables a better monitoring of its ODI enterprises, both large SOEs and SMEs, particularly with respect to their activities abroad, perhaps with regular rating of ODI enterprises in accordance with their CSR performance.

Such a common framework can build on, enhance, and align the relevant work of several public bodies in developing ODI-related environmental and social guidelines, notably MOFCOM, NDRC, SASAC, MEP, SFA, and the CBRC. The host country and China could evaluate and rate the ODI enterprises in accordance with their CSR performance. Such information could be made publicly available both domestically and to host countries. Those rated high on CSR performance might be provided incentives like tax breaks, preferential finance, or customs clearance access.

Evaluation should be based on a commonly-held information base generated by MEP, Customs, Industry and Commerce Administrative Agencies, Taxation Agency, CBRC, Chinese embassies, and consulates, and could potentially include credible civil society organizations in both China and hosting countries. China should start to exercise such oversight starting with its SOEs that are "going global". Reciprocity by other governments overseeing their own outward investors could be developed using the proposed dialogue platforms described above.

(5) Require under Chinese law that Chinese SMEs "going global" legalize their status in host countries. Also, ensure their access to capacity building for appropriately-designed operations abroad.

Chinese SMEs should be required to register with their local consulate or embassy any changes in business sector activities they have undertaken once they have moved abroad. This will help meet China's expectation for their actions abroad especially if backed up by regular monitoring.

(6) Strengthen, align with green development, and clarify internationally the basis on which the Chinese government and its financial sector are willing to provide concessionary finance to host country governments or enterprises as part of China's trade and investment promotion, and to improve the efficiency of these activities.

This will demand consistency across its policy banks, joint stock banks, other lending institutions, and state-directed investment funds and vehicles.

5.6.3.3 Promote corporate social responsibility (CSR) for enterprises engaged in FDI or ODI

As a global player, China needs to work together with the international community and enterprises to guide FDI and ODI for the promotion of green transformation under non-discrimination principles.

China therefore should:

(1) Ensure, as a matter of principle and legal framework, that FDI into China and China's ODI should be held to a high standard of corporate social responsibility.

If the investing or host country is a developing nation with environmental laws and standards that are below internationally advanced ones, the FDI and China's ODI enterprises should at least meet Chinese law and standards.

(2) Establish a new *Guideline on Corporate Social Responsibility* that makes China's own standards consistent with internationally-recognized CSR elements.

This guideline should address some areas of environmental, social or sustainability performance that are not currently subject to Chinese oversight, and those areas currently regulated at levels below internationally recognized standards. The guideline should encourage good performance, with disclosure of environmental and social information by headquarters domestically and in host countries.

(3) Create Sustainable Development Funding Mechanisms to mitigate the impact of China's natural resource procurement activities, particularly when they result in depletion of non-renewable mineral, oil and gas, natural forest, and other biological resources, either domestically or abroad.

There are a number of such funds in the world, some of which have served to offer alternative development options to the populations affected by these extractive activities. Others have just created a savings account instrument to be used by future generations, when these resources will have been depleted. Such funds must be structured jointly between the host state, its local community, and the investor with strong stakeholder participation. They can be capitalized through payment of royalties levied on the resources that are being explored and should be managed by third-party professionals as independent trust accounts, which must be accountable to the public and other related stakeholders, not just to the host government. The lessons learned from resource-depleted sites indicate that part of the proceeds from resource exploration must be reserved for on-site ecological restoration, industrial diversification, and local social development.

A number of successful examples may be useful models, such as the Norwegian Investment Fund for Developing Countries (Norfund) or the Alaska Permanent Fund Corporation (APFC). In most cases, these funds help improve the image of the investor as they are managed in full transparency and are subject to the interests of the community. Generally, revenues and dividends should be used to: diversify the economy of communities exposed to resource depletion; finance poverty reduction; and provide housing and education, improved medical services, environmental protection, green transformation, and other aspects of human and social development.

(4) Create awareness-raising and capacity building on the importance of the investment and environment nexus, whether via FDI or ODI. Chinese central and local governments should provide training for entrepreneurs so that Chinese companies are aware of, and equipped with, the necessary instruments for building image, reducing risk, and implementing CSR activities.

It is very important to encourage information exchange among companies, and to identify and disseminate good CSR practices of foreign investors in China as well as those of Chinese enterprises operating abroad. Training programs can be derived from these activities, and disseminated widely among all companies participating in investment flows both ways. Awareness of CSR among the Chinese public is also needed.

5.6.4 Policy recommendations on trade and environment (green trade)

China should align its trade, energy, and environmental policies in order to send consistent signals about its use of market mechanisms and economic policies to promote energy savings and emission reductions.

Better communication facilities and coordination among relevant ministries are needed to reduce policy conflicts, overlaps, and implementation gaps. This is essential to improve China’s trade structure and accelerate the transformation of its economic development model towards sustainable development.

More specifically China should:

(1) Make greater use of market-based policy mechanisms in setting natural resource, environmental services, and energy pricing.

Internalizing environmental costs with appropriate market mechanisms is essential for adjusting the foreign trade structure, as well as implementing energy-saving and emission-reductions targets. The government should accelerate the updating of the pricing mechanism of resources and energy products such as water, electricity, coal, oil, and natural gas. This will help to move the pace of structural reforms of the corresponding sectors, so that the prices of energy and resources reflect the degree of scarcity. Market mechanisms include: accelerating reform and the further establishment of resource taxation; reforming the environmental tax system; examining carbon taxes and carbon trade; and establishing resource compensation funds and sustainable development funds.

(2) Encourage and expand imports to promote a better trade balance.

China's trade surpluses are associated with increasing deficits of natural resources that are embedded in goods traded for consumption outside China. A large trade surplus can cause high embedded energy exports and serious pollution increases within China. The Chinese government should research its relevant policy options, such as lowering tariffs, to encourage the importation of high-energy products, and thereby help reduce domestic production levels. In other words, China could reduce export trade surpluses, promote the upgrading of domestic industrial structures, and move towards a real balance in trade, while fulfilling the double objectives of reducing domestic emissions and lowering domestic energy use.

(3) Shift to a more environmentally favorable export structure by offering guidance and policy incentives towards promoting the export of lower energy-consuming and less environmentally-damaging products.

Examples of specific actions on energy-saving and emissions-reduction actions related to export profiles include: classification of export products on the basis of total energy consumption and pollution emissions (including direct and indirect emissions) in the production processes; promotion of green certification and eco-labeled products; increase of export tax rebate for low energy-consuming and low-pollution products; cancellation of the export tax rebate policy of high-energy and high-pollution products; and implementation of an export tariff policy to high energy-consuming and high-pollution products.

(4) Invest in better national-level accounting and reporting to reduce the environmental impacts of its imports, mainly in terms of reduced energy and carbon intensity.

On the export side, and particularly for commodity exports (mined, harvested, and grown), China should adopt internationally-accepted standards to continuously re-evaluate the risks of resource depletion and environmental degradation related to these exploitation activities. In general, it must manage its export sectors with a stronger focus on their pollution content and encourage environmental supervision of high-pollution export enterprises.

5.6.5 Policy recommendations on rule–making in relation to international, regional, and bilateral trade and investments

China should play a more active role in rule-making in relation to international, regional, and bilateral trade and investment arrangements in order to help promote green transformation. In addition to various legally-binding standards and agreements, this might include creation of a *Green China Consensus* on various voluntary standards where industrial and service industries and associations need to reconcile international and Chinese interests in establishing green certification systems.

More specifically China should:

(1) Continuously promote the enforcement domestically and internationally of international environmental treaties to which China is a signatory member.

Enforcement of existing agreements is often very weak in many parts of the industrial and developing regions. China should voice its concerns about international transfer of pollutants and wastes through international trade and investment. Such concerns should cover the overall impacts of international environmental treaties on competitiveness, employment, and environment at domestic and international levels.

(2) Take the initiative in including environmental and social clauses while negotiating bilateral or regional trade and investment agreements.

Such recommendations can include flexible and progressive implementation mechanisms, which take into account the development stage of each party, consistent with the trend adopted in these agreements in recent years.

(3) Encourage enterprises and organizations to examine international best practice on green transformation, and to identify and promote best practices in this area, whether inside or outside China. Develop *Green China Consensus* voluntary standards based on Chinese characteristics and promote these, especially for domestic use and, where appropriate and necessary, for equivalency with international standards. In some instances it should be possible to promote *Green China Consensus* standards as new international best practices.

Examples include certification for sustainable palm oil import, aquaculture exports, sustainable mining, and green tourism certification, among many others. Some of the standards will relate to emerging environment and sustainable development technologies arising from China’s science and technology investments, for example on battery technology. All such actions will also help improve the global perception of China as an important and dedicated advocate of sustainable development.

China’s own standards organization should be tasked to look at international voluntary standards for environmental protection and sustainable development, and gradually help Chinese enterprise adopt or adapt these for domestic use with governance structures appropriate to China’s conditions.

(4) Promote South-South-North cooperation within existing frameworks. China should explore the opportunities offered by its singular emerging-to-developed economic status to seek special joint development niches, where it can bridge and align common experiences and expectations of some of its less advanced international commercial partners with those of more advanced partners.

On climate change, for example, China can provide African countries with appropriate and affordable low-carbon technologies such as small hydropower, solar water heating devices, and household biodigesters; European countries can buy emission-reduction credits at low costs and cooperate with China on advanced technologies.

5.7 Acknowledgements

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Chapter 6 Practices and Innovation of Green Supply Chain

6.1 Background and Research Objectives

6.1.1 Background

On February 15th, 2011, Apple Inc. issued its Supplier Responsibility Report 2010 and reported that 137 workers at a supplier factory in China suffered adverse health effects following exposure to a chemical cleaning agent.On August 31st, 2011, a group of Chinese NGOs issued a report accusing more than a dozen suspected China-based Apple suppliers of making unlawful discharges and polluting the ambient environment. These reports aroused extensive attention both in China and the international community.[1] In 2008, a number of Chinese enterprises and transnational companies including Mengniu, Yili, Nestle, Cadbury and Starbucks were affected by supplier factories that were producing Melamine-tainted Milk Powder. These events, and others like them, have spotlighted the risks of supply chain management. In these cases, not only has public health been endangered, but the supplier companies and their multinational clients have suffered economic and reputational losses.

Under the backdrop of globalization, green supply chain management is recognized as a direct and effective mechanism to address environmental problems along the global value chain. Using the purchasing power and consumption behaviors of governments, large enterprises and the public, green supply chain management is a market mechanism for reducing pollution and improving energy and resource efficiency. When combined with

1 Apple Inc. communicated with the research team of this CCICED report and stated that less than 50% of the listed suppliers in the NGO's report are actual Apple suppliers. According to Apple, Apple is in communication with those NGOs and is using expert third party auditors to audit those Apple suppliers identified in the report and intend to work intensively with those suppliers to ensure compliance and the highest standards of environmental protection.

effective enforcement of national and regional environmental laws and policies, it can result in the green transformation of entire industry sectors. Green supply chain management can be an innovative tool for environmental management. This works through the incentive-based market system to encourage enterprises to take actions. Therefore, green supply chain management is closely related to the green transformation in China.

6.1.1.1 Green supply chain management is an innovative mechanism to facilitate China's green transformation

According to the "12th Five-Year Plan", which covers a key period in China's overall transformation, economic policies should focus on changing the economic development mode and structure to promote green transformation and green growth.

Green supply chain management can serve as a significant tool to realize China's "green transformation". In the long run, green supply chain management – which takes environmental protection and energy conservation into account during the life cycle of production from design, to resource extraction to manufacturing, marketing and recycling or end-of-life management – will not only reduce environmental impact but also optimize resource allocation in China, making it an innovative system to foster the country's green transformation.

6.1.1.2 A green supply chain management system is vital to achieve the goals of energy saving and emission reduction set by the state

During the "11th Five-Year Plan" period, China focused on energy conservation and emission reduction as an engine to adjust its economic structure, change its development mode, address climate change and promote scientific advances, and set a target of reducing energy consumption per unit of GDP by 20% and major pollutant emissions by 10%. By 2010, the targets set for "11th Five-Year Plan" had mostly been realized, with national energy consumption per unit of GDP falling by 19.1%, total national emissions of sulfur dioxide reduced by 14.29% and national emissions of chemical oxygen demand reduced by 14.25%.

In the "12th Five-Year Plan", emissions reduction targets have been further upgraded by the Chinese Government. The "Double Ten" (10% reduction of SO_2 and COD) was extended to the "Double Ten and Double Eight", that is, emissions of four major pollutants, Chemical Oxygen Demand (COD), sulfur dioxide, ammonia nitrogen and oxynitride should be reduced by 8%, 8%, 10% and 10% compared to 2010. However, as China's economy continues to grow, it is facing huge pressures in the area of energy conservation and emission reduction. Simply continuing the emission and energy reduction measures instituted under the "11th Five-Year Plan" may lead to huge investment with limited achievements. A system of green supply chain management, which uses market forces to promote lower lifecycle environmental impacts and energy usage, will provide a new avenue for meeting the ambitious goals of the “12th Five-Year Plan”.

6.1.1.3 A green supply chain management system is necessary to promote “made in China” products going global

As the global financial crisis goes deeper, a growing number of international trade disputes are arising, with trade barriers based on environmental issues being more frequently applied. In general, China’s environmental standards are lower than those of developed countries due to the differences of development stage, but the international community tends to mistake the products of “Made in China” as high-carbon and heavy-polluting products. Today, significant changes have taken place in the international market, and China, as a major exporter, is directly or indirectly forced to address environmental issues that could become barriers to international trade. A fully realized green supply chain management program would be beneficial not only for China to reduce environmental impacts and energy consumption domestically, but also to avoid the economic risks arising from green barriers to international trade.

6.1.1.4 The development of a robust green supply chain program relies on improving governments’ and enterprises’ green procurement and the public viewpoint on green consumption

With the growing public awareness of environmental protection, consumers in particular are increasingly demanding environmentally-friendly products. Their viewpoint on green consumption and actions to protect the environment will promote the development and production of environmentally-friendly products, with associated benefits in resource saving and environmental protection. Consumers are regarded as the end users, their green consumption patterns will urge Chinese enterprises to implement green supply chain programs and increase their green competitiveness.

Furthermore, the public’s increasing recognition of green products will promote a change from the traditional procurement mode to green procurement for governments and enterprises. With huge buying power represented by government and large enterprises, green procurement can quickly promote changes in production throughout the industrial supply chain.

6.1.2 Research objectives

CCICED has set up this Special Policy Study (SPS) to provide a systematic examination of green supply chain development and management in the Chinese context. The hope is that through the analysis of international experience as well as research and case studies concerning domestic experience, operable policy recommendations can be identified. It is hoped that the research also can push forward green industry supply chain management by Chinese enterprises, influence China's industrial restructuring, and contribute to sustainable economic development.

The Green Supply Chain SPS focuses on the following elements:

(1) Examining linkages of green supply chain management, green transformation and the driving forces;

(2) Analyzing international green supply chain management experience and its implications for China;

(3) Sorting out the status and issues of the green supply chain management in China's development;

(4) From the perspective of strengthening the operability of implementation policies and environmental assessment, researching the existing government green procurement system and its implementation results;

(5) Identifying and sorting out the corporate case for good practice pertaining to green supply chain management, offering guidance to Chinese enterprises, so as to improve their ability of comprehensive environmental management.

The goal of the SPS is to put forward policy recommendations and operational measures that reinforce domestic policies and measures associated with government procurement, greening supply chain with enterprises, environment and sustainable development.

6.2 The Concept of Green Supply Chain

6.2.1 The concept of green supply chain

The complete concept of "green supply chain" (GSC) was first proposed by the Manufacturing Research Consortium (MRC) of Michigan State University in the U.S. in 1996, for comprehensively considering environmental impacts and resources optimization of manufacturing supply chains. That is to say, it aims to minimize the environmental impacts of the products end-of-use by tracking and controlling the raw material procurement, in order to ensure compliance with environmental rules and regulations starting from the stage of product R&D.

There is no existing standard definition for green supply chain, and many definitions are available. For the purpose of this report, the concept of green supply chain can be put in this way: when considering the impact of its products on the environment, the enterprise should not only take its own processes into account, but also the sourcing of raw materials, the consumption of the products, as well as the recycling of the wastes, i.e., the whole process of the product life cycle (see Figure 6-1). To ensure enterprises in supply chain comply with the unified environmental requirements is the way to improve their environmental performances and reduce environmental impact so that green and low-carbon development can be realized.

Green supply chains differ from traditional ones in that green supply chain management is integrated into the entire process including planning, procurement, production, consumption, and reverse logistics. The entire supply chain is managed as a green system and every process focuses on environmental management and risk control.

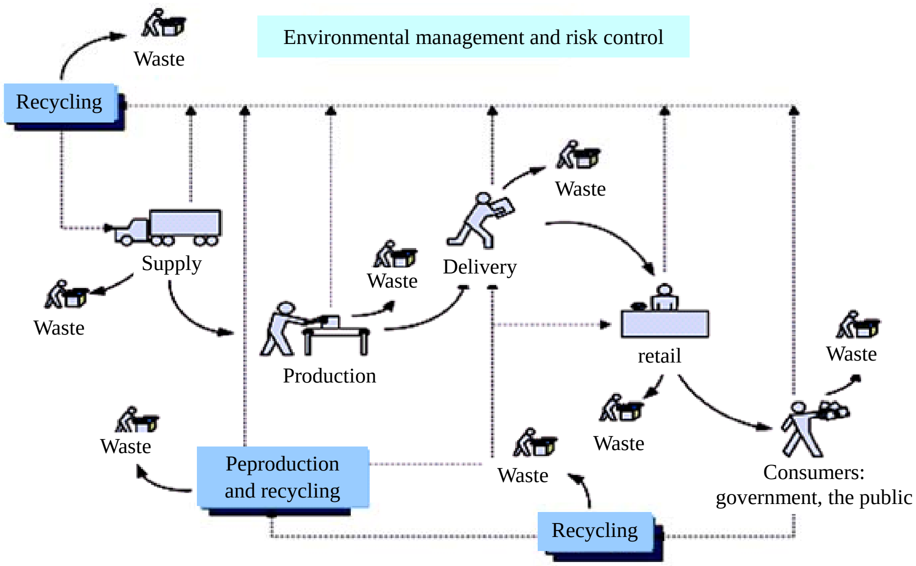

Figure 6-1 Management system of green supply chain

6.2.2 Differences between green supply chain and traditional supply chain

The green supply chain focuses on changes in the following five aspects compared to traditional types of supply chain:

(1) The goal. The traditional supply chain aims to lower the cost and improve the efficiency of supply chain enterprise so as to maximize the economic benefits. Green supply chains also seek to maximize economic benefits, to decrease the consumption of

resources and energy and to reduce the emissions of pollutants – all in an effort to create a socially responsible enterprise, and to balance the economic benefits, social effects and environmental effects.

(2) Management structure of supply chain. For green supply chain management, environmental performance is included in the enterprise's internal and external management, which is lacking in traditional supply chains.

(3) Business model. A green supply chain means a more complete business model. Elements including low carbon and environmental protection must be included in the entire logistics and supply chain to realize a complete green and low carbon supply chain system through the whole life cycle, from raw material sourcing and industrial design to production and delivery.

(4) Business process. The traditional supply chain starts with suppliers and ends with users, and the products flow is one-way and irreversible, known as "Cradle- -to-Grave". The green supply chain changes this management mode and hopefully realizes "Cradle-to-Reincarnation". In green supply chain thinking, product flow is circular and reversible and all products must be managed throughout the entire life cycle, and beyond so that "waste" finds a second life or becomes raw material available for new production or other purposes.

(5) Consumption pattern. The consumption pattern of the traditional supply chains is a voluntary initiative governed by consumer interests and business activities. Green supply chains can be promoted through green government procurement, corporate social responsibility, and sustainable consumption education and practices.

6.3 International Experiences of Green Supply Chain

6.3.1 The United States government and enterprises – sponsor and promoter of green supply chains

The U.S. government has issued vigorous, flexible and scientific laws and regulations to guide policy development of green supply chains. Policies and regulations concerning pollution control, traffic control, food contamination prevention, and interests to safeguard consumers' health have already been issued, and corresponding monitoring systems also have been established.

6.3.1.1 Market incentives are developed to guide enterprise's environmental behaviors

Taxes and incentives have been set in place by the U.S. government to change the financial decisions of a company and therefore help promote greater efficiency, adoption of renewable energy or better resource use. Market incentives for reducing aggregate supply chain energy use can also include the implementation of subsidies to support renewable energy initiatives in companies along the supply chain.

6.3.1.2 Enterprises are required and encouraged to report on supply chain-related environmental impacts by laws and regulations

The U.S. government requires enterprises to disclose information about the environmental impacts of areas of their operations including their supply chain. The Toxics Release Inventory requirement from the EPA, which requires companies to report on their toxic chemical releases, including location, is an example of such a program[2].

In addition, the U.S. government also makes efforts to carry out reporting systems on environmental information. American companies, along with many companies doing business in the United States, are required to report on a wide variety of financial and corporate governance issues. This reporting is highly regulated, takes place regularly, and includes exhaustive amounts of information about the companies and their operations. Most corporate reporting is overseen and published through the Securities and Exchange Commission.

6.3.1.3 Enterprises are encouraged by the government to launch voluntary programs to reduce the environmental impact of supply chain

The U.S. government has sponsored voluntary programs to encourage enterprises to participate in green supply chain as part of helping them work towards more sustainable operations. The government-sponsored programs are not only guidance-based, but also tend to be collaborative. Voluntary programs can also provide a forum for companies to share best practices, which can have significant cascading benefits in an industry sector. Smart Way program is one of the examples. Initiated by the EPA in 2004, the Smart Way program is a partnership between government and industry that provides logistics for companies with strategies for reducing fuel use through efficiency measures[3].

6.3.1.4 Promotions on government green procurement

The U.S. government has a complete green procurement system that plays an incentive

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2 http://www.epa.gov/tri/, E.P.A. (2011 19-April). *TRI Home*. Retrieved 2011 20-April from Toxics Release Inventory Program: http://www.epa.gov/tri/.

3 US EPA. (2011 1-April). *Smart Way*. Retrieved 2011 7-April from U.S. Environmental Protection Agency: http://www.epa.gov/smartwaylogistics/.

role in the healthy development of green supply chain. It mainly adopts federal acts and presidential executive orders as the legal basis for promoting green procurement. These acts and orders include: Executive Order No. 12873 *Federal Acquisition, Recycling and Waste Prevention*, No. 13101 *Greening the Government through Waste Prevention, Recycling and Federal Acquisition*, No. 13148, *Greening the Government through Leadership in Environmental Management* presidential executive order, and so on.

6.3.1.5 Prudence in partnership establishment for a win-win result

Leading American enterprises have many concerns with establishing partnerships with suppliers and often giving priority to environmental performance in their evaluation of suppliers. Final suppliers are selected based on their compliance with environmental laws and regulations as well as the strength of the enterprise's own indicator systems, the data and information provided by suppliers through questionnaires, and the results of quantitative and qualitative analysis. Once the suppliers actually become partners, the leading enterprises won't rely only on monitoring and evaluation, but will establish a win-win partnership with them by providing guidance, support and help. For example, meetings and environmental forums will be held with suppliers, and training will be provided for them.

6.3.2 EU – Expanding global impacts of green supply chains by green products specifications

The EU promotes the spread of green supply chains globally through specification and designation of green products. They hope to take the lead in the environment-friendly development of the manufacturing industry based on the massive business market within the EU and beyond. Major EU measures include those noted below.

6.3.2.1 Environmental laws promoting a green supply chain revolution

EU approved Waste Electrical and Electronic Equipment (WEEE) and Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS) specifications have far-reaching influence on the electrical appliance manufacturers worldwide; and, as well, on the entire electronics industry supply chain consisting of electric items manufacturers, distributers, as well as contractors. Electric appliance manufacturers seeking market share in the EU have to on the one hand sustain higher costs arising from "green barriers", and on the other hand, advance their production technologies which include the extension of product life, the reduction of high energy-consuming products, the application of friendly-assembly and easy-disassembly design, the alternatives of hazardous substances and the continuous greening of production line. In this sense, the WEEE and RoHS help to establish green supply chains throughout the global electronic industry and to provide experience in electronics waste management for other countries in various parts of the world.

6.3.2.2 Eco-labels

As early as 1992 the European Ecolabel[4] was launched as a voluntary scheme to encourage the private sector in its development and marketing of environmentally friendly products and services. Products and services that have earned the label carry a simple flower logo, which allows for easy recognition across the 27 member states (plus Norway, Iceland and Liechtenstein).

6.3.2.3 Green Public Procurement (GPP)

Central to the EU's policies is Green Public Procurement, seen both as a spur and model for the private sector to emulate, and a significant weight in its own right as a portion of GDP. Europe-wide, public authorities account for approximately €2 trillion, or 17% of EU GDP, and constitute therefore a major lever in shifting markets towards sustainable development. GPP provides an incentive for industries to develop green technologies and products and represents sufficient volume to help industries reach critical mass for making the sustainable production of goods and services viable.

6.4 Status Quo and Challenges of Green Supply Chain in China

6.4.1 Status quo of green supply chain development in China

The Chinese Government and businesses lag behind in understanding the concept of green supply chain. As a result, green development of the entire supply chain has started late by comparison to some other countries, and the theoretic studies and practices are still in the infancy. In light of the high consistency between green supply chain and green transformation in terms of the target and actions, green supply chain could evolve to be a vital environmental and economic tool at the micro level to achieve the green development and green transformation.

The Government increasingly has recognized the importance of green supply chain development, and therefore has continuously sought to create a favorable environment for market-based approaches through laws, policies and other means. Meanwhile, some

4 http://ec.europa.eu/environment/ecolabel/about_ecolabel/what_is_ecolabel_en.htm.

domestic multinationals and large enterprises in China also have realized the strategic role of environment and resources in building competitive advantage during their operation and management, and therefore have initiated preliminary exploration of green supply chains. Some suppliers with long-term perspectives and capabilities have begun to break the barriers to green exports and embarked on the green supply chain development.

Government, business, the market and the public shoulder different responsibilities in green supply chain development, as shown in Figure 6-2.

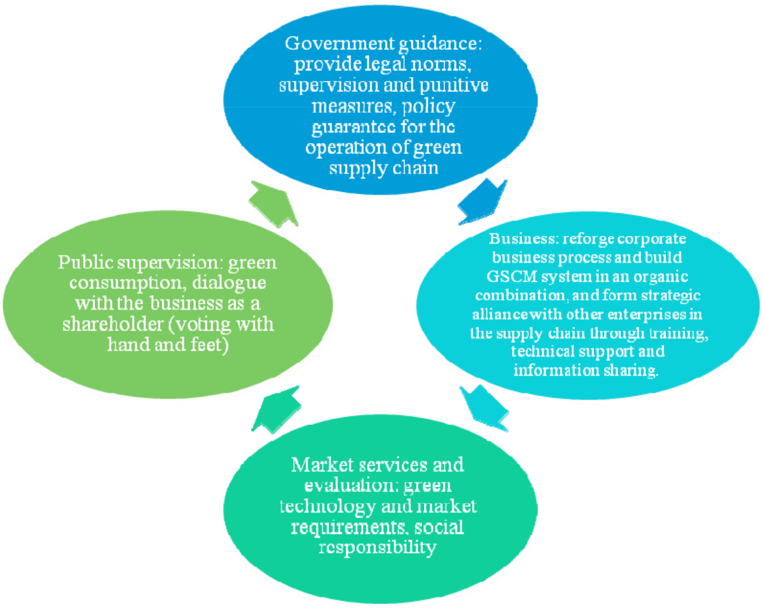

Figure 6-2　Relations among government, business, the market and the public

6.4.1.1　Government guidance on green supply chain

(1) Government as the regulator in the initial stage of green supply chain development

The legal institutional framework for environment and resource protection has been in place in China and progressively improved after years of efforts, such as energy saving system, environmental standards, environmental monitoring and reporting system, environmental resource planning system, target responsibility system for environmental protection, quantitative examination system for comprehensive urban environmental improvement, environmental impact assessment system, the “three simultaneous” system (design, implementation and production), sewage discharge declaration and registration system, natural resources ownership system, the permit system in the field of environmental resources, paid use of natural resources, and the charging system for sewage discharge. Chinese laws and other guidance concerning green supply chains and their significance are listed below.

Law on Energy Conservation

Law on Renewable Energy

Law on Promotion of Cleaner Production

Law on the Prevention and Control of Environmental Pollution by Solid Wastes

Law on Environmental Impact Assessment

Law on Circular Economy Promotion

Directory of Listed Companies Subjective to Environmental Inspection by Sector

Opinions on the Implementation of Environmental Policies and Regulations to Prevent Credit Risk

Guideline for the Preparation of Corporate Environmental Reports

(2) Promote macro-policy environment conducive to green supply chain development

During the "11th Five-Year Plan" period, China has for the first time set the reduction of energy consumption intensity and major pollutant emissions as the binding target of economic and social development, and carried out a series of actions in the hope of energy-saving technological progress, such as shutting down small high-polluting and energy-consuming enterprises. As of 2010, energy consumption per unit of GDP, as well as sulfur dioxide (SO_2) and chemical oxygen demand (COD) emissions have decreased by 19.1%, 14.29% and 12.45% respectively. Not only has the binding target provided in the *Outline of the "11th Five-Year Plan"* been accomplished, but also the obvious rising trend of energy consumption per unit of GDP and major pollutant emissions has been reversed.

Energy saving and emission reduction seems even more arduous in the "12th Five-Year Plan" period. In terms of energy saving, by 2015, energy consumption per 10,000 *Yuan* of GDP shall be declined by 16% over the 2010 level. In terms of emission reduction, COD and SO_2 emissions nationwide shall not exceed 23.476 and 20.864 million metric tons respectively, a drop of 8% compared with the 2010 levels; national ammonia and nitrogen oxides emissions shall be limited within 2.38 and 20.462 million metric tons respectively, 10% down 2010 levels.

Although the emission reduction target during the "12th Five-Year Plan" period is slightly lower than that in the previous period, it is not easy to make it happen, and the pressure is even greater because the marginal effect gradually diminishes with the decline of the baseline of emission reduction. In light of the mandatory targets, emission reductions should be deemed as sourced not only from projects, structure and management, but also should incorporate voluntary market emission reduction arising from green supply chain actions.

(3) Government green procurement – interpreting government's role as a green supply chain program promoter

Government green procurement as an important instrument to promote green supply chain has attracted increasing attention from the Chinese Government. Its main legal basis includes:

1) Law on Cleaner Production Promotion (2002) specifies that Government at all levels should give priority to energy-saving products, water saving products, products with waste recycling, and other products beneficial to environmental and resource protection in the procurement.

2) Law on Government Procurement (2003) specifies that Government procurement should contribute to the objectives of national economic and social policy, including protecting the environment.

3) Law on Prevention and Control of Environmental Pollution by Solid Wastes (2004) encourages units and individuals to purchase and use recycled products and reusable products.

4) Law on Promotion of Circular Economy specifies that government procurement policy should be conducive to the development of circular economy and give priority to energy saving, water saving, materials saving products, products conducive to environmental protection and renewable products.

The State Council issued the *Decisions on Implementing the Outlook of Scientific Development and Enhancing Environmental Protection* in 2005 and further stressed the need to establish a government green procurement system[5]. In the same year, it released *Opinions on Accelerating the Development of Circular Economy* to clarify the policy orientation for government agencies to implement green procurement[6].

In order to implement the documents issued by the CPC Central Committee and State Council, Ministry of Finance (MOF) and MEP jointly issued the *Implementation Opinions on Government Procurement of Environmental Labeling of Products* and publicized the first batch of 14 categories of environmental labeling products for government procurement in

5 The document stipulates "vigorously develop the circular economy...in the consumer sector, greatly advocate environmentally friendly consumption patterns, implement environmental labeling, environmental certification and government green procurement system, and improve the renewable resource recycling system."

6 The document calls for "vigorously advocate consumption patterns conducive to environmental protection and resource conservation, encourage the use of energy-efficiency labeling products, energy-saving and water-saving certified products, as well as environmental labeling products, food with green label and organic label, reduce excessive packaging and the use of disposable supplies. Government agencies implement green procurement."

October 2006. It shows that environmental criteria have been formally incorporated into the Chinese government procurement model. The document requires “state organs, public institutions and organizations at all levels shall give priority to environmental labeling products in the procurement with financial fund and not purchase products harmful to the environment and human health.” Such a system is an important breakthrough in China’s government procurement policy and system and marks the official kickoff of Chinese government green procurement.

In the years of government green procurement implementation, MOF and MEP have jointly announced 8 batches of the lists of environmental labeling products for government procurement, expanding the product scope from the original 14 categories to the current 24, enterprises from 81 to 550, and product models from 800 to over 18,000. These products include IT equipment, such as automobiles, personal computers, copiers and printers, building materials, such as paint, furniture and plates, and also solar products, as shown in Figure 6-3.

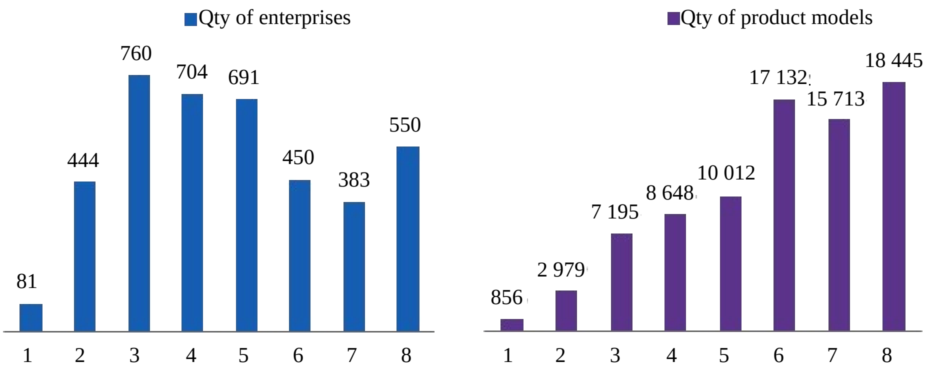

Figure 6-3 Numbers of enterprises and product types in the lists of Chinese government green procurement

Government procurement of environmental labeling products has played an active role in guiding and promoting green production and consumption and building a resource-saving and environmentally-friendly society, and won strong support and popularity among the various manufacturers of green products. Data show that in 2009, the national procurement of green products was valued at 14.49 billion *Yuan*, accounting for 74% of the government procurement of products in the same category, while the number of government green procurement amounted to 272.6 billion *Yuan* during the “11th Five-Year Plan” period, accounting for about 65% of the government procurement of products in the same category.

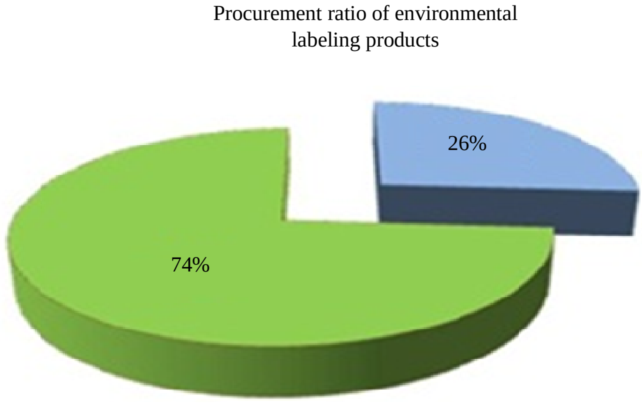

Figure 6-4 Government procurement ratios of green products in 2009

Government green procurement was officially incorporated into the "12th Five-Year Plan" in 2011, making an innovative move in the new era of environmental protection. Its implementation positively advances the building of a resource saving and environmentally friendly society and thus enjoys great support and welcome from the majority of manufacturers of green products, and moreover, guides sustainable consumption in the whole society.

(4) Green trade transformation supports green supply chain development in China

International trade and green supply chains are closely connected. International trade not only promotes the transnational spread of green supply chains, but also drives the sustainable trade. In consideration of China's actual situation, there are three main influencing factors.

Firstly, China frequently encounters friction in its international trade. China may have more acute confrontations with trading partners with as its share of products in the international market increases. For purposes including environmental protection and trade protectionism, other countries engaged in international competition sometimes have used environmental standards higher than those of China as a means to restrict the exports of Chinese products. With movement up the value chain of China's export structure, direct competition with the developed countries will become more intense, which will require raising the environmental requirements on China's exports.

Secondly, the issue of climate change has brought new challenges to China's economic and trade development. Border tariff measures developed countries might take, such as carbon tariffs, would directly affect China's export competitiveness. The Chinese Government has to develop response measures to strengthen green supply chain and thereby help improve the international competitiveness of Chinese enterprises.

Thirdly, building a green supply chain network should serve not only as a measure in response to green trade barriers, but also as a barrier to resist contaminated products entering from developed countries, and to stimulate development of domestic market standards. Developed countries should conform to such green market standards when exporting products or investing in China and setting up factories, otherwise, the products should not be allowed to enter any link in the supply chain. Such market constraints sometimes are more effective than policy constraints.

The Chinese Government has already implemented a series of “green trade policies” and thus has played a positive role in promoting green supply chain development in China, mainly reflected in the development of environmental certification standards in accordance with international standards and the imposition of export tariffs on high-polluting industries.

6.4.1.2 Corporate green supply chain practices

(1) Multinationals play a promoting role in the initial development of green supply chain in China

Multinationals play a positive role in guiding the implementation of the green supply chain system in China. To meet the parent company’s requirements or respond to the needs of business globalization, such companies take the lead in green supply chain practice in China and gradually extend it to the upstream suppliers. A number of foreign invested enterprises or joint ventures have put requirements on the GSCM of suppliers, such as IBM, Dell, HP, Sharp, Sony, Samsung, Motorola, Ricoh, Shanghai GM and Wal-Mart.

At present, most multinationals implementing green supply chain in China raise requirements on suppliers’ environmental compliance. For example, suppliers are required to pass the certification of ISO14001 environmental management system. According to the characteristics of their own products, as well as product-related requirements in international laws and regulations, some manufacturers also put forward requirements on the hazardous substances in raw materials and components, design and recycling. In general, different types of enterprises have different priorities in green supply chain implementation. For example, manufacturing enterprises pay more attention to green design, green supply, green production, etc., while retail enterprises are more likely to consider green logistics and green supply.

It can be said that, green supply chains cannot take root and sprout in China without the contribution of excellent multinationals. Such enterprises promote green transformation in accordance with the actual situation in China in the initial phase of supply chain development.

(2) The practices of China-invested companies

In the face of rising green consumption trends, increasing numbers of domestic enterprises in China are beginning to attach importance to green competitiveness. In terms of the implementation of green supply chains, domestic enterprises are evidently polarized in their performance. On the one hand, large and medium-sized enterprises, especially state-owned enterprises, promote green supply chain practices in China, whether actively or passively. However, the other pole is represented by many SMEs, which often are unable to carry out professional transformation, or technology R&D. Due to their thin profit margins and limited financial resources, it is impossible for them to implement green supply chains. This reflects the reality of China's industrial development at present.

6.4.1.3 China's green consumer market and green supply chain management development

The observation that "China has limited capacity of green consumption and the Chinese consumers do not know green products" forms the biggest misunderstanding of the Chinese market. TüV SÜD Asia Pacific Limited conducted a green market research initiative in China, India and Singapore in 2010. The company compared the attitude towards green products, services, policies and certification of consumers and businesses. Several sectors (appliances, food and beverage, footwear and apparel) were examined. Its official survey report released in January 2011 shows that, compared with India and Singapore, China has paid the most attention to and demand of "green" products.

94% of the Chinese urban consumers surveyed are willing to pay high additional costs for clearly proven "green" products and services; 45% more than that for non-green goods on average. However, only 60% of the Chinese companies think that consumers would like to spend more for "green" certification, and expect them to pay at most only 13% more. In the survey, 59% of the enterprises in the three major sectors have already produced or traded "green" products, but they still fail to properly assess the urgency of such demand among urban consumers. Most companies have not yet formulated or explicitly expressed the formulation of appropriate rules or guidelines to minimize the environmental impact.

To sum up, the green consumer market has taken its initial shape in China, with tremendous progress in market consumer desire and spending power. The green consumer market has become the basis for green supply chain development. Traditional supply chains have had difficulties in meeting "the desire for green" in the consumer market. Many

Chinese enterprises have not yet realized the point, and squander away opportunities by comparison with transnational corporations.

6.4.1.4 Enhanced public environmental awareness pushes ahead green supply chain development in China

The consumer is the ultimate driver determining whether green products thrive or not, and to what extent. Increasing public attention to environmental issues will press the government and industry to improve green standards and norms. After a series of environmental and human health hazard events, such as “heavy metal pollution, soil pollution, water pollution”, the public environmental awareness of the Chinese consumers has been significantly enhanced.

According to the TüV SÜD Asia Pacific Ltd. survey, about 50% of urban consumers think action should start at the level of individual green consumption but rely on the collective public power for a final solution, while 75% of the businesses said the government should introduce explicit initiatives to promote sustainable development and corporate social responsibility. The majority of businesses pointed out that industrial and government regulations are the main reasons behind their enforcement of social responsibility and sustainable development criteria.

As the mainstay of the market and the endpoint and target of industrial supply chains, the consumer determines the “survival” of the market and individual businesses. With the awakening of consumers’ green consumption awareness, GSCM has been endowed with the fertile soil for rapid development.

6.5 Main Conclusions and Policy Recommendations

Greening supply chains is important for China’s green transformation. Although there are some beneficial conditions in place for developing green supply chain development in China, the lack of government policies, absence of industrial guidance and corporate strategy on green supply chain, the situation of an immature market of green consumption and public awareness, and long-way-to-go green trade transformation greatly challenges the development of green supply chains in China. Below are the main conclusions arising from the study and key policy recommendations.

6.5.1 Main conclusions

(1) Pressure from the international market and monitoring of domestic environment

pressures will support Chinese enterprises to participate in green supply chain management. As China is facing growing pressures from its economic transformation and international trade, the establishment of a green supply chain program would be consistent with the goals of green economic development and sustainable development of China's economy in the future.

(2) Though China's green supply chain is in an initial stage, the policy and market will provide support for its establishment. Most of China's laws and regulations on environment and resources overlap with those concerning green supply chain, and governments have the ability to play roles as regulator, driver and monitor. Meanwhile, as green consumption patterns grow, they will also provide support for the establishment of green supply chain.

(3) Practices of green supply chain for enterprises tend to be spontaneous and voluntary in light of the lack of guidance by laws and regulations and policies. Though China has no specific laws and regulations and policies relevant to green supply chain, both transnational enterprises and leading Chinese enterprises have a strong interest in China's green supply chain implementation. At present, some transnational enterprises have introduced green supply chain concepts to China while Chinese state-owned enterprises and private sectors are likely to participate in this initiative. However, these are individual instances, and pollution and resource over-use are still occurring in practice due to the inconsistent application and environment of environmental standards.

(4) The government, enterprise, the market and the public all interact with one another in an integrated green supply chain program.

The government can develop policies and programs that mandate and reward green supply chain management; enterprises will carry out the green supply chain management practices; market forces will monitor implementation of green supply chain by bringing more business and reputational benefits to those enterprises that participate, and the general public will reinforce green supply chain success through consumer loyalty to those enterprises and products that reflect green supply chain management.

6.5.2 Policy recommendations

China's green supply chain has just been initiated. The government and enterprises are gradually accepting the idea that enterprises should be guided by "Green" concept systems in an integrated way so as to achieve a green transformation of the market. Green supply chain, which serves as a tool to address environmental problems through a market mechanism, will not only complement and complete China's current environmental management system, but also effectively intensify environmental management by enterprises.

6.5.2.1 The guiding and regulating role of government should be emphasized to establish and complete China's laws and regulations and standards concerning green supply chain

The full implementation of green supply chain requires the government's decision-making; only when the government's policies for encouragement, coordination and investment are matched can green supply chain be promoted.

(1) The government should play a leading role in the green supply chain system, and develop *Green Supply Chain Management Regulation* and *Industry Evaluation Standard on Green Supply Chain*. It also should develop its green supply chain certification in combination with the existing environmental certification system.

It is recommended that the Ministry of Environmental Protection should take the leading role, while Ministry of Finance, Ministry of Commerce, National Development and Reform Commission, China Banking Regulatory Commission, China Securitas Regulatory Commission and other government departments offer collaboration. In this way, a *Policy Guideline for Green Supply Chains in China* should be introduced, helping enterprises realize the goals of sustainable operation and green supply chain starting from complying with regulations, reducing commissions to carrying out low-carbon and green development. Additionally, in adapting to the policy guideline, *Industry Standards and Procedures for Green Supply Chains* for different industries should be developed. Meanwhile, combining with the existing environmental certification system, green supply chain certification also should be developed so as to ensure the green supply chain can be standardized, operational, monitored, legitimate, and evidence-based.

The government should adopt product stewardship programs for key consumer and industrial products. These programs should be designed to minimize the end-of-life impacts of key products and to encourage reuse and recycling by requiring manufacturers to take back, recycle or properly dispose of those products. Product categories to be addressed in the stewardship programs should include: consumer electronics, batteries, paint, tires, carpet, mercury-containing products (like thermostats and fluorescent lights), bottles and cans.

The programs would be designed to share responsibility among government, manufacturers and consumers of products as follows:

1) Government will establish goals and timelines for recovery and recycling of each product category, and will launch programs to educate consumers and manufacturers on the aims and requirements of the stewardship programs.

2) Manufacturers will be individually responsible for meeting their market share of

specified recovery and recycling goals, but will be allowed flexibility for how the goals are met. For example, manufacturers may join a collective system for managing end-of-life products, or may establish a third party organization to meet the program requirements.

3) Consumers will participate by bringing appropriate products to designated collections sites at their end of life. Consumers will not be expected to pay for product collection (although compliance costs can be passed along through product pricing).

Each product stewardship program would have enforcement provisions that allow for daily monetary penalties should any manufacturer not have a plan in place to meet program goals within a set period after program commencement, and should any manufacturer not meet the performance goals and timeline outlined in their own compliance plan.

The government should consider adopting a joint Extended Producer Liability law under which all links in the supply chain could be considered liable for violations of environmental and health laws, contamination or misuse of property, or damages to health and public resources. Consistent with Chinese practices for environmental enforcement and for civil liability, an Extended Producer Liability law would extend responsibility to all of the following:

1) The current owner or operator of the facility immediately responsible for the violation or damage;

2) The owner or operator of the facility at the time the violation occurred or the damage was first initiated; and the purchaser of the products or services whose production contributed to the violation or damage incurred.

(2) The economic policy should be combined with green supply chain, thus effectively changing the market behaviors of suppliers from market-oriented to green-based.

1) Provide enterprise participating in green supply chain with favorable taxation measures and green loan support. Support the green supply chain market through guidance of economic means. Through the introduction of green tax incentives, green subsidies and other policies, the enterprises should be guided with regards to production and operation, and be encouraged to improve efficiency and increase investment in environmental improvement, thereby contributing to the sustainable development of the supply chain.

2) Establish voluntary projects of green supply chain to encourage enterprises to participate in such projects. The government can sign voluntary agreements of green supply chain with enterprises, and effectively realize the implementation of green supply chain.

3) Require listed enterprises to disclose information about the environmental impacts from all aspects of their supply chain operations through verification measures on listed

enterprises. The government should develop a list of the most harmful toxic substances and require enterprises to report publicly on their annual emissions of those substances. Enterprises should be encouraged to publish, on a regular basis, sustainability development reports and corporate social responsibility reports for the production chain.

4) Carry out demonstration projects by building green supply chain system in Eco-industrial zone. At present, the construction of China's Eco-industrial zone coincides with green supply chain, thus it can be the location for demonstration practice.

5) Improve performance standards and industry technical standards to meet international level. Enterprises should be encouraged to promote technological innovation, stimulate green transformation, and gradually establish performance standards and industry technical standards. In this way, the green supply chain in enterprises can be strengthened to provide support for the successful completion of emissions reduction targets during the "12th Five-Year Plan".

(3) The government should play leading and exemplary roles, and intensify green public procurement policies.

Government should focus on the integration of green public procurement plan with the existing procurement policy, consider how to reduce the environmental impact of supply chains and reduce procurement costs. Specifically, the government can carry out green procurement policy through the following aspects, so as to enhance the effectiveness and impact of green supply chain in China:

1) Complete *Government Procurement Law* that requires all central and provincial procurement officials to assess and give preference to those products and services that are environmentally preferable.

2) Through the platform of government public procurement and giving priority to labeling product standard, the green product procurement indicators should be implemented and general principles and guidelines for government green procurement should be developed. On the platform of government public procurement and by the way of certification, green product procurement indicators should be set, so as to compulsorily promote enterprises entering into the public procurement platform to adopt green supply chain. Industries and products exerting significant impacts on environment should take the lead in indicators and compulsory government procurement so as to give full play to the government procurement measures and enable the government procurement to play an important role in pollutants emission reduction, environment monitoring and green economic development.

3) Develop *General Principles on Government Green Procurement*, which should

integrate government green procurement requirements and enterprises carrying green supply chain requirement, and specific requirements on initiators, management, procurement standard, evaluation and monitoring, and performance report. Green procurement guidelines should require that government goods and services are procured only from enterprises able to demonstrate current and consistent compliance with all relevant central and provincial environmental rules and guidelines, including policies and regulations to promote clean production, circular economy, and environmental labeling.

4) Establish standard database of government green procurement to provide a platform for information exchange on green products, offering green products information and technical services for suppliers, manufacturers, purchasers, and consumers.

(4) Green trade should be promoted with the supply of public services and research on performance evaluation of green trade.

The existing public service platform for foreign trade should be supplemented with contents of green trade, introducing the technical standards, laws and policies of major countries with regards to environmental protection and low-carbon development, and advanced experience of advanced green trade enterprises. The platform can also provide enterprises with technical training and management personnel for green trade.

In order to enhance the transparency of green trade, and make an objective evaluation on the economic and social benefits of green trade policies, a green trade policy performance evaluation system should be gradually established: to monitor the carbon dioxide emissions of import and export of goods in the whole process of production, from raw materials, manufacturing, contracting, transportation, storage, marketing, to waste recycling; to evaluate the positive results of enterprises which have adopted low-carbon technologies and management practices; and to assess the performance of China’s government policies for green trade.

(5) Pilots should be considered to promote green supply chain nation-wide.

One effective way to promote green supply chain management system is to conduct pilots in certain regions first and then extend to the whole nation. The pilots should include the policy innovation and strengthened supervision from the government, activated market forces of certification and other public services, educating consumers for green consumption and so on. With regard to the locations for conducting the pilots, regions like Tianjin Binhai New Area, Yangtze River Delta and Pearl River Delta with sound economic infrastructure and motivations for green transformation are recommended.

6.5.2.2 Practice in enterprises should be promoted to establish China's economic system of green supply chain

(1) Through the model effect of green supply chain, "Star Enterprises for Green Supply Chain in China" should be cultivated, which can drive the overall development of green supply chain.

Further enthusiasm of enterprises for environmental protection can be created through honorary recognition awards, publicity and other forms, and enable enterprises to realize that the development of green supply chain can improve their core competitiveness. "Star Enterprises for Green Supply Chain in China" can be fostered through competition and industry consolidation, and these star enterprises can gain further market acceptance and public awareness through the "Green Supply Chain Certification System in China".

(2) A "Green Supply Chain Network Platform" should be constructed to strengthen the cooperation among industries, enterprises, government, NGOs and other external institutions.

Through the establishment of "Green Supply Chain Network Platform", Chinese enterprises on the green supply chain can further expand market reach, play the active role of the network platform, integrate market resources, promote the integration of upstream and downstream enterprises on green supply chain, and play the role of intensification and integration of the platform.

Establish standard database of government green procurement to provide a platform for information exchange on green products, offering green products information and technical services for suppliers, manufacturers, purchasers, and consumers.

(3) Green supply chain pilot programs should be carried out within enterprises to verify regulations and policies in practice. Green supply chain pilot programs are suggested among enterprises and follow MRV (measure, reportable and verifiable) principles. A third party is responsible for evaluating the initiatives in green supply chain.

6.5.2.3 Market forces should be activated to reinforce the service and regulation of the market

(1) Industry associations should take the lead to establish a "Promotion Center for Green Supply Chain", and undertake the functions of regulation for the Fund, green certification, and advocacy organizations.

Cooperation among enterprises, governments, non-governmental organizations and industry should be promoted by giving full play to the functions of Promotion Center for Green Supply Chain. Such organizations can be firstly started in areas and locations with green supply chain basis like Tianjin Binhai New Area, Yangtze Delta and Pearl River Delta, so as to intensify the sustainable promotion of green supply chain.

(2) A Fund for the Development of Green Supply Chain by Enterprises should be set up in combination with Promotion Center for Green Supply Chain to provide economic incentives for enterprises carrying out green supply chain measures.

It is proposed that the government should take the lead to establish foundation for the development of Green supply chain, whose funding should come from government, enterprises, and social institutions. The foundation can fully mobilize the enthusiasm of enterprises, especially SMEs, which can be encouraged to use more advanced environmental technologies and environmental management concepts, so as to promote a more comprehensive and balanced development for green supply chain in China.

6.5.2.4 Engagement of the public should be emphasized to create an enabling environment for China's green supply chain

Consumer demand for responsibly produced products can provide a strong market incentive for enterprises to move toward green supply chain management, as can consumer anger toward those enterprises it believes have not acted responsibly.

(1) The concept of green supply chain should be continuously promoted, thus increasing public awareness.

Through the competition and recognition awards of “Star Enterprises for Green Supply Chain”, propaganda of green government procurement, green consumption into the community, and other social activities, the importance and urgency of environmental protection should be promoted in the whole society to awaken green philosophy and green consumption awareness among social organizations, so as to create a favorable public opinion and social environment for the implementation of green supply chain, to develop public awareness of green supply chain, and to foster “green consumption thinking” among the Chinese population.

(2) The public should be aware of the environmental performance of local enterprises.

Emissions reports, compliance records and information on specific enterprise and government procurement performance relative to GSCM policies and guidelines should be made easily accessible to the public through online publishing or local dissemination. Through educational programs and community outreach, the public should be encouraged to review enterprise emissions data and CSR reports, as well as local government green procurement performance, and to engage local enterprise managers and government officials in improving GSCM practices.

6.6 Acknowledgements

We appreciate the China Council for International Cooperation on Environment and Development (CCICED) for leadership and guidance on the special policy study. We would also like to thank the Environmental Defense Fund for the generous financial support, and the Shanghai Environmental Protection Bureau, Tianjin Financial Administration Office, Shanghai General Motors, Wal-Mart China, Wal-Mart Global Sourcing Office (Shenzhen) and Tianjin Municipal Center for Government Procurement Center for participation and support to the case studies. We also want to give special thanks to Mr. Li Ganjie, Mr. Shen Guofang, Dr. Hanson, Mr. Ren Yong, Ms. Fangli, CCICED Secretariat and its International Support Office, your tireless work ensured the success of this project.

Chapter 7 Mercury Management in China

In order to propose policies regarding China's approach to the protection of the environment and public health from mercury, the China Council for International Cooperation on Environment and Development (CCICED) carried out the following Special Policy Study of Mercury Management in China. It focuses on mercury pollution and management measures, and offers recommendations for priority actions to reduce mercury release and use in China.

> The Issues
>
> i. Preventing the Exposure of Chinese Citizens to Mercury.
> ii. Reducing Mercury Releases to the Environment.

7.1 Background

Mercury[1] is a naturally occurring element that is persistent, bio-accumulative and toxic at very low levels to human health and aquatic and terrestrial ecosystems.

Mercury is also an important environmental contaminant that is long lived in the atmosphere and can be transported globally. It is unlike any of the other metals, and several characteristics that are unique to mercury — liquid at room temperature, readily transported in the atmosphere and in water — give rise to risks from its release to the environment that must be addressed.

1 When the word "mercury" is used in these recommendations, it should be interpreted to include all species particularly total-mercury and methyl-mercury.

The Arctic

The Arctic Monitoring and Assessment Programme reports that a substantial amount of the mercury arrives via long-range transport from human activities at lower latitudes.

Mercury is released from many industrial processes (coal-fired power generation, mining, non-ferrous metal smelting, etc.) and is used in the production of numerous manufactured products (PVC, medical devices, compact fluorescent lights, batteries, dental fillings, etc.). Its control thus requires complex and widespread measures. International action is required to reduce environmental and health risks at local, regional and global scales[2].

There are several different chemical forms of mercury, including elemental, inorganic and organic forms. Methyl mercury, an organic form, is particularly toxic and is formed in the environment through microbial activity. Methyl mercury in a local environment accumulates in living organisms and is concentrated as it moves up the food chain (bioaccumulation). Human exposure can cause damage to the brain, nerves, kidneys, and lungs, and in extreme cases can result in coma and death. Exposure to even low levels of methyl mercury can cause neurodevelopmental effects in humans and mammals, particularly during the vulnerable development stages of fetuses and children. Young women of childbearing age are therefore a particularly vulnerable segment of the population.

Mercury released from either natural and anthropogenic[3] sources can travel long distances through air and water (see Figure 7-1), and inorganic forms of mercury will change into methyl mercury under certain environmental conditions, for example in sediments and wetland environments.

The toxic properties of mercury have been known for centuries, but the first evidence of the severe impacts through environmental exposure, emerged in Japan in the 1950s. In the fishing village of Minamata, more than 20,000 people were poisoned after a factory released methyl mercury into the local bay and area residents consumed fish from that same water. Among other things, the disaster demonstrated the elevated sensitivity of the human fetus to methyl mercury: mothers whom themselves had minimal symptoms of poisoning gave birth to severely damaged infants[4]. Additional evidence of the severe impacts of methyl mercury

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2 UNEP Report on “A general qualitative assessment of the potential costs and benefits associated with each of the strategic objectives set out in Annex 1 of the report of the first meeting of the Open Ended Working Group.” June 30, 2008.

3 Human activities.

4 Mahaffey KR. Fish and shellfish as dietary sources of methyl mercury and the omega-3 fatty acids, eicosahexaenoic acid and docosahexaenoic acid: risks and benefits. Environmental Research, 2004, 95: 414-428.

became evident in Iraq in the 1970s where about 6,500 people were affected after consuming methyl mercury-impregnated grain.

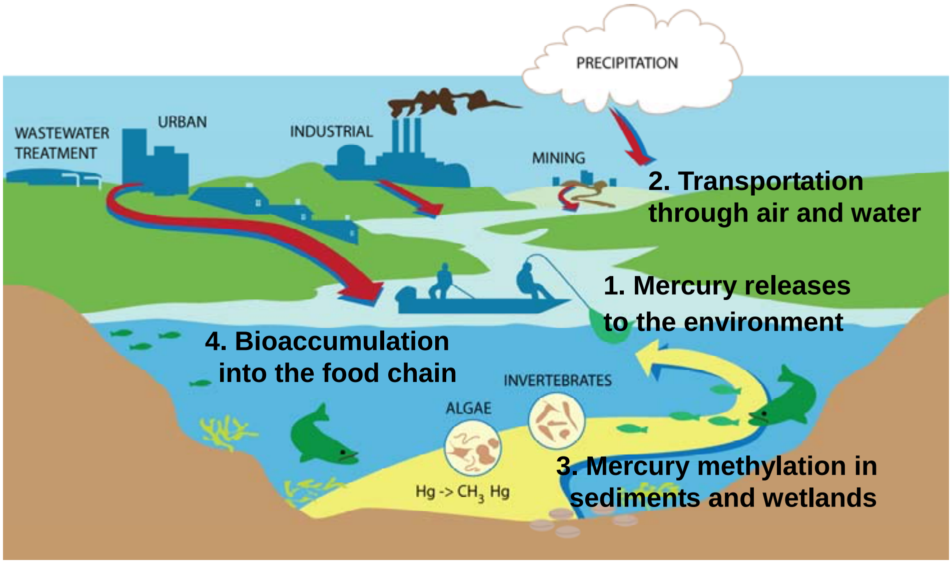

Figure 7-1 A simplified illustration of the mercury cycle[5]

Evidence of the transformation of methyl mercury from releases of inorganic mercury and subsequent accumulation in fish emerged from research in Swedish lakes in the late 1960s and early 1970s. Shortly after, bioaccumulation of methyl mercury was also found elsewhere in Europe and North America. Today, mercury exposure is a widespread concern. For example, the US-EPA estimates that more than 300,000 newborns each year in the United States have an increased risk of learning disabilities associated with in utero exposure to methyl mercury[6].

Historically, Europe and North America have been the major regions for anthropogenic mercury releases. However, after substantial reductions of the releases in these regions over the past three decades, Asia is today by far the largest source of mercury releases (see Figure 7-2), and China is the largest contributor.

An Arctic Monitoring and Assessment Program reported recently that mercury continues to present risks to Arctic wildlife and human populations as levels are continuing to rise in some species despite reductions in mercury emissions from human activities over

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5 United States Geological Survey (USGS) Fact Sheet FS-102-97 by Martha L. Erwin and Mark D. Munn August 1997. available at: http://wa.water.usgs.gov/pubs/fs/fs.102-97 (Accessed Oct. 25, 2011)

6 http://www.epa.gov/hg/exposure.htm (Accessed Sept. 6/2011).

the past 30 years in some parts of the world[7].

Mercury pollution has gained global attention. At present 140 member countries of the United Nations are negotiating a binding treaty to reduce risks to human health and the environment because mercury pollution is an important global concern. Action is needed in China to ensure that it can continue its remarkable economic growth while reducing its contribution to global mercury emissions and domestic mercury pollution. Due to the special chemical properties of mercury, it can remain in the atmosphere for a long time (months to years) and be transported to the most remote places. China, as the world's largest emitter of mercury, is therefore particularly important when targets are being set for reducing total global releases and reducing impacts of mercury. Hence China is a crucial country in the negotiations of a global mercury treaty.

Meaningful treaty obligations will allow China to have a track record on mercury that is consistent with its green development plans. Reduced use and releases of mercury in China will benefit China not only by protecting its environment and human health, but also by safeguarding its international trade which could otherwise be compromised by restrictive measures as trading nations seek to limit their exposure to mercury (illustrated by recent EU measures to restrict trade in mercury).

In facing these great challenges China has the benefit of its proven capacity to bring innovation and modern techniques to bear in the search for solutions. China has set itself on an exemplary course with its commitments to clean energy strategies, energy conservation and green production systems. These efforts, including China's ambitious climate change undertakings, will offer direct and indirect benefits through reduced mercury pollution. The co-benefits[8] of action to address climate change and other atmospheric pollutants can be optimized through improved coordination in planning and implementation. In turn, actions to reduce mercury pollution will also assist in reducing pollution from other heavy metals.

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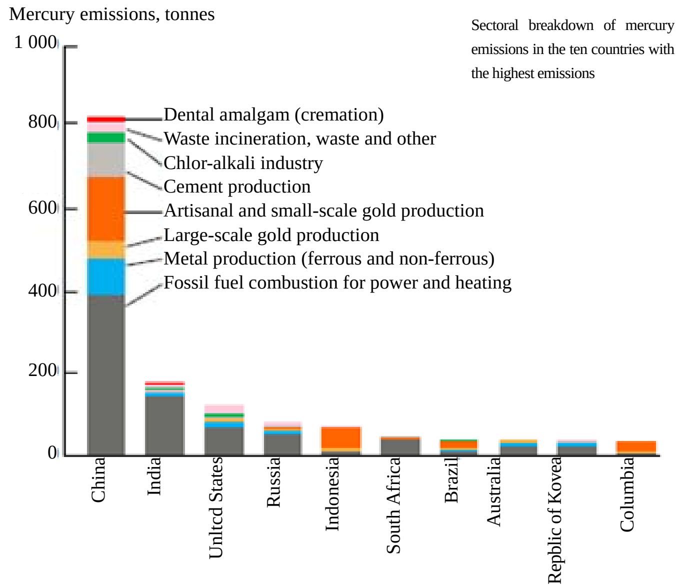
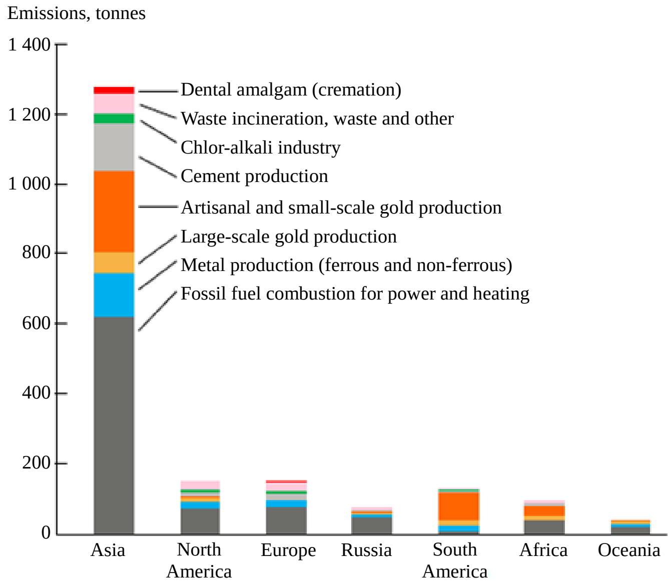
7 AMAP, 2011. Arctic Pollution 2011. Arctic Monitoring and Assessment Program (AMAP), Oslo. Vi + 38pp ISBN-13 978-82-7971-066-0.

8 When equipment is installed to capture or reduce air pollutants such as particulates, SO_2 and NO_x, then mercury emissions may also be captured or reduced as an additional benefit of the processes. Energy efficiency measures or a switch to clean fuels can also reduce mercury emissions from the burning of coal.



(a)



(b)

Figure 7-2(a)(b) Anthropogenic atmospheric emissions of mercury (2005) [9]

9 The Global Atmospheric Mercury Assessment: Sources, Emissions and Transport. United Nations Environment Programme. Chemicals Branch, DTIE. Geneva Switzerland, December 2008. Page 18. Available at: http://www.unep.org/hazardoussubstances/LinkClick.aspx?fileticket=Y0PHPmrXSuc%3d&tabid=3593&laguage=en-US (Accessed Oct 25/2011).

7.2 Mercury Pollution in China

7.2.1 Mercury pollution in China: status, trends and problems

The historic use of mercury in China dates back to 1100 BC, as early as the Shang Dynasty, when people began to use cinnabar (HgS) as a coloring pigment. Currently China is by far the world's largest producer, consumer, and releaser of mercury. The intentional mercury use in China exceeds 1,000 tonnes annually[10], which accounts for about 50% of the world's total. Almost all the 11 categories and 59 sub-categories of emission sources defined by the UNEP Toolkit for Identification and Quantification of Mercury Release[11] are present in China.

China is one of the few countries still undertaking mercury mining. Some of its core industries will continue to use mercury in the near future. The PVC production process, for example, is the largest intentional user of mercury in China. A large part of PVC is produced from coal and this process currently requires the use of a mercury-containing catalyst (most other countries produce PVC using oil or natural gas, ingredients for which the process does not require a mercury catalyst). The other major use of mercury is in the production of goods to which mercury is deliberately added: these include: medical equipment (thermometers and blood pressure monitors), batteries, and fluorescent lamps (see Figure7-3). Unless measures to reduce mercury use are taken, the consumption of mercury is projected to increase rapidly.

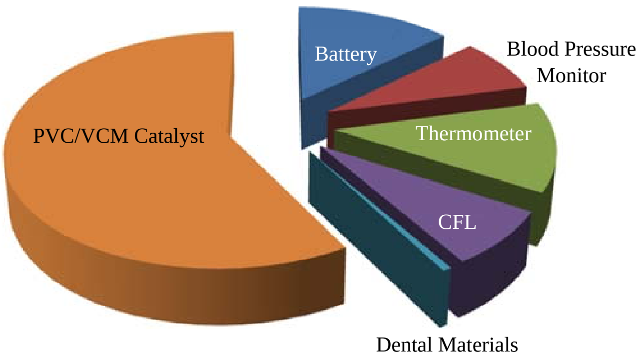


Figure 7-3 Major sectors and their scale of mercury use in China in 2007[12]

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10 There are uncertainties in the figures regarding mercury use and different sources of data report different numbers. Details are given in the sectoral descriptions in Section 7.2.3.

11 www.chem.unep.ch/mercury/toolkit or www.unep.org/hazardoussubstances/mercury/publications - Toolkit for identification and quantification of mercury releases; revised level 2; March 2010.

12 Source: SPS Mercury Team 2011.

The industrial use of mercury in China has caused severe pollution incidents in the past, for example in the Second Songhua River in the northeast and in the Jiyun River in Hebei Province in the 1970s. Today, as a result of past practices, very high mercury levels are found in water, soil and rice near abandoned mercury mining and smelting areas, for example in some areas of Guizhou Province.

The release of mercury to the environment is also high from industrial activities of which mercury is an unintentional by-product. Mercury is incidentally released to air, water and soil, but quantitative estimates are available only for the emissions to the atmosphere.

Rapid industrialization and urbanization has dramatically increased China's mercury emissions to the atmosphere in recent decades. Atmospheric emissions in 2007 were estimated to be 643 tonnes[13]. As reported previously[14], such estimates remain subject to significant margins of error but will improve as more rigorous pollutant release reporting comes into use. While there is some debate about the fate of these emissions, mercury's ability to stay in the atmosphere over long periods of time assures that significant amounts travel downwind from China and are thus a concern for other nations[15].

Despite the numerous ways that mercury finds its way into the air, coal combustion in industrial boilers and power plants remains the largest source of atmospheric mercury emissions in China, accounting for more than 50% of the total (see Figure7-4)[16], with substantial additional contributions from non-ferrous metals smelting and cement production.

Atmospheric Emissions

Approximately half of the mercury released to the air falls out locally. The other half of the mercury travels, and while doing so, changes its chemical and physical form. Most local deposition occurs as dry particles, while global deposition occurs mainly with rain and snow.

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13 Source: SPS Mercury Team 2011.

14 Wu Y, Wang SX, Streets DG et al. Trends in anthropogenic mercury emissions in China from 1995 to 2003. Environmental Science &Technology, 2006, 40, 5312-5318.

15 Adapted from: Mason R.P. and Sheu G.R. 2002. Role of the ocean in the global mercury cycle. Global Bio- Chem Cycles. 16(4): 1093.

16 Source: SPS Mercury Team 2011.

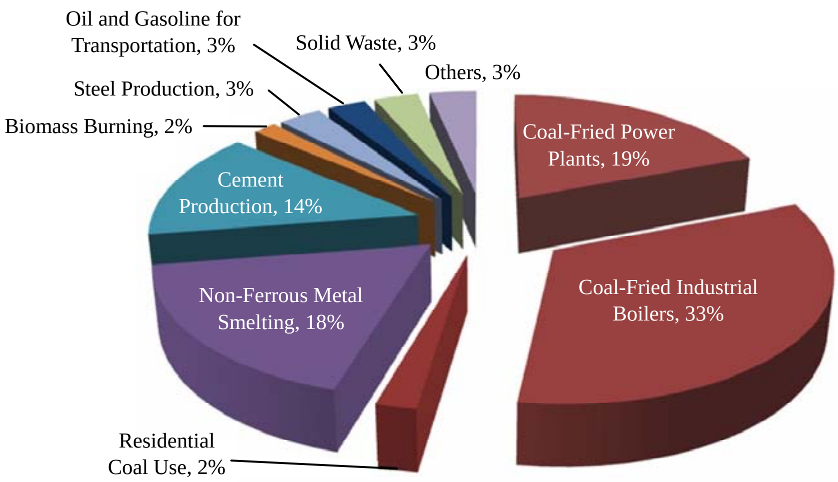

Figure 7-4 Atmospheric mercury emissions from major sectors in China in 2007[17]

China has serious problems with local mercury pollution, particularly in areas near abandoned mercury mines and old, highly polluting smelting and non-ferrous metal plants. In addition, the industries where mercury is released to the atmosphere as an unintentional by-product (e.g. coal burning, non-ferrous metal production) contribute to the mercury loading of the environment locally as well as regionally and globally.

7.2.2 Health impacts from mercury pollution

Mercury exposure of the general population most often involves dietary intake of methyl mercury. Globally the greatest concern is the uptake of methyl mercury through fish and marine mammals. In China, however, different dietary habits in different parts of the population will mean differences in mercury exposure. In the coastal populations, fish and seafood are important sources; for people living inland, rice consumption may be more important[18].

Mercury exposure of the general Chinese population appears comparable to levels found among human populations elsewhere that have low fish consumption. There are, however, small groups of people who may be exposed to dangerously high levels of mercury. These include people living close to mercury-contaminated sites and dependent on locally grown food, fishermen and their families having particularly high fish and seafood consumption, and workers with occupational exposure in the mining, smelting and PVC

17 Ibid.

18 Zhang H, Feng XB, Larssen T, et al. Bioaccumulation of methyl mercury versus inorganic mercury in rice (Oryzasativa L.) Grain. Environmental Science & Technology, 2010, 44: 4499-4504.

industries. It is also important to note that there exist large uncertainties regarding the risks of mercury exposure through rice consumption; the uncertainty is due to the lack of data for dose-response analysis of rice consumption.

There is a paucity of data on human mercury exposure in China, but several studies have been carried out in Guizhou Province. Here, the mercury intake levels estimated for the general population were low, but with important exceptions in heavily contaminated mining areas. Since mercury pollution exists at many contaminated sites where rice is also grown, further investigation is critical to assess exposure and to correlate it with human bio-monitoring (especially for pregnant women) and with potential health effects. It is uncertain whether the advisory limits for human intake, which are based on fish consumption, provide adequate protection for a population with rice-based exposure; rice lacks the micronutrients found in fish that might partly offset neurotoxicity. Data on health impacts are not available.

Blood, hair, urine and milk have been used to assess human exposure to mercury. Hair is a particularly attractive human sample as it is easy and relatively non-intrusive to obtain, and as it gives information of exposure over time (typically one cm of hair records one month of dietary exposure). Some data exist on the mercury content of human hair from assessments of mercury exposure in China: a survey[19] of the general population (659 individuals) in coastal areas found a geometric mean concentration of 0.83 μg/g and values ranging from 0.03 to 8.7 μg/g. Fifty-seven percent of the samples had concentrations below the reference dose value set by the US-EPA[20] and 13% above the tolerable daily intake value set by WHO[21].

There are large differences in the distribution of mercury concentration in hair in different parts of the Chinese population due to very different food consumption patterns. An identified high exposure population is found on the Island of Zhoushan, off the coast of Zhejiang province, where many of the inhabitants are fishermen and their families, with a large portion of wild-caught fish in their diet. The mean mercury concentrations in their hair samples were higher than the corresponding concentration of the WHO provisional tolerable

19 Liu XJ, Cheng JP, Song YL, et al. Mercury concentration in hair samples from Chinese people in coastal cities. Journal of Environmental Sciences-China, 2008, 20: 1258-1262.

20 A hair concentration of 1 μg/g corresponds to US-EPA's Reference Dose for MeHg exposure. Mercury study report to congress. EPA-452/R-97. US Environmental Protection Agency, 1997.

21 The FAO/WHO Expert Committee on Food Additives value for provisional tolerable weekly intake is 1.6 μg/kg body weight/week, corresponding to 2.2 μg/g in the hair.

weekly intake[22]. These levels of mercury in hair were similar to what is reported in other populations with a fish-rich diet (including fishermen in Malaysia, Kuwait and Colombia, sport fishermen in Canada, and many Japanese communities[23]).

High mercury concentrations in hair were also reported for workers living in the mercury mining areas in Guizhou province[24,25]. These workers have both occupational exposure to gaseous mercury and exposure from contaminated rice in their diet.

Also, workers in other industries have occupational exposure to mercury, together with other toxic substances in the forms of gases and dust. Higher-risk industries include mining and smelting in general, and industries intentionally using mercury in the process or as a part of the final product. Workers in the VCM/PVC industry are one example of a situation of particular concern where there is exposure to numerous toxic compounds.

7.2.3 Mercury pollution prevention and control in China by sector

7.2.3.1 Coal fired power plants and industrial boilers

China is the largest consumer of coal in the world, with coal accounting for almost 75% of its energy production. The coal-fired industry includes coal-fired power plants and industrial boilers. Of these two, the power plants sector is the largest consumer of coal, but the industrial boiler sector is a larger source of atmospheric mercury emissions due to less air pollution control in this sector. Typical mercury content in the coal being burnt is 0.15—0.20 μg/g, but there are large variations between regions and coal qualities.

(1) Power plants

Coal-fired power plants in China consumed 1.33 billion tonnes of coal in 2007, accounting for 42% of national coal consumption. The coal demand by power plants is predicted to double by 2020, and, without further pollution control measures, such an increase would also double the mercury emissions. However, there are considerable co-benefits in terms of reduced mercury emissions from control measures for other pollutants (SO_2, NO_x, PM) (see Table 7-1).

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22 Hair concentrations were 5.7 and 3.8 μg/g, respectively, for men, 2.3 and 1.8 μg/g for women, and 2.2 and 1.7 μg/g for children; Cheng JP, Gao LL, Zhao WC, et al. Mercury levels in fisherman. and their household members in Zhoushan, China: Impact of public health. Science of the Total Environment, 2009, 407: 2625-2630.

23 Comparison between available data from Chinese populations and other countries provided in a background document from Prof. Thorjørn Larssen and Yan Lin.Thorjorn.larssen@niva.no (June 2011).

24 Li YF, Chen CY, Xing L, et. al. Concentrations and XAFS speciation in situ of mercury in hair from populations in Wanshan mercury mine area, Guizhou Province. Nuclear Techniques, 2004, 27: 899-903.

25 Li P, Feng X, Qiu G, et. al. Mercury exposure in the population from Wuchuan mercury mining area, Guizhou, China. Science of the Total Environment, 2008, 395: 72-79.

Table 7-1 Co-benefit of mercury removal by various air pollution control devices

Control methods	Intentional pollutant to be controlled	Hg removal efficiency (%)
Coal washing	Particulate matter and SO_2	30
ESP	Particulate matter	29
ESP+WFGD	Particulate matter and SO_2	62
ESP+WFGD+SCR	Particulate matter, SO_2 and NO_x	66
FF	Particulate matter	67
WSCRB	Particulate matter	6.5
CYC	Particulate matter	0.1

ESP: electrostatic precipitator; WFGD: wet flue gas desulfurization; SCR: selective catalytic reduction; FF: fabric filter; WSCRB: water scrubber; CYC: cyclone dust collector.

Because of the stricter control of SO_2 during the "11th Five-Year Plan" period (2005—2010), the installation of flue gas desulfurization (FGD) has become mandatory for coal-fired power plants. In 2005 only 10% of the power plants had FGD installed; by 2009, 71% had the technology. As a result, despite a large increase in energy consumption and coal use over that period, there was a slight reduction in the SO_2 emissions and a slight reduction in mercury emissions from the power plants. An example of the co-benefit of SO_2 emission abatement and mercury emissions abatement in the power plant sector is illustrated in Figure 7-5.

During the "12th Five-Year Plan" period (2010—2015), NO_x emission control is given priority and equipment to reduce NO_x (Selective Catalytic Reduction – SCR) is to be installed at coal-fired power plants. SCR installations can further reduce mercury emissions from power plants (see Table 7-1).

As mercury is removed from the flue gas by the air pollution control devices (APCDs), the mercury enters the solid waste streams from the power plant. The mercury trapped by the particle control devices ends up in the fly ash and that trapped by the FGD system ends up in the gypsum. Both the fly ash and gypsum are resources that can be used in other industrial processes, for instance in the cement industry. Proper handling of the mercury-containing solid wastes thus becomes increasingly important as these control methods take effect.

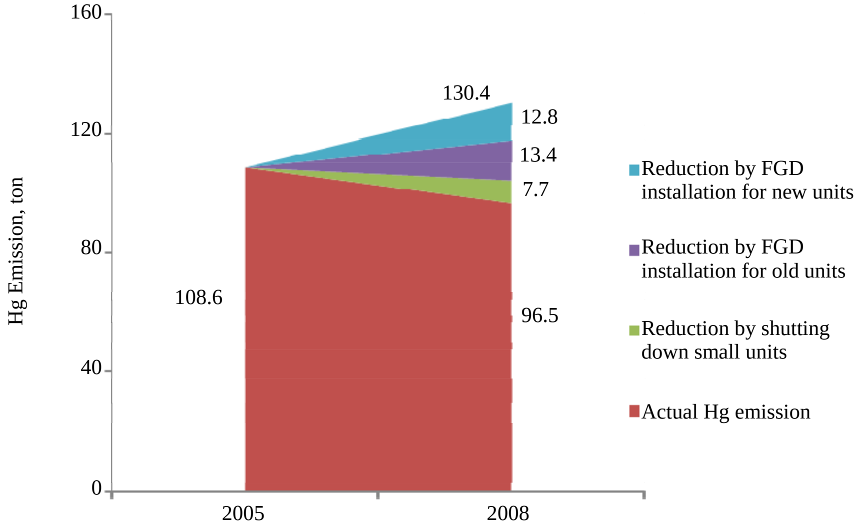

Figure 7-5 Illustration of the co-benefit of mercury removal by SO_2 control measures during 2005—2008

If no measures for SO_2 control were taken, the mercury emissions in 2008 would have been 130.4 tonnes. The four different types of control measures that have been undertaken have brought that total down to an actual emission of 96.5 tonnes[26].

The total mercury emission from power plants was estimated to be 123.3 tonnes in 2007, with Jiangsu, Inner Mongolia, Shandong, Henan and Guangdong the provinces having the highest emissions (12.4, 11.8, 10.8, 9.9, and 7.5 tonnes, respectively).

(2) Industrial boilers

There are nearly 550,000 industrial boilers in China. The total coal consumption associated with these was 960 million tonnes in 2007, accounting for 30% of the total coal consumption in China (38% if coke consumption is included).

The application of APCDs on industrial boilers is not widespread and usually involves only simple equipment for particle removal that only removes a small fraction of the mercury. Due to limited capture of mercury by APCD, mercury emissions from industrial boilers are higher than from power plants. Total emissions were about 213.5 tonnes, with Shandong, Henan, Shanxi, Hebei and Guizhou as the top five emitters (22.6, 20.1, 19.4, 16.1, and 15.7 tonnes).

26 Source: SPS Mercury Team 2011.

In summary, total mercury emission from coal combustion in China in 2007 was 368.5 tonnes. Of the total, power plants contributed 33%, industrial boilers 58%, residential use 5%, and other 4%. It bears repeating that even though power plants burn far more coal, mercury emission from power plants was lower than that from industrial boilers because modern APCDs were applied.

7.2.3.2 Non-ferrous metals smelting

The non-ferrous metal smelting industry includes zinc smelting, lead smelting, copper smelting and gold smelting (and other metals not discussed here). Current production of zinc, lead and copper is shown in Table 7-2.

Mercury is found in ores used by the sector. It is released during the smelting process, after which it can variously be: collected and used as a resource; released as a pollutant in other by-products (e.g. sulphuric acid); released into wastewater, solid waste or the atmosphere.

Table 7-2 Zinc, Lead and Copper production in China in 2010[27]

Metals	Production (10^6 tonnes)
Zinc	5.16
Lead	4.20
Copper	4.57

Non-ferrous metal smelting in China still involves a large number of small- and medium-sized plants. Many use out-dated technology and hence have large mercury releases to the environment. These mercury emissions are a great challenge; the sector is developing rapidly while pollution-prevention techniques remain out-dated. The total mercury emission from non-ferrous metal smelting in China in 2007 was 116 tonnes. Emission from zinc smelting was the highest, estimated at 50 tonnes.

(1) Zinc smelting

China has been the biggest zinc producer in the world since 2002.

The out-dated small- and medium-sized smelters usually allow a very high fraction of the mercury in the ore to be emitted to the atmosphere. More modern and larger smelters typically use the sulphur in the ore to produce sulphuric acid as a by-product. At these plants about 99% of the mercury will be absorbed in the sulphuric acid rather than being emitted to the

27 CNIA (China Nonferrous Metals Industry Association), http://www.chinania.org.cn/web/website/index_1010030397983910000.htm.

atmosphere. The most modern plants also have mercury removal and reclamation equipment, which may reduce the atmospheric mercury emissions further and reclaim mercury from the sulphuric acid. Removal of mercury from the sulphuric acid is important if the acid is to be sold for other uses, and in particular for fertilizer used to grow food crops. The mercury removal efficiency of each process of the zinc industry is shown in Table 7-3.

Table 7-3 Mercury removal efficiency (%) for different technologies

	Mercury Removal +Acid Plant	Acid Plant	Without Acid Plant	Artisanal Process
Efficiency	99.3	98.9	15.2	0

The mercury content of zinc concentrate (refined ore) is a very important parameter for emission estimation and varies greatly with the source of the ore. Especially for out-dated smelters, where mercury is not captured, the concentration of mercury in the zinc concentrate is determinative for the emissions. In modern plants that are able to capture and reclaim, this is obviously of less importance.

Table 7-4 Example of zinc production, mercury content in zinc concentrate and the mercury emission from the zinc smelting in two provinces

Province	Zinc Production (tonnes)	Mercury Content in Concentrate (ppm)	Mercury Emissions
A	230 000	500	22
B	780 000	5	1.4

For example, Province “A” had 500 ppm of mercury in their concentrate, while Province “B” had less than 5 ppm. “A” produces 230,000 tonnes of zinc while “B” produces 780,000 tonnes. Despite having more than three times higher production of zinc in “B”, the mercury emissions were much lower (1.4 tonnes in “B” vs. 22 tonnes in “A”) due to the differences in the mercury content of the raw material and the more out-dated equipment in “A”.

The total mercury emission from zinc smelting was estimated to be 50 tonnes, with 14% from large smelters, and 86% from small smelters. In contrast, the zinc production is 87% by large smelters and 13% from small ones. Enlarging the scale is necessary for applying modern technology and reducing mercury emission.

(2) Copper smelting

Mercury emissions from copper smelting were estimated to be 10.2 tonnes in 2007. Among the provinces, mercury emissions were highest in Inner Mongolia, Yunan and Hubei. High mercury content in copper concentrate and out-dated processes may be the reason for high mercury emissions in Inner Mongolia despite a relatively low copper production. In contrast, although high copper production and high mercury content in copper concentrate occur in Jiangxi province, mercury emissions are not high because of the low-emission process applied.

(3) Lead smelting

It is estimated that the mercury emission from lead smelting in China was 21.0 tonnes in 2007. The most important provinces were Henan, Hubei and Anhui.

(4) Gold smelting

In 2007, gold production was 236.5 tonnes. The mercury emission from gold smelting was estimated to be 37.2 tonnes, with 5.0 tonnes coming from large smelters and 32.2 tonnes from small smelters.

7.2.3.3 Cement production

There are about 4,000 cement producers in China currently, but this is expected to drop to between 500 and 1,000 through industry restructuring in the next five years[28]. Close to half of the world's cement is produced in China[29]. Mercury is a trace element in the raw feedstock materials, and in the fuels (mostly coal), making the cement industry a major mercury pollution source. In 2005, just over one billion tonnes of cement were produced in China[30], while 1.68 billion tonnes were produced in 2009. Cement demand will keep growing in the near future as development goals continue to be pursued.

7.2.3.4 VCM/PVC industry

PVC is a type of plastic that is used for everything from water and sewer pipes to plastic toys and clothing. Most manufacturing of PVC around the world uses natural gas or petroleum as the raw material from which the plastic is manufactured. However, most PVC manufacturing in China uses a different process (the calcium carbide process) that starts with coal as the feedstock to produce VCM (from which PVC is made). In that coal-based process, mercury is a catalyst to spark the chemical reaction among the ingredients.

In PVC production through the calcium carbide process, low-mercury catalyst has been used to some extent in several VCM plants. However the industry has indicated that the use of this catalyst requires careful attention to process conditions (temperature less than 150

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28 Quote of Lei Qianzhi, President, China Cement Association – China Daily, page 17, September 21/2011.

29 http://www.cembureau.be/sites/default/files/Activity_Report_2010.pdf.

30 Opportunities for improving energy and environmental performance of China's cement kilns. Lawrence Berkeley National Laboratory Report (LBNL-60638).

centigrade and controlled acetylene flow rates)[31]. This may be difficult for smaller and less advanced plants as significant capital investments are required.

Currently there are no mercury-free catalysts available for commercial use but there are ongoing efforts by Chinese institutions[32] to develop a mercury free catalyst for VCM production using coal. Recently a UK-Dutch consortium reported promising results from a pilot scale test of a catalyst that may be affordable[33]. If this catalyst proves to be effective and affordable under commercial operating conditions, optimistic estimates are that the technology could be available for initial commercial use as early as 2013. The mercury free catalyst is based on a noble metal, which will require care in catalyst transport and recycling.

As a result, large amounts of waste mercury catalysts, mercury-containing active coal, mercury-containing HCl, and mercury-containing alkaline agents are generated during production and, with the exception of the used catalyst, these are rarely recycled for technical and economic reasons. Each type of material poses serious environmental risks.

Handling of the used catalyst causes an additional problem, as workers are exposed to high levels of extremely reactive chemicals, including the mercury.

In 2009, the coal-based process was used at 94 of China's 104 VCM/PVC plants. The VCM/PVC industry has used between 570 and 940 tonnes of mercury annually in recent years (see Figure 7-6). It is predicted that by 2012, China's VCM/PVC industry will reach 10 million tonnes of production and exceed 1,000 tonnes of mercury consumption. China's VCM/PVC manufacturing industry is among the most significant users of mercury in the world today.

In China, three different ministries (NDRC, MIIT and MEP) carried out a series of programs to initiate reduction of the mercury consumption by this sector. They have established the following goals:

(1) By 2012: achieve 50% of the VCM industry using low-mercury catalyst, which is expected to reduce mercury use by 208 tonnes annually;

(2) By 2015: only use low-mercury catalyst (mercury use per tonne of PVC produced to

31 R&D and Application of the technology for the replacement with low-mercury in PVC Industry. Xin Jiang Tian Ye Co. Ltd. UNEP Workshop on Feasibility of China's Mercury-Free Catalyst Research and Development in the VCM Industry. Beijing September 19, 2011.

32 The study development of Chinese mercury-free catalyst. China Petroleum and Chemical Industry Federation and China Chlor Alkali Industry Association. UNEP Workshop on Feasibility of China's Mercury-Free Catalyst Research and Development in the VCM Industry. Beijing September 19, 2011.

33 Mercury Free VCM Catalyst. Presentation by Johnson-Matthey and Jacobs (copyright). UNEP Workshop on Feasibility of China's Mercury-Free Catalyst Research and Development in the VCM Industry. Beijing September 19, 2011.

drop 50%) and full recycling of the used low-mercury catalyst[34]; and

(3) By 2020: promote mercury-free catalyst and gradually become mercury-free across the VCM/PVC industry[35].

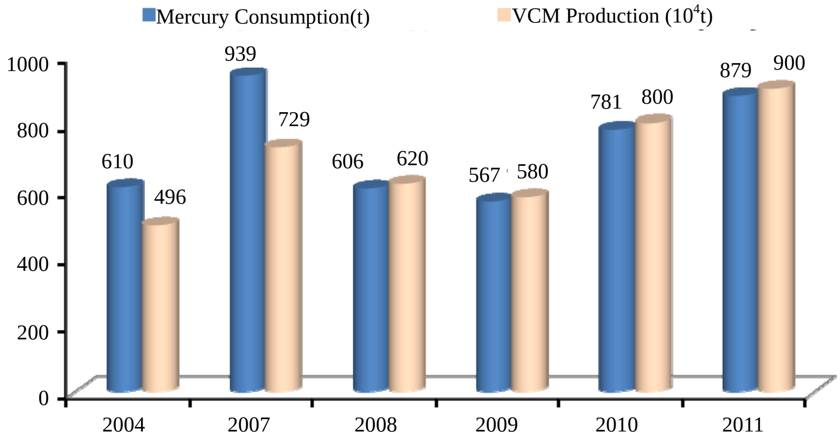

Figure 7-6 VCM production and mercury consumption in VCM industry[36]

With the VCM/PVC sector forecast to grow significantly in the near-term, experts suggest that the industry should actively seek opportunities to shift from the coal-based acetylene process to the ethylene process and to encourage facilities using the acetylene process to further invest in the transformation to lower-mercury and eventually to mercury-free methods.

7.2.3.5 Mercury-added products

In the production of mercury-added products such as medical devices, dental amalgam, fluorescent lamps, and batteries, the major problems are the management and disposal of wastes. Currently in China, most mercury-added products are sent to landfills along with

34 Cleaner production technologies program in the PVC industry, MIIT (Ministry of Industry and Information Technology of the People's Republic of China), 2010. http://www.dhp.gov.cn/upload/2011/3/2412262376.pdf.

Mercury prevention and control in respect to industries related to PVC produced by calcium carbide method program, MIIT (Ministry of Industry and Information Technology of the People's Republic of China), 2010. http://baike.baidu.com/view/3717369.html.

35 Mercury prevention and control planning in the VCM industry. CPCIF (China Petroleum and Chemical Industry Federation), CCAIA (China Chlor-Alkali Industry Association). http://wenku.baidu.com/view/ 4188021ba8114431b90 dd883. html.

36 Data compiled from these sources, LIU Dong-sheng, Fan Hong-bo. Strengthen mercury contamination prevention and treatments promote calcium carbide process PVC industry health sustainable development. China Chlor-Alkali. 2011, 4: 1-3.

JIAN Xiao-dong, SHENYing-wa, YAOWei, et al. Status Analysis and Reduction Countermeasures of China's Mercury Supply and Demand. Research of Environmental Sciences, 2009, 22 (7): 788-792.

municipal solid waste. The absence of an effective recycling system and proper hazardous waste handling process therefore poses a risk of mercury pollution to the environment.

(1) Medical products

China's current suite of mercury-added medical products include thermometers and blood pressure monitors. Annual thermometer production was 107 million units with about 50% being exported; blood pressure monitors production was 2.6 million units with about 20% being exported.

Table 7-5 Mercury consumption for medical devices (tonnes)

Industry	Product	1995[37]	2000[38]	2004[39]	2007[40]	2008[41]
Medical Devices	Thermometer	40.4	100	179	210～233	109
	Blood Pressure Monitor	15.7	50～60	95	86～98	118
Dental Material	Amalgam	6	5～6	6	5～6	Not Known
Total		62.1	155～166	280	301～337	227

(2) Compact fluorescent lamps

Mercury-containing bulbs remain the standard for energy-efficient compact fluorescent lamps (CFL). Ongoing industry efforts to reduce the amount of mercury in each lamp are countered, to some extent, by the ever-increasing number of energy-efficient lamps purchased and installed around the world. There is no doubt that mercury-free alternatives such as light-emitting diodes (LEDs) will increasingly become available, and technological developments have led to marketing of comparable mercury-free alternatives to the CFLs. Nevertheless, at present, for most lighting applications, the alternatives are very limited and/or quite expensive.

China is the world's largest producer of compact fluorescent lamps, with approximately 500—600 fluorescent lamp-producing enterprises. From 2000 to 2010, the industry's output increased from about 1 billion to about 6.7 billion lamps (see Figure 7-7), accounting for 80% of global production[42]. Of those 6.7 billion units, 55% were exported. The latest available information indicates that the sector used 78.2 tonnes of mercury in the production

37 SEPA (Now MEP). The Study of environmental protection register and important environmental management in the 21st Century (M). Beijing: China Environmental Science Press, 2001, 229.

38 The investigated results of five key mercury related industries.

39 JIAN Xiao-dong, SHEN Ying-wa, YAO Wei, et al. Status analysis and reduction countermeasures of China s mercury supply and demand (J). Research of Environmental Sciences, 2009, 22(7): 788-792.

40 Ibid.

41 China Association for Medical Devices Industry (CAMDI). http://www.camdi.org/.

42 Source: SPS Mercury Team 2011.

of 4.8 billion lamps in 2008[43].

CFLs in China are produced using three processes:

1) Small-scale processing uses manual pipetting to deposit the mercury. The pipetting drops can range from 20 – 60 mg per lamp.

2) State of the art factories with automatic dosing of the mercury. The range of mercury dosing is 10 – 20 mg per lamp.

3) Best available technology where the dosing technology is via mercury-amalgam glass capsules plus special glass preparation. The range of mercury dosing is 3.5—5 mg per lamp.

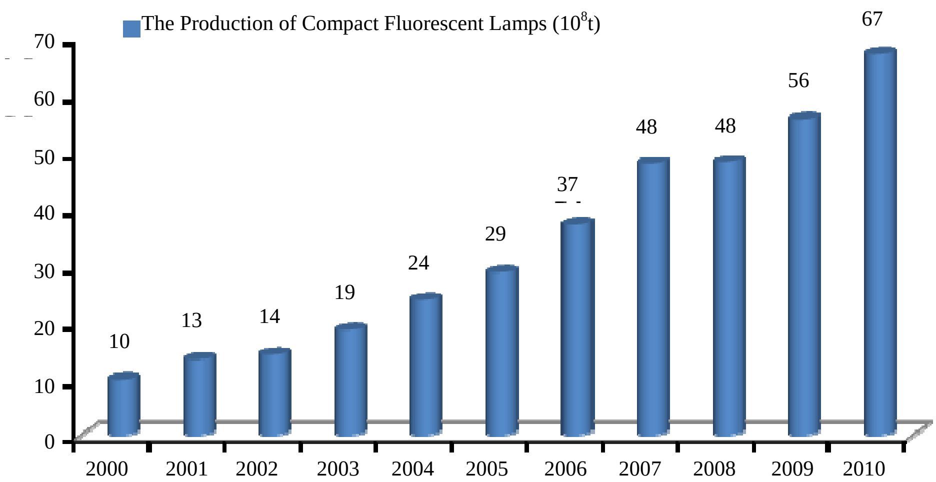

Figure 7-7 Compact fluorescent lamp production in China

In recent times the government has been working with the industry association to have producers work towards limiting the mercury content of CFLs to 5 mg, but MEP officials advised that that this goal may not be reached until about 2013. With such a reduction the mercury consumption of the industry would decrease by about 35 tonnes. Additionally, China produces a large number of regular fluorescent lamps for use in residential, commercial, and industrial settings. For these, MEP officials advised that the government, in collaboration with industry, has established an anticipated limit of 10 mg per bulb. Unfortunately the production levels and mercury consumption of this sub-sector are not well understood at the moment. Anecdotal information points to an annual production of about 2.9 billion of these regular fluorescent lamps in 2010.

43 Mercury related industries inventory report, 2008, MEP/CRC.

(3) Batteries

The use of mercury in batteries, while still considerable, continues to decline as many nations have implemented policies to deal with the problems related to mercury pollution from batteries.

While mercury use in Chinese batteries was confirmed to have been high before 2000, most Chinese manufacturers have reportedly now shifted to lower-mercury technologies, following both domestic and international legislative trends and customer demands. However, there are still vast quantities (tens of billions) of batteries with relatively low mercury content produced in China, and lesser quantities in other countries as well. From statistics, the current mercury consumption is reported by CRC/MEP to be 200 tonnes per year (2008)[44] however it is reported by MIIT to be 140 tonnes (2009)[45]. Over this same period, annual battery production was 39 billion units with 56% being exported[46].

The MIIT Heavy Metal Pollution Comprehensive Prevention Plan[47] released for consultation in November 2010 sought agreement with the battery industry to phase out production by 2013 of alkali manganese button batteries having more than 5ppm mercury[48]. The plan also calls for the Chinese battery industry to reduce its use of mercury by 80% by 2015.

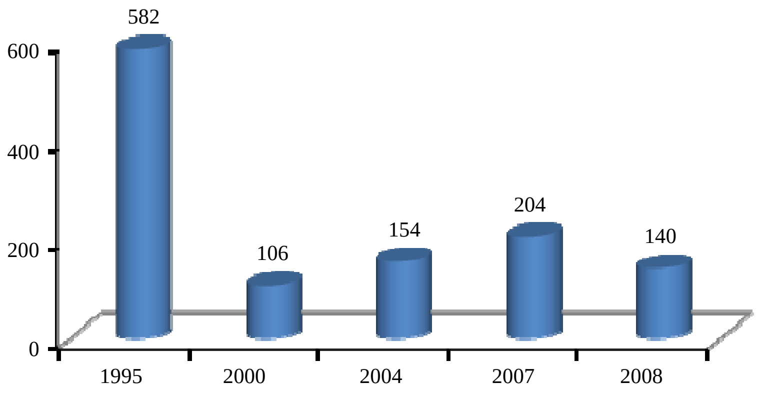

Figure 7-8 Mercury consumption of the battery industry in china in tonnes[49]

44 CRC/MEP, 2010. JIAN Xiao-dong, SHEN Ying-wa, CAO Guoqing. Investigation of mercury usage in the battery production and recommended reduced countermeasures (J). Environmental Science and Management, 2008, 33(10): 10-16.

45 http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/13505234.html(Chinese only accessed Sept 21, 2011).

46 CRC/MEP. Mercury related Industries Inventory Report, 2008.

47 http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/13505234.html(Chinese only accessed Sept 21, 2011).

48 5 ppm is considered the natural background of mercury therefore when 5 ppm is mentioned as a target it means “no added mercury”.

49 Source: SPS Mercury Team 2011.

7.2.3.6 Mercury mining industry

China is one of only two countries in the world that still produces primary mercury (i.e., from mining). Most of China's mercury production is probably used domestically, though data on the domestic trade, imports, and exports of mercury are not available. The mercury used in industry in China is supplied by several sources: mining, imports, and recycling. In fact, China continues to import several hundred tonnes of mercury each year to meet domestic demand. Although mercury mining decreased temporarily about a decade ago, domestic mercury production has since increased steadily each year to meet the domestic demand.

In China there is currently only one active, large scale — and legal — mercury-mining operation, located at Xunyang, Shaanxi Province. This mine is reportedly close to being fully depleted, and is expected to produce for only a few more years. The possible depletion of domestic resources is of potential concern for China's mercury-using industry, though less mining may increase recycling efforts and may promote efforts to find alternatives. On the other hand, it may also put pressure on the authorities to relax import restrictions, and also encourage illegal imports.

Either way, a legacy of closed mines is a major problem for China; there are dangers for local populations not just from mercury pollution but also from mine tailing pond collapses, several of which have occurred in China recently[50].

7.2.4 Mercury pollution prevention and control in China

7.2.4.1 Regulatory system for mercury pollution prevention and control

In recent years China has strengthened its efforts to prevent and control pollution by mercury and other heavy metals through a number of laws, guidance documents and other domestic measures including a mercury pollution monitoring system. However, concerns have been identified about their scope, stringency, implementation and enforcement. The MEP develops and updates technical policies, BAT guidelines and standards related to the prevention and control of heavy metal pollution. There are about 20 mercury-related environmental standards, including a number of mandatory pollution control standards. Approximately 20 industrial standards address mercury production, consumption and disposal for activities such as the manufacture of batteries and lamps.

50 http://www.wise-uranium.org/mdaf.html.
http://www.chinadaily.com.cn/bizchina/2011-02/18/content_12040016.html.

In February 2011 the State Council approved The Heavy Metal Pollution Prevention and Control Plan (2011—2015) which focuses on mercury, lead, cadmium, arsenic and chromium. The Plan stipulates that "by the end of 2015, a few prominent problems that endanger public health and the ecological environment should be settled; a complete heavy metal pollution prevention and control system, emergency handling system and environmental and health risks assessment system should be established to solve prominent problems that impair public health; the heavy metal-related industrial structure should be further optimized and the frequent occurrence of contingent heavy metal pollution should be suppressed." MEP has provided Guidelines for the Formulation of Local Plan of Heavy Metal Pollution Prevention and Control to local governments[51]. As one of the most important heavy metals, mercury is included therein.

Although policies, regulations and standards to control mercury pollution have been established in China, compared with developed countries China's mercury management is still in the initial stages of development. It will be essential to establish efficient and effective mercury pollution prevention and control systems drawing upon lessons and experience from developed countries.

7.2.4.2 Responsible authorities for mercury pollution prevention and control

(1) National level

The Environmental and Resources Protection Committee (ERPC) of the NPC is responsible for developing, reviewing and enacting environmental laws.

Under the State Council, the MEP, the highest administrative body for environmental protection, is responsible for developing environmental policies and programmes. MEP deals with policy and regulatory matters from standards setting to enforcement, environmental impact assessments, and international conventions. As a cabinet-level ministry, MEP has the authority to co-ordinate other cabinet-level ministries to address environmental problems. Other ministries and agencies involved in environmental management are the State Development and Reform Commission, the Ministry of Health, the Ministry of Industry and Information Technology, the State Oceanic Administration, and the State Food and Drug Administration. An environmental protection management system spanning the relevant departments is gradually being established, but needs further development. Approaches to engage the broader society in mercury management still need to be developed.

51 http://hbj.huaian.gov.cn/filedown? (Accessed Sept. 8, 2011).

(2) Local levels

The MEP supervises Environmental Protection Bureaus (EPBs) at the provincial, refectoral and county levels. As part of the provincial Governors' Offices, EPBs implement national and provincial environmental protection laws, regulations and standards and monitor pollution. Since the MEP became a cabinet-level Ministry in 2008, Directors of the EPBs will all eventually report directly to the MEP rather than the Governors' Offices. This change is being phased in with some Directors still operating under a co-management arrangement.

Various other sub-national administrative units also play important roles in environmental protection: Mayors' Offices; Planning Commissions; Industrial Bureaus; Finance Bureaus, and Urban Construction Bureaus. As at the national level, local levels are establishing coordination mechanisms under which EPBs take the leading role and are supported by other departments.

(3) Industrial associations

There are several industrial associations that can help to improve mercury management in China, for example: China National Coal Association, China Non-Ferrous Metals Industrial Association, China Battery Industrial Association, China Association of Light Industry, China Petroleum and Chemistry Federation, China Medical Devices Association, and so on. A more efficient and effective process is needed to engage all of the relevant industries.

7.3 International Experiences on Mercury Pollution Management

Developed countries have demonstrated that significant reductions can be made in mercury emissions from human activities without damaging their economies. They have used a wide range of strategies and approaches adapted to the particular circumstances of different industries that release or consume mercury.

7.3.1 Management strategies with clear emission reduction objectives

The United States, for example, developed emission reduction objectives for different industries (see Box 7-1). With implementation of its most recent rule, the power plant industry will achieve a mercury emission reduction of 78% between the baseline year of 2005 and the target year of 2015[52,53].

52 http://epa.gov/mercury/pdfs/FINAL-Mercury-Roadmap-6-29.pdf. (Accessed Sept.7, 2011).

53 http://www.federalregister.gov/articles/2011/05/03/2011-7237/national-emission-standards-for-hazardous-air-pollutants-from- coal--and-oil-fired-electric-utility. (Accessed Sept. 7, 2011).

Box 7-1 US management of mercury polluting industries

The United States has introduced a series of control measures to address mercury emissions. Mercury is managed primarily under the Clean Air Act, which regulates hazardous air pollutants through a series of regulations and standards, including National Emission Standards for Hazardous Air Pollutants (NESHAP) Rules.

Between 1990 and 2005, the US promoted mercury emission reductions through the control of large mercury emission sources, such as domestic garbage, hazardous waste, medical waste and chlor-alkali production.

For the subsequent 10 years, the US will focus on smaller sources and industrial uses that collectively contributed over 20% of the nation's mercury air releases in 1999. Through such efforts, mercury emissions in the US decreased from 220 tons in 1990 to 113 tons in 1999 – a 45% reduction.

The recently proposed Power Plant Air Toxics (NESHAP) Rule listed in the Federal Register in May 2011 expects mercury emissions to be further reduced from the 2005 baseline of 53 tons to about 11 tons by 2015 – a 78% reduction.

From 1970 to 2010 Canada reduced its mercury emissions by 90% using a mixture of mandatory and other instruments[54]: ① plant closures, ② regulations, ③ national emission standards adopted by the federal government and all Provinces and Territories (Canada-Wide Standards), ④ guidelines, ⑤ a voluntary "Accelerated Reduction/Elimination of Toxics Program"[55], ⑥ environmental codes of practice, ⑦ mandatory pollution prevention plans, and ⑧ the creation of the National Pollution Release Inventory[56].

From a co-benefit perspective, the Government of Canada is currently moving forward with the development of regulations to reduce greenhouse gas (GHG) emissions from coal-fired electricity generation in Canada, to take effect July 1st, 2015[57]. These regulations are expected to reduce mercury emissions from the electrical power generation sector by about 40% by 2020 and 65% by 2030 compared with 2005 levels, and could reduce mercury emissions by up to 96% by 2050.

Norway's efforts to minimize harm caused by hazardous substances include mercury. The national target is for releases and use of mercury and other substances that pose a serious threat to health or the environment to be continuously reduced with a view to

54 Risk management strategy for mercury. Environment Canada and Health Canada. October 2010.http://www.ec.gc.ca/doc/mercure-mercury/1241/index_e.htm (Accessed August 30, 2011).

55 http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=A2A7F1B4-599A-47C3-BF0E-F075B8211D91 (Accessed Sept. 7, 2011).

56 http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1. (Accessed Sept. 7, 2011).

57 Risk management strategy for mercury. Environment Canada and Health Canada. October 2010 http://www.ec.gc.ca/doc/mercure-mercury/1241/index_e.htm (Accessed August 30, 2011).

eliminating them completely by 2020.

In 2008, Norway introduced a general ban on the use of mercury in new products, with only a few time-limited exceptions. The ban applies to the production, import, export and placing on the market of products containing mercury. The decision to introduce the ban was based on an overall evaluation of risks to people and the environment, and assessments of the availability of alternative products that do not contain mercury. The ban also applies to any new areas of use for mercury that may arise in the future. Norway was the first country to ban the use of mercury dental amalgam fillings. A summary of Norway's efforts in reducing and eliminating mercury pollution is available in English[58] and Chinese[59].

In 2005, the European Union launched a mercury strategy[60] containing 20 measures to reduce mercury emissions, cut supply and demand and protect against exposure, especially to methyl mercury found in fish. This strategy sits atop many specific EU regulations and directives established since 1990 to reduce the use and emissions of mercury to air and water. The strategy has resulted in restrictions on the sale of measuring devices containing mercury and a ban that came into force in 2011, on exports of mercury from the EU. New rules on safe storage will follow shortly. The EU's mercury strategy is a comprehensive plan addressing mercury pollution both in the EU and globally.

The EU reduced its mercury emissions by 67% between 1990 and 2009[61]. In 2009 the EU-27[62] had total mercury air emissions of 73 tonnes. The member states that contributed the most to these emissions were Poland, Spain, Italy, and the UK respectively, representing a total of 38 tonnes.

7.3.2 Collaborative horizontal and vertical management

Due to the complexity and diversity of mercury pollution sources and impacts, prevention and control actions require collaboration amongst many institutions and interested parties. Multiple government agencies need to be engaged through several levels of jurisdiction, and several industry sectors have key roles to play in preventing and controlling mercury pollution. Citizens need to be engaged at the level of the general public but also as communities that may be at risk due to their location, occupation or susceptibility.

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58 http://www.klif.no/no/Publikasjoner/Publikasjoner/2010/Juni/Reducing-and-eliminating-mercury-pollution-in-Norway-The-mercury-problem.

59 http://www.klif.no/no/Publikasjoner/Publikasjoner/2011/Februar/Reducing-and-eliminating-mercury-pollution-in-Norway-pa-kinesisk.

60 EU community strategy concerning mercury. 28.01.2005. COM (2005) 20 Final. SEC (2005) 101. (Reviewed: Sept. 20/2011).

61 EU emission inventory report 1990—2009. EEA Technical Report No. 9/2011. (Reviewed: Sept. 20/2011).

62 Twenty-seven member countries.

Effective inter-agency collaboration requires the clear definition of roles and responsibilities and the coordinated planning of operations and management. In most countries a lead Department assumes overall responsibility for environmental protection, while other departments contribute in accordance with their particular mandates (see Box 7-2[63]).

Box 7-2 Division of responsibilities among us federal departments

The US Environmental Protection Agency develops standards related to air, water and soil pollution and controls mercury emissions from pollution to reduce the environmental risks caused by mercury; the US Food and Drug Administration is mainly responsible for the management of mercury in cosmetics, food and dental products; the Occupational Safety and Health Administration is mainly responsible for the management of mercury exposure in the workplace.

In large countries and federations such as China, particular attention is required to ensure coherence and coordination of efforts by the central and regional levels of governments. Consistent application and enforcement of national standards is often a challenge in such cases. In the case of Canada, both the federal and Provincial/Territorial governments have jurisdiction over environmental protection and thus there are both federal and provincial or territorial organizations that develop policies and provide inspection and enforcement services in their respective jurisdictions. Coordination of efforts is done both at operational levels and policy levels through the joint development of Canada-Wide Standards. Several Canada-Wide Standards played a role in the reduction of Canada's mercury emissions[64].

7.3.3 Effective legislation and innovative regulatory approaches

In managing mercury pollution, developed countries generally use broad empowering legislation for environmental protection under which regulations are developed to control mercury emissions and releases and to limit mercury uses and exposure to mercury.

These countries use a standard regulatory life cycle of the kind depicted in Figure 7-9. The early stages of the cycle include issue identification and analyses that draw upon

63 Note: All three accessed on Sept 7/2011. http://www.fda.gov/food/foodsafety/product-specificinformation/seafood/foodbornepathogenscontaminants/ methylmercury/ucm115644.html.
http://www.epa.gov/hg/.
http://www.osha.gov/SLTC/mercury/index.html.

64 Risk management strategy for mercury. Environment Canada and Health Canada. October 2010 http://www.ec.gc.ca/doc/mercure-mercury/1241/index_e.htm. (Accessed August 30, 2011).

environmental risk assessments, cost-benefit analyses, and other techniques for regulatory impact assessments to support decision making that balances social, environmental and economic values.

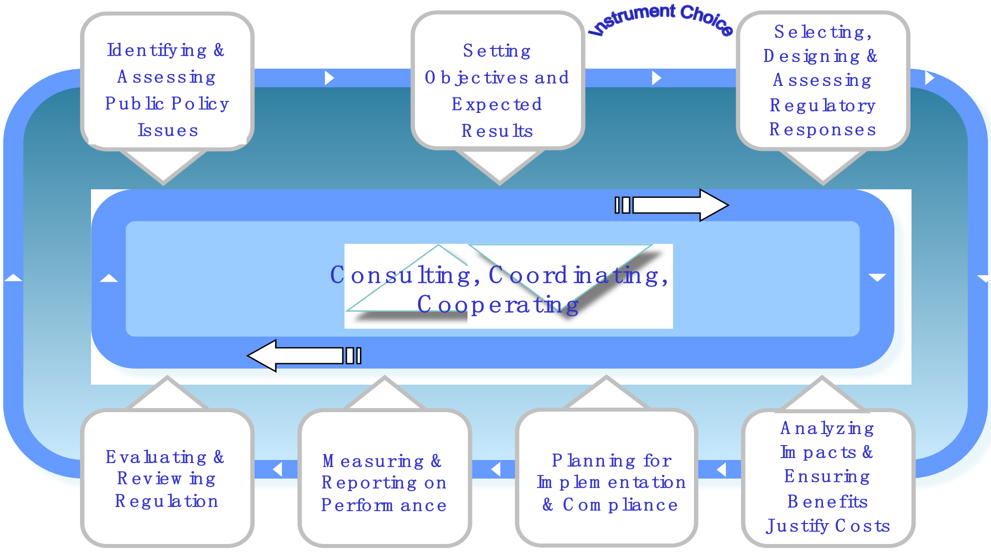

Figure 7-9 Lifecycle approach to laws and regulations[65]

Box 7-3 describes important work by US-EPA on the early stages of this cycle[66].

Box 7-3 Mercury study report to congress: overview 1997
A Mercury Study Report to Congress was prepared by the US-EPA. The Report provided a mix of strategies for the effective control of mercury emissions. The four major types of control techniques reviewed included: Pollution prevention measures, including product substitution, process modification and materials separation; Coal cleaning; Alternative approaches; and Flue gas treatment technologies. Additionally, the EPA provided the associated costs, the regulatory issues, and the financial impacts for a number of potentially affected industries if the proposal was to be successful.

Instruments ranging from mandatory to "voluntary", including market forces and information, may be used to change the behaviour of industries and consumers (see Figure 7-10). Choosing amongst the many possible approaches requires collaboration amongst technical experts (who are familiar with the risks and measures that might be taken) and economists or policy experts who can assist with the assessment of the social and economic

65 Figure 7-9 courtesy of Treasury Board of Canada Secretariat.
66 http://www.epa.gov/hg/report.htm (Accessed Sept. 7, 2011).

implications of possible actions[67].

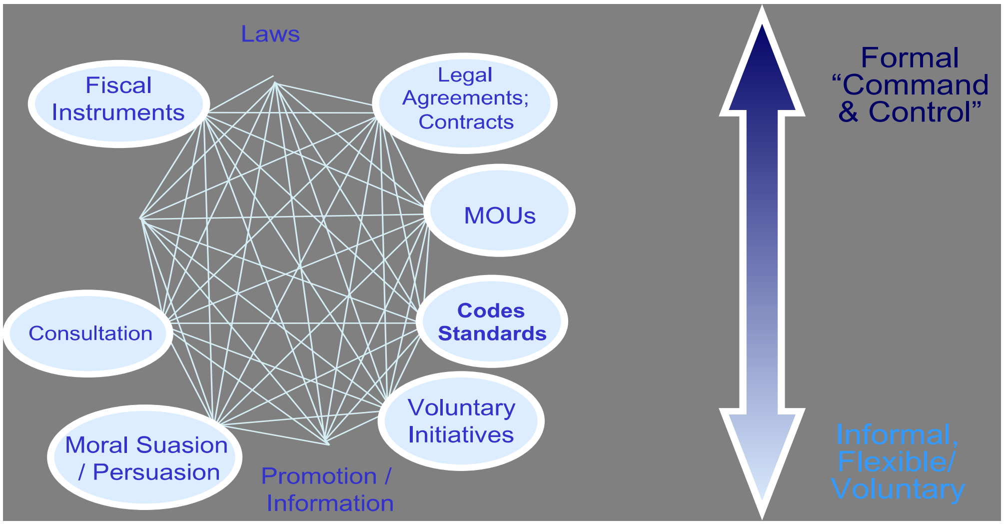

Figure 7-10 Innovative approaches to regulation using different instruments[68]

With an expanded arsenal of tools many innovative approaches can be taken. Consider for example the use of mandatory, publicly accessible, facility-based inventories of pollutant releases[69, 70]. These have a powerful regulatory effect[71] in the context of an open economy where public disclosure becomes an important environmental management tool. Rigorous mandatory reporting of mercury releases would provide China with credible data to support its national management decisions (e.g. to determine how much reduction is needed, or whether measures taken are having an impact) and for international negotiations. A system established initially for mercury could be extended eventually to include other heavy metals and other priority pollutants.

In terms of economic instruments, a cap-and-trade (CAP) system was proposed to

67 Environment Canada uses an internal guidance document (Instrument Choice Framework for Risk Management under the Canadian Environmental Protection Act (1999) – March 2009) based on a document published by the Treasury Board of Canada Secretariat on "Assessing, Selecting and Implementing Instruments for Government Action (http://www.tbs-sct.gc.ca/ri-qr/documents/gl-ld/asses-eval/asses-eval00-eng.asp). Accessed: Sept.14/2011.

68 Figure 7-10 courtesy of Treasury Board of Canada Secretariat.

69 Pollutant release and transfer registers as a reporting mechanism for mercury release and transfers. UNEP (DTIE)/HG/INC.2/INF/6 12 January, 2011 accessed November 19, 2011 at: http://www.unep.org/ hazardoussubstances/ Portals/9/Mercury/Documents/INC2/INC2_INF6_PRTR.pdf.

70 http://acts.oecd.org/Instruments/ShowInstrumentView.aspx?InstrumentID=44&InstrumentPID=41&Lang=en&Book=False. (Accessed Sept 7/2011).

71 Archon Fung and Dara O'Rourke. Reinventing environmental regulation from the grassroots up: explaining and expanding the success of the toxics release inventory. Environmental Management Vol. 25, No. 2, pp. 115–127.

reduce mercury emissions from coal-fired power plants in the USA[72]. Under this system, those manufacturers who could not meet the new requirements would have had the opportunity to purchase emission rights for their excess emissions from the manufacturers who had met and surpassed the emission standards by improving and upgrading their equipment.

While this initiative was not successful for legal reasons[73], a cap-and-trade regime may nevertheless be a viable approach for mercury and the US-EPA did considerable work to design such a system. However it is a controversial approach that can be opposed by opponents as “trading in toxics”. If caps are sufficiently stringent they could lower emissions overall, but would do so at variable levels in different locations (less reductions from plants that would buy credits from those making the most reductions) – and it would of course be hard to explain to residents in the less-favoured locations why it is acceptable for their exposure to be higher than in other locations.

Industry-led mercury management initiatives driven by societal and market pressures can also be effective. During a mission to Canada in July 2011, SPS Team Members heard from leaders of the Canadian chemical, mining and forestry industry associations. The global chemical industry’s “Responsible Care Program” was launched in 1985 as a response to the Bhopal, India crisis and other events that had eroded public confidence in the industry to the point of threatening their “social license” to operate. Under Responsible Care each facility operated by member companies is required to develop environmental and safety programs that are shared with local communities and subject to third party reviews[74].

Following reports of significant environmental damage inside and outside of Canada, the Canadian Mining Association created a similar program to protect their “social license” to operate. Member companies establish targets above and beyond regulatory requirements, recognizing that the public wants to see transparent management and that local communities near mines and processing plants want to be informed and involved.

Members of the Canadian Forestry Products Association, not wanting to wait to be regulated by Governments or attacked in the marketplace where their brand can be seriously damaged, chose to get ahead of these threats by making the changes themselves. A leading example of this is the recently signed Canadian Boreal Forest Agreement under which the industry has committed to adopting good stewardship standards and to protecting a

72 http://www.epa.gov/air/mercuryrule/ (Accessed Sept. 7/2011).

73 http://www.cadc.uscourts.gov/internet/opinions.nsf/68822E72677ACBCD8525744000470736/$file/05-1097a.pdf Accessed Sept. 7/2011.

74 http://www.ccpa.ca/ResponsibleCareHome.aspx. http://www.icca-chem.org/en/Home/Responsible-care.

significant proportion of the forest from logging. In return environmental organizations agreed to cease media and market campaigns that were hurting the industry in the marketplace[75].

Evolving trade rules are also a major instrument to drive industries and governments to strengthen their management of environmental issues such as mercury pollution. There are newly emerging restrictions on the trade in mercury and mercury-containing products[76]. At the level of the WTO a dialogue continues to develop at the trade and environment committee on proposals to establish “border tax adjustments — to address competitiveness and leakage issues that may develop” as some countries, for example, fail to take sufficiently stringent measures to deal with green house gas emissions[77]. It is reasonable to think that mercury pollution could be the subject of similar discussions in the future given calls for global action, including, most recently, by the Arctic Council in its report on Arctic Pollution 2011[78].

As new regulations move their way through the development and approval stages it is often the case that a Regulatory Impact Analysis Statement (RIAS) be prepared so as to clearly outline the anticipated business and consumer impacts and the domestic and international governance impacts of the proposed regulation. An important part of the RIAS process is the cost-benefit analysis (CBA) statement wherein the social, economic, and environmental costs of the proposed regulation are discussed. In the case of pollution prevention regulations, the CBA will, in most cases, outline the environmental release reductions expected. In Canada[79], the USA[80], and the EU these RIAS and CBA procedures are open to public scrutiny. It is essential that evidence on implementation, impacts, and compliance be gathered to support these analyses. In the case of pollution regulations, the EC National Pollution Release Inventory[81] is built to provide essential information on impacts.

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75 For more information see: http://canadianborealforestagreement.com. http://www.canadiangeographic.ca/boreal. (Accessed August 15, 2011).

76 Mr. Kees den Herder, an SPS Member from the Netherlands, presented the SPS Team with a large number of WTO restriction notices (for example) by the EU, Korea, and China alerting that those nations/regions were imposing border tariffs and/or import bans on certain mercury-added devices. Sept.4/2011.

77 Climate change takes centre stage at WTO Environment Committee. Bridges Trade BioRes. Volume 11 Number 13, 11 July 2011. International Centre for Trade and Sustainable Development. http://ictsd.org/downloads/biores/biores11-14.pdf (Accessed August 30, 2011).

78 AMAP, 2011. Arctic Pollution 2011. Arctic Monitoring and Assessment Program (AMAP), Oslo. Vi + 38pp ISBN-13 978-82-7971-066-0 (full report available from http://www.amap.no/) (Accessed: August 30, 2011).

79 http://www.gazette.gc.ca/rp-pr/p1/2011/2011-02-26/html/reg4-eng.html (Accessed: Sept. 7/2011).

80 http://www.epa.gov/ttn/ecas/regdata/RIAs/ToxicsRuleRIA.pdf (Accessed: Sept. 7/2011).

81 http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1 (Accessed: Sept. 7/2011).

7.3.4 Upgrading of industrial structures and making a shift to a green economy

There are many sectors that use or produce mercury, and thus the matter is complicated. Japan, the US, Canada, Norway and the EU have adopted practical and feasible measures to stop or restrict mercury use in many sectors. Their experience is that these changes require adjustments to the industrial structure, often with significant capital investments for technological upgrading. Supporting policy measures that favour such investments, for example tax relief to encourage capital investments for cleaner production can facilitate these.

7.4 Strategy and Action Plan for Mercury Management in China

China announced a program to address heavy metal pollution in its "12th Five-Year Plan" and is actively involved in multilateral negotiations on a proposed international mercury convention.

Both initiatives will require the improved management of mercury through a well-coordinated national strategy and action plan. This chapter describes what the strategy and action plan should include and examines the required supporting elements.

7.4.1 Nation-wide mercury management strategy and action plan for China

The goal of this management strategy and action plan would be to protect human health and the environment from the dangers of mercury pollution and to reduce China's contribution to global mercury releases. Key features of this strategy and action plan would include:

(1) *Short and long-term goals to reduce mercury releases* consistent with the current "12th Five-Year Plan" for heavy metals for the period 2011—2015 and beyond;

(2) Strengthened measures to *protect the health of the Chinese population and the environment* from exposure to mercury;

(3) A compulsory *National Pollution Release and Transfer Inventory* information platform to support decision making;

(4) *Improved environmental performance in key mercury-dependent industry sectors and communities* consistent with national strategies for clean production and greening of the economy;

(5) *Strengthened regulatory policies and instruments* for the management of mercury;

(6) A *comprehensive management system* based on a continuous improvement approach with effective and consistent implementation throughout China;

(7) *Market-based mechanisms* gradually introduced as a supplement to enforceable command and control measures;

(8) Targeted *science and technology improvements* to provide the evidence base to support decision making for mercury risk management and control; and

(9) *Increased enforcement capacity* for the consistent national implementation of the action plan.

The following sections set out approaches and actions required to support such a robust Strategy and Action Plan.

7.4.2 A sound mercury information base to identify and manage risks

The National Action Plan will need more timely and reliable information on the production, distribution, use, release, recycling, disposal and the resulting flows of mercury in China. Generating such information will require compulsory monitoring and reporting of mercury releases from key pollution sources. The ability to display this data by sectors, key regions, air sheds and water basins will allow managers and scientists to document the distribution and flows of mercury. It will further allow them to establish industrial emission factors that are appropriate for use by regulators in China and to identify, assess and reduce risks to the health of the Chinese population.

Environmental risk and early warning systems need to be established along with industry-specific risk profiles.

Finally, adequate data are needed to support assessments of the social and economic impacts of mercury reduction measures.

To improve the evidence base for the cradle-to-grave management of mercury and the related risks in China, and to support China in its international mercury activities, key features of an information collection and analysis base need to include:

(1) A transparent, compulsory, nationally coordinated, facility-based, and regularly updated mercury release and transfer reporting system – designed to adopt the best practices from UNEP's inventory of tools and the pollutant release and transfer registry systems described by UNEP[82] and currently recommended by the OECD for implementation by its member states[83];

(2) An inventory of mercury movements into air, water, land, and waste streams to

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82 Pollutant release and transfer registers as a reporting mechanism for mercury release and transfers. UNEP (DTIE)/HG/INC.2/INF/6 12 January, 2011 accessed November 19, 2011 at: http://www.unep.org/ hazardoussubstances/ Portals/9/Mercury/Documents/INC2/INC2_INF6_PRTR.pdf.

83 http://acts.oecd.org/Instruments/ShowInstrumentView.aspx?InstrumentID=44&InstrumentPID=41&Lang=en&Book=False.

support the identification of human health and environmental risks to determine the priorities for control interventions; and

(3) An environmental risk information and early warning system to prevent environmental risks and to promote early identification and response to emergencies.

Note: The infrastructure and procedures used in a system of this kind for mercury could also be used to address other heavy metals, persistent organic pollutants and other pollutants of national concern.

7.4.3 Information and actions to reduce risks to public health

There is a high degree of uncertainty in the estimates of China's mercury emissions and releases and consequently the distribution and fate of large amounts of the mercury released in China, is not clear. Therefore, studies on the speciation, molecular transformation and transport of mercury are needed along with a strengthening of monitoring and evaluation to support the assessments of risk to human health. This work would provide the key information needed for scientific evidence-based assessments of potential risks.

To reduce the impacts of both new and historic mercury pollution on human health it will be necessary to establish appropriate public advisories, and occupational health measures. Steps to address these needs should include:

(1) Strengthening monitoring for mercury in the environment, in foods, and in humans;

(2) Re-evaluating consumption standard limits for rice (and other crops), fish, cosmetics, etc. to provide guidance for cases where the levels are elevated;

(3) Developing appropriate communications messages particularly for populations in contaminated areas and in areas where food products are found to have elevated mercury, and for other vulnerable populations (e.g. pregnant women and young children); and

(4) Strengthening occupational health and safety monitoring and protection programs for persons in high-risk occupations (e.g. mining, smelting, PVC production, etc.).

7.4.4 Strengthened risk-based management of contaminated sites

Contaminated soils expose local populations to variable levels of mercury for extended periods through the consumption of mercury-contaminated crops. This differs from the situation in many countries where fish consumption is the major pathway for human exposure to mercury. In China, the foods most often contaminated by mercury are crops, such as rice, wheat and corn. Recent research found that methyl mercury could be highly accumulated in rice, thus posing a health risk to consumers[84].

A risk-based approach should be adopted for the management of contaminated sites[85]. Key actions required to do this are:

(1) Establishing a transparent National Public Registry of mercury-related contaminated sites to support the identification, assessment and categorization of such sites so that priorities can be set and decisions made concerning their remediation and future use;

(2) Establishing a government-wide legislative structure to clearly outline the division of responsibility and to determine the adequacy of laws for the management of both current and legacy sites contaminated by mercury, including financial mechanisms to support the decommissioning and remediation of priority sites;

(3) Remediating sites giving priority to those posing the greatest risks to human health and the environment;

(4) Supporting the creation/emergence of a domestic industrial sector capable of providing the various remediation requirements including supporting demonstration projects; and

(5) Establishing a long term monitoring system at mercury-contaminated sites to protect (local) public health and the environment.

7.4.5 Promote green transformations of industries and communities

China's technical capacity needs to be strengthened with further acquisition, development and application of cost-effective mercury pollution control techniques and alternatives to the use of mercury.

China's commitment to reduce GHGs by 40% per unit of GDP[86] will require industry sectors to adopt cleaner production methods. These will assist in reducing mercury use and releases. Such improved environmental performance will protect the health of the Chinese workforce and local communities, aid in securing community acceptance, and protect global competitiveness.

Additional strategies will be needed to provide support for the economic diversification of communities faced with the closure of small plants, and faced with the end of practices such as small-scale mining and smelting and dangerous waste management practices.

Key features of these transformations would be:

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84 Hua Zhang, Xinbin Feng, Thorjorn Larssen et al. In Inland China, rice, rather than fish is the major pathway for methyl mercury exposure. Environmental Health Perspectives 118:1183 – 1188.

85 Informed by the CCICED special policy study on soil environmental protection in China, 2010. http://www.sfu.ca/international-development/cciced/pdf/2010_ReportofSoil.pdf.

86 State Council announcement of 2020 commitments for reduced CO_2. 26th November 2009. http:// finance. people.com.cn/GB/10461522.html [Chinese only].

(1) Promoting structural adjustment by industries that release or consume mercury, taking appropriate account of urban, rural and regional factors;

(2) Supporting the introduction and commercialization of mercury pollution-prevention technologies including the promotion of clean production process technologies, and the demonstration of best available and best achievable techniques and technologies (BAT[87]/BEP/MACT[88]) projects;

(3) Supporting industry to reduce the use of mercury in processes and products by using a range of financial incentives, and by compulsory and voluntary measures to encourage industry modernization and reform;

(4) Promoting alternate consumption choices and improving waste management and recycling; and

(5) Developing "Green" economic diversification strategies for communities affected by the elimination of mercury-based industries[89, 90].

7.4.6 Strengthen China's management and regulatory regimes for mercury

China needs to systematically strengthen the management of its mercury pollution prevention and control activities at all stages of the regulatory lifecycle (see Figure 7-10).

Policy advice needs to be founded on greater capacity for risk assessment and analysis of management options to prevent and control mercury pollution in key sectors. Enhanced capacity is needed to select and apply appropriate technologies and clean production mechanisms and to monitor releases and oversee facility operations for key sectors and regions. Many of China's existing standards and specifications lag behind modern requirements for pollution control and management. Consistent national application of mercury pollution prevention and control measures is needed at a time of Township

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87 In EU BAT is defines as best available techniques and hence includes BEP (best environmental practice. For a specific sector a BAT reference document (BREF) gives detailed information on available and emerging techniques in the sector. BREFS are available at: http://eippcb.jrc.es/reference.

88 MACT is a US-EPA standard. "When developing a MACT standard for a particular source category, the EPA looks at the current level of emissions achieved by best-performing similar sources through clean processes, control devices, work practices, or other methods. These emissions levels set a baseline, often referred to as the "MACT floor" for the new standard. At a minimum, a MACT standard must achieve, throughout the industry, a level of emissions control that is at least equivalent to the MACT floor. The EPA can establish a more stringent standard when it makes economic, environmental, and public health sense to do so. http://www.cdphe.state.co.us/ap/mact.html accessed September 10, 2011.

89 A helpful example is the small scale economic development work of UNDP in Kyrgyzstan found at the following link (Accessed September 22, 2011) .
http://www.unep.org/hazardoussubstances/Mercury/InterimActivities/Partnerships/SupplyandStorage/PrimaryMercurySupplyProject/tabid/3547/language/en-US/Default.aspx.

90 The UNIDO office in China is developing a project proposal with MEP/FECO to seek GEF funding, focusing on the zinc smelting industry (UNIDO Representative, personal communication). This project could provide an opportunity to explore ways to support the adaptation of communities affected by the closure of small smelters.

Industrialization to avoid risks of an East-to-West transfer of polluting industries.

Despite important high-level economic policies to support environmental protection in China, economic instruments do not yet play a significant role in the control and prevention of mercury pollution. Measures could include tax provisions to promote environmental protection beyond basic compliance with the laws, as well as supportive investment and financing mechanisms. The funding of mercury pollution prevention, control or remediation activities have yet to be fully explored.

Not least amongst the challenges for the regulatory system are the governance issues identified in OECD reports on China's environmental performance[91] and on regulatory governance in China[92]. With regard to policy, opportunities were identified to improve regulatory impact assessments and the integration of environmental and economic policies. An operational priority for the management of mercury and other heavy metals is the need to increase national consistency in the implementation of standards and regulations through provincial and local levels of government.

In order to strengthen its capacity for effective and efficient regulation of industries which release or use mercury, and the pollution resulting from past practices, China will need to:

(1) Strengthen all aspects of the regulatory life cycle as described in 7.3 (see Figure 7-10);

(2) Improve Regulatory Impact Analysis in line with the recommendations of the OECD Review[93] and use the OECD checklist[94];

(3) Strengthen the chain of command from National to Local levels to ensure consistent implementation, compliance, and enforcement of regulations and the application of other measures. This can be advanced by completing a transition now underway for Provincial Environmental Protection Bureau Directors to report directly to MEP Headquarters;

(4) Ensure that adequate operational capacity exists for inspection, enforcement and management of emergency responses;

(5) Promote voluntary initiatives by industrial sectors, for example, adoption of the international industry-led "Responsible Care" program by the chemical industry; and

(6) Enforce national standards in rural regions and Western China to prevent the migration of polluting industries from more developed regions.

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91 OECD Environmental Performance Reviews: CHINA. OECD 2007. http://www.oecd.org/ document/24/ 0,3343,en_2649_201185_38952984_1_1_1_1,00.html (Accessed August 30).

92 OECD Reviews of Regulatory Reform. China. Defining The boundary between the market and the state. OECD 2009. http://www.oecd.org/document/36/0,3746,en_2649_37421_42222884_1_1_1_37421,00.html (accessed August 30, 2011).

93 OECD Reviews of Regulatory Reform. China. Defining the boundary between the market and the state. OECD 2009. http://www.oecd.org/document/36/0,3746,en_2649_37421_42222884_1_1_1_37421,00.html (accessed August 30, 2011).

94 The OECD reference checklist for regulatory decision making. OECD 1995.http://www. oecd.org/dataoecd/ 20/10/35220214.pdf (Accessed August 30, 2011).

7.4.7 Develop and apply knowledge to reduce mercury use, releases and impacts on public health and the environment

Public information, awareness and education are needed on practical measures to reduce exposure to mercury and on the release of mercury, especially for those vulnerable populations, such as indigenous people, women, children, and workers living close to industrial and mining activities. Thus it is important to improve the current knowledge base and to begin reducing the knowledge gaps in environmental impact assessment processes, environmental management tools, and the scientific advice available to government, industry and the public.

To reduce knowledge gaps and the levels of uncertainty in the technical and scientific advice available to government, industry, and the Chinese people, actions should include:

(1) A thorough national review of the current status and knowledge of mercury similar to those completed or underway in other nations and regions[95];

(2) Improved monitoring and reporting of the various species of mercury in the environment, foods and humans, recognizing the differences between China and other regions of the world where such research has been carried-out;

(3) Establishing and refining dose response relationships for human health impacts, as current data are based on locations that may not be reflective of the Chinese situation[96];

(4) Improving the understanding of the fate and effects of mercury emissions and their biogeochemical cycles;

(5) Confirming that the methylation of mercury following the flooding of lands for the creation of hydro-reservoirs in China does not represent a problem, given the experience of other countries;

(6) Developing and importing innovative emission-reduction technologies;

(7) Improving communications that promote mercury product recycling and the use of alternate products and devices;

(8) Strengthening occupational safety training for persons (including management, technologists and operators) in mercury-dependent industries.

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95 For example:AMAP, 2011. Arctic Pollution 2011 (Mercury in the Arctic). Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. vi+38 pp. http://amap.no/documents/ The US-EPA mercury risk Assessment http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/A&N%20Hg%20Risk%20Assessment%20TSD!OpenDocument &TableRow=2.2 Canadian Mercury Science Assessment http://www.ec.gc.ca/scitech/default.asp? lang=En&n=1890C965&xsl= articlesservices,viewfull&po=3CEEE8E1#9.

96 The Seychelles and the Faroe Islands.

7.4.8 Strengthen international cooperation and actively support the global campaign to eliminate mercury pollution

As China develops its capacity for mercury management, a strengthening of international cooperation will secure support for improved mercury management in China. Such cooperation will also increase the introduction of capital and technology, develop personal and technological collaboration, and strengthen overall international cooperation for environmental protection. There is great reputational value in strengthening China's international image through the promotion of a global campaign to prevent mercury pollution. As China is in the midst of negotiations on a global mercury convention, strengthened international cooperation will assist the formulation of practical provisions for the mercury convention and will guide China's mercury management policies in the future.

Key features of this task should include actions to:

(1) Establish policy dialogues and information exchanges with key international partners to promote the global strategic campaign on mercury;

(2) Promote cooperation and communications with developing countries and countries with economies in transition;

(3) Strengthen bilateral communications and cooperation on management, technology, international trade, capital investments, human resource capacities and governance of the mercury problem;

(4) Promote the introduction of best available and best achievable techniques and technologies for mercury pollution and control from other countries, and spur the development of domestic technologies to improve mercury management; and

(5) Monitor and contribute actively to discussions on trade and environment at the WTO as it may relate to mercury in the future.

7.4.9 Improve the environmental performance of industries that use or release large quantities of mercury – sector specific strategies

Regulation of each of the major sectors, which are described in detail in Section 7.2.3, will require strategies that take account of technical options, economic and social factors, trade strategies, international norms and the interplay with broader national policies, for example, on energy. Mercury reduction strategies will be needed with short-term strategies focused on early returns – i.e., the most mercury reduction at the lowest cost, and long-term strategies focused on more complex and costly reductions that will require time for careful investments.

Such approaches require discussions and collaboration amongst leaders from the industry sectors, academia, energy and industry ministries and central policy agencies to ensure that opportunity for innovation, future energy supply, and economic, industrial and social strategies and impacts, are fully considered in such key decisions. It will also be necessary to engage the provinces and local governments to the extent that their support will be needed for effective implementation and enforcement.

There will be requirements for command-and-control types of mercury emission regulations that progressively implement more demanding standards. Standards to be set in China should take account of international examples and factors ranging from the protection of the environment and human health in China to assuring the continuing access of Chinese products to international markets that are currently, and may become, sensitive to environmental performance.

The industries targeted for priority attention based on their impact on human health and the environment can be divided into two categories: those that release mercury, and those that use mercury in their processes or produce mercury-containing products.

The Key Sources of Mercury Releases

(1) Coal-Fired Power Plants and Industrial Boilers

(2) Non-Ferrous Metal Smelting

(3) Cement Production

The Key Mercury Users/Producers

(1) VCM/PVC Production (using the Calcium Carbide Process)

(2) Mercury Mining and Smelting

(3) Recycling and disposal of Mercury-Containing Wastes

(4) Mercury-Added Products

1) Battery Producers

2) Compact and Fluorescent Lamp Producers

3) Medical Devices Producers

Proposals for actions in these industries are set out in the following sector-specific strategies. These should form the basis for comprehensive consultations with the industries concerned and with other Ministries and stakeholders as regulatory impact assessments are prepared, leading to appropriate “Made in China” management and regulatory measures. A summary of the anticipated benefits from actions in these sectors is set out in Table 7-6.

As part of its ongoing work the MEP should assign a national team leader to each of the key sectors to lead the building of the required sector-specific strategies and plans.

7.4.9.1 Coal-fired power plants and industrial boilers

China's resource and energy strategies dictate that coal will continue to be an important energy source, even in the long-term. Mercury emissions from the use of coal will be reduced as China improves its energy efficiency and increases its use of renewable and alternate energy sources. On the other hand, while desulfurization and de-dusting facilities have been installed in most coal combustion industries in China, techniques dedicated to the removal of mercury remain absent.

In order to reduce mercury emissions from these sources the following steps are required:

(1) Promote cleaner production such as advanced coal processing techniques and the use of low-mercury coal[97];

(2) Reduce mercury emissions by measures to control other air pollutants (SO_2, NO_x, PM) through timely national implementation of the new standards released on September 21/2011 to take affect on January 1/2012[98], and by improving the stability and availability of existing devices. Simultaneously, it is necessary to promote the development and the demonstration of approaches to establish best available and best achievable techniques and technologies (MACT, BAT/BEP)[99];

Box 7-4 Possible emissions reductions from coal-fired power plants and boilers
Estimates are that emissions from coal-fired power plants in China can be significantly reduced from 2005 levels by 2020 using BAT. The SPS Team suggest that a target of <5 μg/m^3 is doable by 2015 and <3 μg/m^3 could be doable by 2020. Estimates are that emissions from industrial boilers in China can be significantly reduced from 2005 levels by 2020 using BAT. The SPS Team suggest that small inefficient boilers of less than 14 mega-watt capacities should be discontinued. Boilers up to 75 mega-watts capacities should have an emission target of <10 μg/m^3 and boilers larger than 75 mega-watts should have an emission target of <3 μg/m^3 by 2020.

(3) Establish mercury pollution controls for the coal-combustion industries, including

97 Which can be further aided by utilizing coal washing techniques, low-order coal extraction, and CWS preparation.

98 Statement by Wu Xiaoqing, Deputy Environment Minister [MEP]; China Daily, page 1, September 22/2011. Relates to new more stringent standards targeting SO_2, NO_x, Mercury, and soot discharged from coal-fired power plants.

99 Activated carbon injection, addition of bromine or bromides before combustion, in flue gas additives, or at points in the generation process, and others.

an industry-wide regulatory regime, appropriate emission standards[100] (Box 7-4) and some necessary economic incentives;

(4) Improve the plan of action and the enforcement of mercury pollution regulations to ensure mercury emissions standards are met;

(5) Discontinue small high-polluting industrial boilers or shift to natural gas where available; and

(6) Improve the management flow of mercury-containing waste products such as fly ash, FGD gypsum, and wastewater.

7.4.9.2 Non-ferrous metal smelting[101]

There are many medium- and small-sized enterprises operating at different technical levels in the non-ferrous metal smelting industry in China. In order to reduce mercury releases, the following measures should be adopted:

(1) Phase in binding production-based emission limits based on BAT from international sources (Box 7-5) to improve the environmental performance of this industry sector while encouraging further research and development of domestic technologies;

(2) Strengthen research and the introduction of relevant core technologies for mercury pollution control within the industry;

(3) Promote the application of mercury removal technologies to enable enterprises to collect, process or release mercury for further use or resale;

(4) Reduce from the current 10 ppm[102] to 1 ppm the upper limit for mercury in sulphuric acid as it may be used as a raw material for the production of other materials including fertilizers, which could then re-introduce mercury into the crop food chain;

(5) Close small inefficient and highly polluting plants. Current regulations banning the operation of small-scale facilities need to be better enforced. Structural change in the non-ferrous industry will require government support for adaptation by the communities affected; and

(6) Improve requirements to track and control mercury entering the sulphuric acid streams of these plants and other reclaimed mercury wastes.

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100 For example: the currently proposed emission standard of 30 $\mu g/m^3$ is considered far too high. A new standard should be set taking into consideration levels being targeted by the USA [1.5 $\mu g/m^3$] and the EU [3 $\mu g/m^3$].

101 In particular: zinc, lead and copper.

102 Sulphuric Acid for Industrial Use – Standards Press of China GB/T 534. 2002-09-24.

Box 7-5 BAT emission limits
Emission limits may initially be set in line with Canadian legislation, i.e. 0.2 gram of mercury per ton of finished zinc, nickel, or lead, or 1 gram of mercury per ton of finished copper. More stringent emission limits should be phased in on new installations. The current BAT for instance suggests that less than 0.01 gram per ton of zinc is realistic and doable.

7.4.9.3 Cement production

The mercury emissions from cement production are highly dependent on the mercury content of the raw material used and also the mercury content of the coal. Currently very little information is available on the mercury content of this raw material. Mercury emissions from cement production should be reduced by actions to:

(1) Seek co-benefits from other pollution control measures, including energy saving and air pollution control[103] and from strengthening mercury control technologies in this area;

(2) Establish binding emission limits[104] and mercury management[105,106];

(3) Phase in improved requirements to track and control waste mercury entering the cement industry from gypsum and fly ash (as outputs from the coal combustion industry), and other waste streams; and

(4) Improve the availability of information on the content of mercury in the raw material in order to help guide the selection of low-mercury feedstock.

7.4.9.4 VCM/PVC production

In China, the acetylene production process — using a mercury catalyst — still dominates the VCM/PVC industry, accounting for more than 70% of the total, which leads currently to a huge demand for mercury. The following steps should be taken to accelerate mercury reduction in the VCM/PVC sector:

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103 Including changing particle emission control from ESP to FF.

104 By applying BAT, a limit of mercury emission of < 0.05 mg/m^3 is achievable. [http:// www. environment-agency.gov.uk/static/documents/Business/How_to_Comply_-_Cement_EPR3_01a.pdf]. There is also a new US production standard of: 55lbs/million tons clinker for existing sources and 21lbs/million tons clinker for new sources: www.epa.gov/ttn/atw/pcem/pcempg.html - Table 1 of the final rule [page 55052]. The emission standard is 10 μg/m^3 for existing sources and 4 μg/m^3 for new sources.

105 Management measures are described in the Reference Document on BAT in the cement, lime and magnesium oxide manufacturing industries, European Commission, May 2010. (ftp://ftp.jrc.es/pub/eippcb/doc/clm_bref_0510.pdf).

106 The replacing materials are added as powder after milling of the clinker in a cold mixing process with other additives such as gypsum.

Acetylene Process
It takes 1.2 kilograms of mercury in the catalyst to produce each metric ton of VCM

(1) Priority must be assigned to achieving mercury-free PVC production processes. Recalling the 2007 guidance provided by the NDRC, the industry should actively seek opportunities to shift from the coal-based acetylene process to the ethylene process, which is more energy efficient;

(2) Facilities using the acetylene process should be encouraged to further invest in the transformation to lower-mercury processes and eventually to mercury-free methods of production. Binding regulations and improved enforcement measures should be phased-in to track and control mercury entering the waste streams and by-products;

(3) Research on mercury-free technologies and processes should be strengthened[107];

(4) Explore the extent to which a shift away from the acetylene method will provide co-benefits in reduced GHG emissions[108] and thereby reduce pressure on other industrial sectors that share a GHG cap with the VCM/PVC industry; and

(5) Work should be done to strengthen the control and management of the whole process, establishing economic incentives to reduce the use of mercury, and to promote the recycling of low mercury catalyst. Authorities should also explore "cap and trade" systems or fees for mercury use.

7.4.9.5 Mercury-added products

The following recommendations should be considered to reduce mercury in the mercury-added products sectors:

(1) Promote the development and use of mercury-free or low mercury-added products as alternatives to the current mercury-added products;

(2) Establish mercury content limits on production, import, export and consumption of mercury-added products;

(3) Develop an action plan to reduce the use of mercury-added products including the industrial structural adjustments required;

(4) Encourage, through regulatory measures, the gradual transition of mercury-added

107 Such as: new molecular sieve fixed-mercury catalysts and integrated large-scale chloride fluidized bed reactors.

108 The production of one metric ton of PVC by the acetylene process produces twice the CO_2 emissions than the ethylene process used in Europe and North America.

products at the poorest level of mercury content to meet the same limits of products at the best level of mercury content;

(5) Improve the development, introduction and promotion of recycling technologies for existing mercury-added products industries; and

(6) Adopt a production license system that favours extended producer responsibility measures, cleaner production, circular economy initiatives, and voluntary industry sector measures to reduce the mercury-added content of their products.

7.4.9.6 Recycling and disposal of mercury wastes

There is a wide range of mercury-containing wastes that need special attention, such as batteries, mercury-added lamps, medical devices, dental amalgam, VCM mercury catalysts, gas cleaning sludge, and smelting wastes. Currently, in China most used mercury-containing products are sent to landfills along with municipal solid waste. The absence of an effective recycling system and proper hazardous waste handling therefore poses a high risk of mercury pollution to the environment. It will therefore be important to properly enforce China's hazardous waste management regulations. The following steps should be taken to improve recycling, handling and disposal of mercury-containing waste:

(1) Strengthen the introduction and development of mercury wastes recycling and disposal technologies;

(2) Strengthen collection, storage, recycling and disposal systems for mercury-containing waste;

(3) Establish strict recovery efficiency and pollutant discharge standards for the mercury waste handling industries; and establish evaluation methods and indicators;

(4) Promote the use of cost-benefit analyses to determine whether it is more efficient and effective to promote the use of mercury-free products or the recycling of mercury-added products;

(5) Establish market-based incentives for recycling of mercury-containing wastes; and

(6) Enhance consumer awareness and set up special recycling sites at convenient locations in the community. Engage government, manufacturers, recycling professionals and communities in the development and operation of an effective recycling system for waste mercury-containing products.

Note: Dental amalgam can easily and cheaply be removed from dental wastewater. Action might be initiated through a national dental association as a prelude to eventual binding regulations to remove dental amalgam from waste streams.

7.4.9.7 Mercury mining and smelting

Mercury mines and smelting facilities release mercury to the environment through a number of pathways. The long-term legacy of these mines and smelters is an accumulation of mercury in humans, animals and plants in the surrounding environments. The risk of mine tailing collapses poses an additional risk. The following recommendations should be considered to reduce mercury pollution from both the operating and legacy mines and smelters:

(1) Strengthen national government oversight of this industry for the approval, control and reporting of production;

(2) Undertake risk-based management based on human health impacts and impacts to the environment for contaminated sites resulting from closed mines, smelters, and their waste sites;

(3) Strengthen enforcement and emergency response capacity and establish financial mechanisms to support the identification, decommissioning and remediation of both legal and illegal mines and mercury processing plants; and

(4) In order to optimize the use of funds for remediation and protect the environment, food supply and public health, collaboration should be strengthened among authorities responsible for the general security, safety and emergency response capacity (e.g. related to risks of mine tailing collapse).

7.4.10 Overview of the effects of mercury pollution controls on pollution from other heavy metals

Many measures to reduce mercury releases will directly or indirectly reduce pollution from other heavy metals.

Combustion processes that release mercury also emit other heavy metals such as lead, cadmium, thallium and zinc. Hence measures by coal-burning sectors targeting mercury and conventional air pollutants, especially particulate matter, will also reduce those other heavy metal emissions. Similarly, proper treatment of the waste streams in these sectors will not only reduce mercury releases but also the releases of other heavy metals.

In the non-ferrous metals sector, several heavy metals other than the metal being produced are commonly also present in the ore. Pollution control measures will thus reduce the release of mercury and other heavy metals. The closing of small, inefficient and highly polluting non-ferrous metal smelters will be particularly efficient in preventing pollution by mercury and other heavy metals, both to air and water.

Furthermore, the management regime and regulatory capacity established to prevent and control mercury pollution will support the development and implementation of measures required to reduce and prevent pollution from other heavy metals. Table 7-6 indicates qualitatively some of the benefits and co-benefits one could expect following the implementation of improved mercury pollution prevention measures across the sectors previously discussed.

Table 7-6 Qualitative view of anticipated benefits from actions by the various sectors

Sector	Quantity of Mercury Involved[109]	Opportunities for Early Actions	Benefits for Health and the Environment		Co-Benefits for other Heavy Metals
			China	Global	
Coal Fired Power Plants	++				
Coal Fired Boilers	+++				
Non-Ferrous Smelters	++				
Cement Production	++				
VCM/PVC Production	++++				Zero
Battery Production	++				
Thermometers	++				Zero
Blood Pressure Monitors	+				Zero
Compact & Fluorescent Lamps	+				Zero
Dental Amalgam	+				Zero
Mercury Mining	++++				

Good	Better	Best

109 Qualitative scale of "Use" of mercury or the "Release" of mercury. += Not Much ++= Medium Amount +++= Large Amount ++++= Very Large Amount.

7.5 Recommendations for Priority Actions

Europe and then North America were for centuries the major sources of anthropogenic mercury releases. Following substantial reductions of mercury releases from these two regions over the past three decades, Asia is now by far the largest source, and China the largest national producer, user, and releaser of mercury. Indeed, China now accounts for more than 50% of global use.

China's economic development efforts over the past 30 years have spurred significant industrial growth. During this period, as described in previous chapters, China's connection to mercury has grown on three fronts: ① With the expansion of its heavy industries such as non-ferrous metals smelting, cement production, coal-fired power generation, and industries relying on coal-fired industrial boilers, mercury emissions from smelting and coal combustion have made China the biggest emitter of mercury to the atmosphere. ② For the production of PVC in China, coal rather than oil or natural gas is used as a feedstock in a process that demands a significant amount of mercury as a catalyst for the chemical reaction, making this the biggest mercury-use industrial sector in the world. ③ The growth in production of batteries, fluorescent lights, and mercury-added medical instruments has been such that China now produces most of the global supply, thereby contributing significantly to waste streams around the world created as these products reach the end of their useful life.

China now has an opportunity to address these problems through innovation and modernization of its industrial base. As a world leader in international trade and economic growth, and consistent with its green development strategy, it is in China's interest to significantly reduce its use and production of mercury and releases to the environment while strengthening recycling and waste management systems. Now is the time to act as the world is focused on international cooperation to control mercury pollution.

Based on the opportunities set out in 7.4 of this report and in particular the sector-specific analyses (section 7.4.9), recommendations are made for early and longer-term actions consistent with the "12th Five-Year Plan" for heavy metals for the period 2011—2015 and beyond. In addition to the specific priority recommendations that follow, this report identifies several other actions that can usefully be taken by China in the near and long term to reduce mercury pollution and its impacts. Table 7-7 provides an overview of the estimated reductions in mercury emissions and mercury demand that China could expect to achieve if the recommendations provided in this report are implemented over the next decade.

The overall approaches that we recommend are to: ① strengthen the management and regulatory systems to control the use of mercury and other heavy metals, including measures to protect the health of the Chinese population; ② establish ambitious but feasible targets for reduced use of mercury and reduced releases of mercury to the environment, drawing upon experiences of other countries; and ③ foster the development of closed-loop systems for the management of mercury as a resource to reduce and eventually eliminate the demand for new mercury in China.

While this report has focused on mercury, many of the proposed actions will contribute directly or indirectly to the control of pollution from other heavy metals. For example measures to reduce mercury pollution from non-ferrous metal smelters, mining, coal-fired boilers and cement production will also reduce pollution from other heavy metals such as lead and cadmium. Furthermore, the regulatory systems and capacity established for mercury pollution control will support the development and implementation of measures required to reduce and prevent pollution from other heavy metals. A similar CCICED Special Policy Study would be helpful to develop appropriate strategies and action plans for these other pollutants.

In its "12th Five-Year Plan" China has made clear commitments to address pollution by mercury and other heavy metals and is moving forward with early actions. This will require dedication and continued effort that should start immediately and accelerate over the next decade.

Table 7-7 Overview of estimated possible reductions by 2020 (tonnes)[110]

Sector	Baseline Emissions	Anticipated Emission Reduction	Baseline Use	Anticipated Use Reduction
Coal-Fired Power Plants	123 [2007]	12+37= 49 (40%)		
Coal Fired Boilers	213 [2007]	85 (40%)		
Non-Ferrous Smelters	116 [2007]	111 (96%)		
Cement Production	90 [2007]	23+27=50 (55%)		
VCM/PVC Production			780 [2010]	208+286+286= 780 (100%)
Battery Production			140 [2009]	112 (80%)
Thermometers			109 [2008]	54 (50%)
Blood Pressure Monitors			118 [2008]	40 (34%)
Compact Fluorescent Lamps			68 [2010]	35+12=47 (70%)
Fluorescent Lamps			130 [2010]	101 (78%)
Total[111]	542	295 (55%)	1345	1134 (84%)

110 See Sections that follow and the Final Report for calculations and methods used.
111 Be mindful that there is rounding of numbers for display purposes.

7.5.1 Take early actions that offer public health and environmental benefits

There are a number of actions that can be taken quickly to protect human health and the environment from mercury.

7.5.1.1 Non-ferrous smelters

Governments, and in particular Environmental Protection officials, should take immediate steps to close the remaining small, inefficient and highly polluting non-ferrous metal smelters by strengthening and ensuring the implementation and enforcement of regulations banning the operation of such facilities.

These measures will serve not only to protect the health of workers and nearby communities, but will provide a substantial portion of the emission reductions from this sector with limited impact on productivity. Taking the zinc industry as an example, over 80% of the mercury emissions come from these small smelters that produce less than 20% of the zinc.

These actions will also reduce pollution from other heavy metals such as lead and cadmium. Structural change in the non-ferrous industry will require government support for economic diversification and adaptation by the communities affected.

7.5.1.2 Coal combustion

To reduce mercury emissions from the coal combustion sectors China should:

(1) Promote implementation of best available techniques for mercury-specific controls (e.g. activated carbon injection, addition of bromine or bromide) with support for early uptake through training and financial incentives;

(2) Reduce demand for coal combustion through continued efforts to improve energy efficiency and to increase the use of renewable and alternate energy sources; and

(3) Further strengthen requirements for action by the coal combustion sectors to control other air pollutants and thereby increase the co-benefits of reduced mercury emissions, an approach that in recent years has contributed to decreased mercury emissions despite an increase in coal consumption by this sector.

7.5.1.3 Protecting citizens

Health, Labour, Environmental, Safety and Emergency Authorities should collaborate on measures to:

(1) Protect citizens at risk from exposure to mercury as a result of their occupations,

food or place of residence (e.g. near contaminated sites). Measures needed include: ① food consumption advisories based on monitoring and standards appropriate to China, ② effective occupational health and safety programs, and ③ information, advice and support to people living in proximity to contaminated sites;

(2) Ensure secure management of hotspots near abandoned mercury mines and mercury mine tailings to prevent further water, soil and air-pollution and to prevent possible mine tailing collapses; and

(3) Strengthen inspection and enforcement to ensure that illegal activities such as artisanal small-scale gold mining or illegal waste disposal are prevented.

7.5.2 Make major reductions in mercury emissions and releases to protect public health and the environment in China and reduce China's contribution to global emissions

Major reductions in mercury emissions can be achieved in the following sectors through capital investments over the next decade.

7.5.2.1 Coal combustion sectors

(1) Industrial boilers should shift to natural gas where available and feasible. Where coal must be used, advanced coal processing techniques and the use of low mercury coal should be encouraged. Small and inefficient coal-burning boilers of less than 14 mega-watt capacities should be discontinued. Taking account of international practices, boilers above 75 mega-watts capacities could have an emission target of 10 $\mu g/m^3$ by 2020 thereby reducing their emissions by about 40%.

(2) Emissions from coal-fired power plants in China can be significantly reduced from 2010 levels by 2020 using modern technologies. A target of less tham 5 $\mu g/m^3$ seems feasible by 2015 and less than 3 $\mu g/m^3$ could be achieved by 2020. Even assuming a 10% annual growth in coal consumption by these plants, these targets would reduce mercury emissions in 2015 by about 10% and in 2020 by a further 30% from 2007 levels.

7.5.2.2 Non-ferrous smelter sector

The sector should be required to phase in binding emission limits taking account of technologies available from international sources while encouraging further research and development of domestic technologies. For example, an achievable emission limit of 0.2 grams of mercury per ton of finished zinc or lead, or 1 gram of mercury per ton of finished copper could be implemented. These limits, along with the closure of the small highly polluting smelters, would reduce non-ferrous smelter emissions from 116 tons [2007] to about 5 tonnes, a reduction of 96%. More stringent emission limits should be phased in for new smelters since, with the current best available technology, emissions of less than 0.01 grams per ton of zinc are already realistically achievable.

A regulation limiting the maximum mercury content in sulphuric acid produced as a by-product from this sector should be strengthened by reducing the maximum limit from the current 10 ppm to 1 ppm and actively enforced especially where this by-product may be used to produce fertilizers for food crops.

7.5.2.3 Cement sector

Binding emission limits should be phased in for the cement sector based on best available technologies and management measures used in North America and Europe. A standard of 10 $\mu g/m^3$ could reduce emissions in 2015 by about 25% and in 2020 a standard of 4 $\mu g/m^3$ could reduce emissions by a further 30% from 2007 levels. Co-benefits can be achieved from other pollution control measures, including energy saving initiatives and air pollution control.

7.5.3 Reduce mercury use and demand and recycle waste mercury in a closed loop

China can reduce and eventually eliminate the demand for new mercury for its manufacturing sectors by fostering the development of closed-loop systems that manage mercury as a valuable resource, and by reducing the requirement for mercury in manufacturing processes and products.

7.5.3.1 VCM/PVC sector

Priority must be assigned to achieving cost-effective mercury-free PVC production processes.

Recalling the 2007 guidance provided by the National Development and Reform Commission for the Chlor-alkali (caustic soda, PVC) Industry[112], the sector should actively seek opportunities to shift from the coal-based to oil- or gas-based processes, that use no mercury and are more energy efficient.

Every effort should be made to achieve the government's announced goals for this sector, which are as follows:

(1) By 2012 achieve 50% of the sector adopting the low-mercury catalyst process to

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112 NDRC [2007]74. The web site is:
http://www.sdpc.gov.cn/zcfb/zcfbgg/2007gonggao/t20071106_170922.html.
[Accessed by Sep. 26th/2011].

reduce mercury use by an estimated 208 tonnes annually;

(2) By 2015 achieve 100% of the sector adopting the low-mercury catalyst process (mercury use per metric ton of PVC produced to drop by 50% or an estimated reduction of 286 tonnes) and implement the full recycling of the spent low-mercury catalyst;

(3) By 2020 promote mercury-free catalyst use and gradually achieve mercury-free production across the PVC industry.

Facilities that continue using the coal-based process should invest in the transformation to lower-mercury and eventually to mercury-free methods. Additionally, binding regulations and improved enforcement measures should be phased in to track and control mercury entering the VCM/PVC sector's waste streams and by-products.

If a promising new mercury-free catalyst now undergoing commercial trials should prove effective, steps should be taken to encourage its uptake by early adopters while continuing efforts to develop competing methods. There is an urgent need for significant investments in research on mercury-free technologies and processes for PVC production.

The government should foster these technologies by instituting financial mechanisms to assist the sector's transformation to mercury-free processes.

Considering industry forecasts that the sole mercury mine in China could be exhausted within 5 years, and given the need to drive innovation and adaptation in the sector, a policy of preventing fresh mercury from entering China's industrial system as early as 2015 would be an important step toward achieving mercury-free production across the PVC industry.

7.5.3.2 Closed-loop systems for mercury consuming industries

Develop closed-loop systems that capture and recycle mercury to eliminate the need for inputs of new mercury, thus fostering resource conservation and reducing waste. This approach can be applied broadly to capture and reuse mercury from many sources ranging from non-ferrous smelters to medical products.

This will require development of an effective mercury recycling system and proper hazardous waste handling regimes. This will require the strengthening and proper implementation and enforcement of China's hazardous waste management regulations.

China should consider establishing a cap on the available supply of mercury by 2015 to accelerate reduced dependence on the mining of mercury and to promote innovation and adaptation by the PVC sector and other mercury-consuming industries.

7.5.3.3 Improved standards for mercury-added products

Encourage producers of mercury-containing products to use less — or zero — mercury by:

(1) Developing and implementing regulations to gradually require producers of high mercury-added products (e.g. lamps) to meet the same standards as products with the lowest mercury content available internationally;

(2) Developing and using mercury-free or low-mercury-added products and by encouraging their use in place of current mercury-added products (e.g. through free exchange programs for medical devices);

(3) Adopting a production licensing system that favours extended producer responsibility, cleaner production, circular economy initiatives, and voluntary industry measures to reduce the mercury-added content of their products; and

(4) Improving recycling technologies and promoting the creation of the necessary industries.

China should promote, develop and implement the Heavy Metal Pollution Comprehensive Prevention Plan for the battery industry issued for comment by the Ministry of Industry and Information Technology on November 25, 2010. The Plan proposes to phase out alkali manganese button batteries with mercury exceeding 5 ppm by 2013. By 2015 mercury consumption by the battery industry in China would be reduced by 80% from a baseline of 140 tonnes.

As the producer of 80% of the world’s compact fluorescent lamps, China has an opportunity to lead the development of a global standard for the mercury content in these lamps. The government working with the industry association has established a limit of 5 mg that it expects to achieve by 2013; this will decrease the industry’s mercury demand by about 35 metric tons from 2010 levels. Further reductions of an estimated 12 tons could be made by moving to a limit of 2.5 mg in lamps less than 30 watts and a limit of 3.5 mg in lamps more than 30 watts.

Additionally, China produces a large number of regular fluorescent lamps for use in residential, commercial, and industrial settings. In 2010 this fluorescent lamp sector used about 130 tonnes of mercury. For these products, the government is considering a standard limit of 10 mg. This standard would reduce the total mercury used by the fluorescent lamp sector to about 29 tonnes.

7.5.4 Build strong foundations for a mercury–free green economy

Key foundations are required for successful actions to reduce pollution from mercury and other heavy metals. One is an effective national system for regulation and management of these pollutants. Another is a base of knowledge needed to protect public health and the environment and to foster innovation in green technologies to eliminate or significantly reduce pollution.

7.5.4.1 Regulation and management

(1) Establish a mandatory, transparent, facility-based and quality-controlled national inventory of mercury transfers and releases to support evidence-based cradle-to-grave management of mercury and the related risks in China;

(2) Strengthen regulatory capacity at all stages of the life cycle from issue identification and regulatory impact assessments to implementation, enforcement and evaluation, and increase the range of "instruments" used, including market-based and industry-led approaches. Accomplishing these ends will require building specialized capacity for example in the use of alternate instruments, cost-benefit analysis and regulatory impact assessment;

(3) Strengthen understanding and oversight of the key sectors for continuous mercury reduction. This will require dedicated staff to lead this work at the Ministry of Environmental Protection; and

(4) Strengthen management and regulatory systems for mercury and other heavy metals, including increased capacity for timely and effective emergency responses and for consistent application and enforcement of national standards and regulations throughout the country to prevent development of pollution havens in remote and developing regions and to prevent mercury from entering the food supply and other routes of exposure that put the population at risk.

7.5.4.2 Knowledge and innovation

(1) Improve monitoring for mercury in foods, humans, and the environment to support risk assessment and management measures;

(2) Foster new technologies suited for use in China (e.g. a mercury-free catalyst for the PVC acetylene industry, addition of bromine or bromide for coal-burning power plants, and small and clean industrial boilers). Support such efforts through a technology evaluation and verification system;

(3) Promote education and increased awareness amongst the public, government, industry, and medical personnel, including senior leaders, and build capacity for action in these areas.

7.6 Acknowledgments

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As part of the research process, five meetings of the Special Policy Study Team were held including one in Canada. The Canadian study tour included a visit to the TECK zinc smelter in British Columbia, a visit to the ATCO coal-fired power plant in Alberta, and a visit to a contaminated site remediation contractor in Nova Scotia. These visits were for the most part organized by Environment Canada to whom our special thanks are extended. The SPS Team is also grateful to the following executives of Canadian industry associations who shared with us their experiences and lessons learned from industry-led initiatives to improve environmental performance: Richard Paton, President and CEO, Chemistry Industry Association of Canada, Paul Lansbergen, Secretary and Lead Director, Regulatory Affairs, Forest Products Association of Canada, and Gordon Peeling, President and CEO (retired), Canadian Mining Association.

Thanks are also extended to the many experts who attended our meetings to provide presentations and advice on their fields of expertise. The United Nations Environment Programme, Chemicals Branch, and in particular David Piper, provided invaluable information and advice.

The front cover photo-ribbon includes a photograph of a cooling tower and men carting bags of spent mercury catalyst courtesy of Prof. Uwe Lahl of the SPS Team; a photograph of a young child playing with a container of mercury courtesy of Prof. Thorjorn Larssen of the SPS Team; and a public domain photograph of a small stone smelter. The Abstract page includes a public domain photograph of mercury droplets.

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Appendix I Progress on Environment and Development Policies in China (2010—2011) and CCICED Policy Recommendations Impact

CCICED Chinese Chief Advisor & Support Team

Introduction

The China Council for International Cooperation on Environment and Development (CCICED), a high-level policy advisory body, was established with the approval of the Chinese government, with the mandate to provide decision-makers with policy recommendations on critical issues in environment and development. At CCICED's Annual General Meeting (AGM), the Chinese and international members review policy research by Task Forces and Special Policy Studies and prepare policy recommendations for submission to the State Council and other government departments.

Since 2008, in order to further strengthen CCICED to play its unique role, improve its working mechanism, and to build CCICED members' understanding of policy development processes in China, the Chinese supporting team of the Chief Advisors Group has been delegated by the CCICED Secretariat to prepare this report on the Progress of Important Policies on China's Environment and Development, and the Impacts of CCICED Policy Recommendations. This report reviews major policy progress on China's environment and development, and provides some thoughts on the implementation and adoption of CCICED recommendations by the government departments.

The report follows two main lines. It reviews China's major policies introduced during the past year on environment and development, providing an overview of the latest progress. In addition, the report compares China's recent policy development in environment and development with the major issues tackled and policy recommendations submitted by the CCICED previously, especially those considered at the 2010 CCICED AGM.

Policy-making is a complicated process, of course, with numerous sources of inputs. Therefore, it would be arbitrary to attribute a specific policy introduced in the last year by the Government of China to a specific CCICED recommendation. The real impact of the CCICED ultimately may have to be determined by decision-makers themselves. However, by analyzing and comparing China's policy practice with CCICED policy recommendations, the report helps to demonstrate linkages between the relevance of the research topic selection, content of the recommendations, and policy development.

This is the fourth report prepared by the Chief Advisors supporting team since 2008. The report is composed of two parts. Part 1 provides an overview of environment and developments of the "11th Five-Year Plan" and the goals of the "12th Five-Year Plan", including environment and development priorities for 2011. The report outlines important policy shifts in this past year, with comments on the relevance of CCICED policy recommendations to China's environment and development since the 2010 AGM held last November. Part 2 lists the major recommendations from the 2010 AGM.

Part I Progress on Important Policies for China's Environment and Development

1 Overall situation of environment and development

(1) *The "11th Five-Year Plan" was completed with success on environment and development*

The "11th Five-Year Plan" came to a successful conclusion at the end of 2010. The Chinese government achieved major economic and social development objectives set in the "11th Five-Year Plan" while dealing well with the financial crisis, natural catastrophes and other domestic and international challenges, bringing domestic economy to a new stage. By the end of 2010, China's GDP reached 39.8 trillion RMB, with an average annual growth rate of 11.2%. For the same period, the average annual growth rate of energy consumption increased by 6.6 %, which was lower than that of GDP. China's fiscal revenue rose from 3.16 trillion to 8.31 trillion RMB for the same period. Progress was made in energy conservation and emission reduction, ecological construction and environmental protection. During the five-year period, cumulatively there was a decrease in chemical oxygen demand by 12.45%, and sulfur dioxide emissions by 14.29%. These two indicators surpassed the target levels. Cumulatively, energy consumption per unit of GDP decreased by 19.1%, almost reaching the 20% target.

China actively participated in international actions on climate change, developed action goals and policy measures for reducing greenhouse gas emissions intensity by 2020, and made comprehensive plans for the implementation of energy conservation and emissions reduction, which includes reforestation of 25.29 million hectares through major forest ecological projects, overall treatment of 230,000 km^2 of land for soil erosion, water pollution prevention and treatment in major river basins, air pollution prevention and control, and treatment of “three wastes” (air, water and solid wastes) from industry.

All in all, the government achieved major progress in the fields of environment and development during the “11th Five-Year Plan”.

Environmental protection became better understood, and its awareness was raised for the whole society. The government introduced a series of new concepts and measures for enhancing environmental protection. During the “11th Five-Year Plan”, both the CPC Central Committee and the State Council have placed environmental protection in a more important strategic position, raising new concepts of ecological civilization, historical transformation for environmental protection, rehabilitation of rivers and lakes, energy conservation and emission reduction as critical measures for restructuring and transformation, environmental protection as livelihood issues and exploring a new path for China’s environmental protection.

More investment was made on pollution emission reduction through industrial restructuring, leading to continuous improvement in environmental quality. During the “11th Five-Year Plan”, desulfurization facilities with a capacity of 5.32 hundred million kilowatts were installed in coal-fired power plants, with installation of domestic thermal power desulfurization units rising from 12% in 2005 to 82.6%. The increased capacity for wastewater treatment exceeded 60 million tonnes per day, with urban wastewater treatment rate soaring from 52% in 2005 to 77%. More efforts were made on eliminating backward production capacity, and cumulatively 76.83 million kilowatts of small thermal power units were shut down, exceeding the goal of shutting down 50 million kilowatts in 1.5 years ahead of schedule. Elimination of backward production capacity also was achieved covering 120 million tonnes of iron, 69 million tonnes of steel, 350 million tonnes of cement, 93 million tonnes of coke, 10.7 million tonnes of paper, 1.8 million tonnes of alcohol, 300,000 tonnes of MSG , and 38 million weight cases of glass.

Environmental quality is improving continuously. Water sampling from state monitoring points of seven water systems showed that 59.9% exceeded Class III standard compared to 41% in 2005. An average annual concentration of sulfur dioxide in urban air was 0.034 mg/cubic meter, a 19% reduction compared to 2005, and in key environmental protection cities, the concentration was 0.042 mg/cubic meter, a 26.3% reduction. The air quality in 79.6% mid-to-large cities reached or surpassed Grade II national standard.

Clean energy experienced fast development through energy restructuring. From the statistics obtained from the National Energy Administration, during the "11th Five-Year Plan" the increased hydropower capacity put in production was almost the total capacity for the previous 95 years in China. Wind power connected to the grid reached 31 million kilowatts, a doubling for five consecutive years. In 2010, wind power generated 45 billion KWH, up 63% over the previous year. In September and October 2010, Unit 1 in Guangdong Lingao Nuclear Power Station and Unit 3 of Qinshan Nuclear Power Station extension operated by the China National Nuclear Corporation were put into production, with a total nuclear power generation capacity exceeding 100 million kilowatts, the largest scale of any nuclear power station under construction. The five-year cumulative generation of hydropower, nuclear power and wind power surpassed three trillion kWh, an alternative for 1.5 billion tons of coal, with a reduction of nearly 300 million tons of carbon dioxide emissions. After the Fukushima nuclear power plant leak, the State Council suspended approval of new nuclear power projects, including projects that had started preliminary work. Some experts welcomed this temporary slowdown and hoped that in the long run it will serve to reinforce nuclear infrastructure safety.

Environmental monitoring has been intensified, and the integrated role of environmental protection in optimizing economic development is increasingly apparent. In accordance with requirements of the regional economic development plan of the State Council, environmental protection departments have effectively curbed environmental violations by taking the measures of "restrictions by regions" and "restrictions by industries". They have continued to improve the system of strategic Environmental Impact Assessment (EIA), organized and completed EIA on priority industries in five regions, including the Bohai Sea and surrounding areas, west coast of the Taiwan Straits, North Bay, Chengyu region, and the industrial parks of the Yellow River upstream regions. EIA has been applied to more than 10 essential industries covering petrochemical industry, energy, metallurgy and equipment manufacturing in 15 provinces (autonomous regions and municipalities). The EIA findings have also been applied to major industrial layouts and accession to projects.

National environmental standards have been upgraded continuously. During the "11th

Five-Year Plan" more than 60 standards regarding key industrial pollution emissions were either introduced or amended, and another 1,050 national environmental standards have been under revision and amendment.

Pollution control in vital watershed regions has been intensified. Under the guiding thinking of rehabilitating rivers and lakes, the government formulated the "Interim Measures Concerning Assessment of Implementation of Special Plan on Pollution Prevention in Key Watershed". An overall water quality assessment system for sections at provincial boundaries has been established, and water quality in lakes under "rehabilitation" has achieved positive results. Following the air quality control measures for the Beijing Olympics, a new mechanism for joint prevention and control for regional pollution has been set up. The "Guidance of Promoting Joint Prevention and Control of Air Pollution and Improving Regional Air Quality" was issued, for the purpose of building a mechanism with unified planning, monitoring, control, assessment, and coordination.

Actions have been taken to address environmental problems damaging people's health. The government has released the "Urban Drinking Water Sources Protection Plan (2008—2020)", and developed "Ground Water Pollution Prevention Plan". Progress has been made in heavy metal pollution prevention and control, and the development of Prevention Measures on Heavy Metal Pollution (2010—2015) has been completed. The government will make efforts to further optimize industrial structure related to heavy metals, and to improve the system of heavy metal pollution prevention, emergency response, and environmental and health risk assessment by 2015. The Central Government has added a special fund for heavy metal pollution prevention, and issued the first payment of 1.5 billion RMB in 2010 to support the comprehensive prevention and control measures in critical pollution zones, and to demonstrate and promote new control technologies.

Efforts were also made to improve ecological protection for rural areas. In July 2008, the State Council held a national teleconference on rural environmental protection, and proposed policy measures such as "promoting governance with awards and replacing subsidies with rewards". For the first time, the Central Government set up a special fund for environmental protection in rural areas, amounting to 4 billion RMB for three years, attracting nearly 8 billion RMB from local investment. The government completed a survey on soil pollution and issued Opinions on Strengthening the Prevention and Treatment of Soil Pollution and Ecological Protection. Ecological conservation has been carried out. The State Council examined and adopted the China Biodiversity Conservation Strategy and Action Plan (2011—2030), and joined the International Year of Biodiversity. It also issued the National Plan for Ecological Function Protection Zone and National Ecological Function Zoning.

The legal system for environmental protection has been improved, and the scope of environmental economic policies has been expanded. The Law on Prevention and Control of Water Pollution was issued, and the Environmental Protection Law and Law on Prevention and Control of Air Pollution are under amendment. The Law on Circular Economy has been implemented. The Regulations on Environmental Impact Assessment of Planning and Waste Electrical and Electronic Product Recycling Regulations have been issued. Other regulatory documents have been released in succession, including Comprehensive Work Plan For Conserving Energy and Reducing Emissions and National Climate Change Programme. Green trade, green credit, green taxes, green insurance as well as green government procurement policies are being implemented. Sewage fees and desulfurization electricity pricing have been improved. The government is pushing hard in emission trading and ecological compensation.

In his Work Report of the Government (2011), Premier Wen Jiabao made four summary points of economic and social development in the "11th Five-Year Plan".

"First, we must follow scientific development with economic development at its core. The government must put people first, and work hard to improve their livelihood. Wealth should be shared by all, and the fruits of development should benefit all. In urban and rural development, in regional development and economic social development, integrated and coordinated development mode needs to be applied. The transformation of economic development mode needs to be expedited, with the drive for innovation, resource conservation and environmental protection, in order to achieve economic and social development coordinated with population, resource and environment, which will be more balanced and sustainable."

"Second, we must continue to closely integrate government control with market forces. We must improve the socialist market economy, and make full use of the basic role of the market in allocating resources to stimulate the economy while using macro-control tools scientifically to promote long-term, steady and rapid economic development."

"Third, we must consider the overall domestic and international situations, make good use of both domestic and international markets and resources, balance domestic development and openness to the outside world, and take into consideration both domestic and external demand to achieve a balanced development."

"Fourth, we must use reform and opening up to provide the basic driving force for economic and social development. We need to comprehensively carry out economic, political, cultural and social reforms and innovations; eradicate obstacles embedded in systems and mechanisms; fully liberate and develop productive forces; and promote social fairness and justice."

The Ministry of Environmental Protection (MEP) has compared the implementation of environmental objectives with achievements of the "11th Five-Year Plan" and summarized some experiences. They are:

"First, environmental protection must be incorporated into the overall consideration of economic and social development, and environmental problems should be addressed at national macro-strategic level. Second, we must deal with the relationship between environmental protection and economic development and social progress, so as to achieve historic change in environmental protection so that it is tied into economic performance and efficiency as well as to peoples' livelihoods. Third, the environmental problems affecting public health should be solved, and the environmental rights and interests of the public should be protected. Fourth, we must develop environmental economic policies for the whole process of manufacturing—covering production, circulation, distribution and consumption, using various policy instruments. We need to balance environmental protection in consumption, investment and exports. Fifth, we must promote harmony between people and nature, and the restoration of over-burdened ecosystems. Sixth, we must mobilize the whole society to join force for environmental protection."

The CCICED Phase 4 (2007—2011) has witnessed various pressures and challenges at the onset of the "11th Five-Year Plan" as well as the achievements at its close. The CCICED had a mission during this phase, to identify ways in which China might become "an environmentally friendly society". Thus its work was tied closely to China's environment and development efforts during the "11th Five-Year Plan" with annual themes in line with priority concerns: 2007, Innovation and Environmentally Friendly Society, emphasizing the importance of putting forward innovative concepts; 2008, Innovative Mechanism and Harmonious Development; 2009, Energy, Environment and Development; and in 2010, Ecosystem Management and Green Development. In 2011 CCICED has chosen Green Transformation of Economic Development as its theme. Over the past five years, CCICED policy studies have addressed the government need for the transformation of national strategies for environment and development. CCICED recommendations have had impacts on the "11th Five-Year Plan", as pointed out by Premier Wen in his meetings with CCICED members.

(2) *The "12th Five-Year Plan" has set the target of "green development"*

The Fourth Session of the 11th National People's Congress adopted the "12th Five-Year Plan" for National Economic and Social Development on March 14, 2011. In the next five years, the "12th Five-Year Plan" stipulated that new progress should be made in scientific development, and substantial results be achieved in the transformation of the economic development pattern. Continuing to build a resource-saving and environmentally friendly society is an important way to speed up the transformation. We shall forcefully push forward the implementation of the basic national policy of resource conservation and environmental protection, along with energy conservation and reduction of greenhouse gas emission intensity, development of circular economy and low-carbon technologies. We shall actively address global climate change, and follow the path for coordinated and sustainable development. In the following paragraphs the most relevant sections of the "12th Five-Year Plan" are described.

The "12th Five-Year Plan" has proposed a total of 12 binding targets, including seven environmental and resource constraints. The seven are: ① arable land shall be kept above 1.818 billion mu level; ② water consumption per unit of industrial added value shall be reduced by 30%; ③ the proportion of non-fossil fuels in primary energy consumption should reach 11.4%; ④ energy consumption per unit of GDP shall be reduced by 16%; ⑤ CO_2 emissions per unit of GDP should be reduced by 17%; ⑥ the release of major pollutants addressed in the "11th Five-Year Plan" should be reduced by 8%, and ammonia and nitrogen oxides emissions shall be reduced by 10%; ⑦ forest coverage should be increased to 21.66%, and forest stock should reach 14.3 billion m^3.

These indicators concerning resources and environment are more specific and clear than those in the "11th Five-Year Plan". New items to be monitored according to targets include water consumption per unit of industrial added value, the proportion of non-fossil fuels in primary energy consumption, and carbon dioxide emissions per unit of GDP. The "12th Five-Year Plan" also added two new sub-binding targets for emission reduction (emissions of ammonia and nitrogen oxide), and it divided the original forest coverage indicator into forest coverage and forest stock. It has demonstrated the government's resolution for "green-development".

"Green development" was a key word in CCICED's 2010 policy recommendations, and the title for the 6th chapter of the "12th Five-Year Plan" is "Pursue Green Development: Develop A Resource-Conserving And Environmentally Friendly Society", showing "green development" has become a consensus for both the government and CCICED.

In this chapter, there are six sections, including active response to global climate change, enhancing resource conservation and management, developing circular economy, intensifying environmental protection, promoting ecological protection and restoration, and enhancing water conservation and disaster prevention and mitigation systems.

The “12th Five-Year Plan” has pointed out that, in order to achieve economic and social development goals, we must emphasize scientific development, and accelerate the transformation of economic development, together with carrying out overall planning, reform and innovation. We must make more efforts to solve unbalanced, uncoordinated and unsustainable economic and social development problems, and identify major policy directions. These include a sound energy reduction incentive and restraint mechanism; optimization of energy structure and reasonable control of energy consumption; improvement of pricing mechanism for resource products and a tax system for resources and environment; energy conservation laws, regulations and standards, assessment of responsibility in achieving energy conservation targets; incorporating resource-saving and environmental protection into every aspect of production, distribution, consumption and construction; and enhancing capacities of sustainable development.

In dealing with the numerous major environmental accidents in recent years, the “12th Five-Year Plan” suggested prevention of environmental risks, with a focus on comprehensive management of heavy metal pollution, using Xiangjiang River as a pilot and demonstration site for restoration and treatment of heavy metal pollution. We need to intensify pollution prevention and control of persistent organic pollutants, hazardous wastes and chemicals; conduct pilot and demonstration programs for restoration of contaminated regions (soil and water, etc.); strengthen nuclear and radiation monitoring capacity, in order to ensure nuclear and radiation safety; and actively tackle environmental legacies. For sources of major environmental risks, we should enhance monitoring, early warning and control, and improve environmental and health risk assessment capabilities.

An important means to prevent environmental risks is to reinforce environmental regulations. The “12th Five-Year Plan” indicates that it is crucial to improve environmental protection laws, regulations and standards, as well as environmental technologies and economic policies; and to strengthen capacity building for environmental monitoring, early warning and emergency response. We ought to improve environmental law enforcement, with stricter environmental access, perform environmental impact assessment in accordance with the law, and strengthen the environmental regulation for transfer of industry. We also should implement a responsibility system for environmental protection, and an environmental accountability system regarding major pollution incidents, along with a public supervision mechanism for environmental protection.

Since the “11th Five-Year Plan”, green economy polices have played a more and more important role in environmental protection. In the “12th Five-Year Plan” this trend will not only continue, but also such polices will be further polished. According to the new “12th

Five-Year Plan", the reform of resource products pricing and environmental protection fees will be carried out; a pricing mechanism will be established reflecting market supply and demand, resource scarcity and environmental costs of resource products, which would promote structural adjustment, resource conservation and environmental protection. We should push forward the reform of the environmental protection fee system, establish and improve the system of polluter-pays, raise the collection rate of sewage fee, reform fee collection methods for waste treatment, and raise waste treatment standards and financial subsidies. We should actively promote environmental tax reform, and start levying environmental taxes on items that require extensive prevention and treatment and have established technical standards, and gradually expand the application scope. We must establish and improve mechanisms for resources and environmental property rights. With the introduction of market mechanisms, we should establish compensation and trading systems for mineral rights and emission rights; regulate the market of trading mineral exploration rights and mining rights; develop emission trading market, and normalize the trading pricing for emission right; improve the system of laws, regulations and policies; urge the orderly flow of resources and environmental property rights; and ensure open, just and fair trade.

Developing a circular economy will not only save resources and reduce pollution from the source, but also play a role in "green development", as is stated in the "12th Five-Year Plan". In line with principles of reduction, reuse and recycling, we should give priority to reduction, aiming to improve resource efficiency. We need to promote the development of a recycling economy throughout production, circulation and consumption. Moreover, we should accelerate the construction of a resource recycling system for the whole society. We also need step up the implementation of cleaner production in agriculture, industry, construction, business services and other key areas, and bring pollutants and emissions under control from the source throughout the entire process, while reducing resource consumption. We need a sound resource recycling system for renewables, establish and improve systems of classified garbage recovery, sealed shipping, and central treatment. We should promote green consumption patterns and lifestyle, advocating a civilized, economical, and green low-carbon consumption concept in the whole society. We should put green government procurement into practice, and gradually raise the proportions of energy-saving and water-saving products as well as recycled products; strengthen policy support such as fiscal and financial policies, technical support, and planning guidance; improve laws, regulations and standards; establish the system of extended producer responsibility; develop technologies and product catalogues regarding circular economy; and establish a renewable product identification system and a sound statistics and assessment system for circular economy.

In order to ensure the fulfillment of its objectives and tasks, the "12th Five-Year Plan" also emphasized the creation of a performance evaluation mechanism for the benefit of the environment: "accelerating the development and improvement of performance evaluation system and specific assessment methods that will help boost scientific development and step up the transformation of economic development patterns. We should lessen the assessment based on economic growth rate, and strengthen a comprehensive evaluation system based on indicators of structural optimization, livelihood improvement, resource conservation, environmental protection, basic public services and social management. The evaluation results ought to be regarded as an important basis for adjustment, selection and appointment, along with punishment and award for government officials at all levels."

In addition, in the "12th Five-Year Plan", environmental protection is also given a lot of attention in Part III, "Transform and Upgrade Industries: Raise Their Core Competitiveness" and Part V, "Optimize the Structure: promote balanced development between regions and a healthy development of urbanization".

The "12th Five-Year Plan" is the most "green" of the Five-Year Plans, indicating a major transformation in China's development mode, and marking China's entry into a "green development era" along the road of "ecological civilization". It will also be an important contribution to sustainable development of the world as well as a response to global climate change.

The State Council issued the Comprehensive Work Plan for Conserving Energy and Reducing Emissions on August 31, 2011, which stipulated requirements for the overall emission reduction during the "12th Five-Year Plan", in reducing the intensity of energy consumption, reducing the total discharge of major pollutants and reasonably controlling energy consumption.

We will use a forced mechanism for speeding up the transformation of economic development pattern and strengthening responsibility, legal systems and policy implementation combined with effective supervision. We will establish and improve incentive and restraint mechanisms, optimize industrial structure, promote technological progress, improve energy efficiency, and significantly reduce emissions of pollutants. We should build a government-led, business-oriented and market-driven pattern, together with the participation of the whole society in the promotion of energy conservation and emissions reduction; and achieve a resource-saving and environmentally friendly society.

The Comprehensive Work Plan for Conserving Energy and Reducing Emissions contains sections on responsibility in reaching energy-saving and emission reduction targets, adjustment and optimization of industrial structure, energy conservation and management, circular economy, energy-saving technology development and application, energy-saving economic policies, supervision and inspection of energy conservation, and market-based energy conservation mechanisms. The Work Plan also specifies indicators for energy conservation, discharge of sulfur dioxide, nitrogen oxides, ammonia, and chemical oxygen demand for each province, autonomous region and municipality.

(3) *Environment and development priorities for 2011*

In the Work Report of the Government (2011), Premier Wen Jiabao stated that we:

"Should vigorously promote the development of new strategic industries of energy conservation and new energy. We will actively promote changes in the way energy is produced and used, and raise energy efficiency. We will give impetus to the clean use of traditional energy sources, intensify the construction of smart power grids, and vigorously develop clean energy. We will strengthen energy conservation, environmental protection and ecological development, and actively respond to climate change. We will develop circular economy. We will move forward with pilot projects for low-carbon cities. We will strengthen our capacity to adapt to climate change and respond to extreme climate events. We will put in place well-equipped statistical and monitoring systems for greenhouse gas emissions, energy conservation and emission reduction.

"We will accelerate the planning and building of sewer networks and garbage disposal facilities in urban areas, and expand the use of recycled water. We will strengthen the environmental management of chemicals. We will start the work of denitration in coal-fired power plants and strengthen prevention and control of particle pollution. We will step up the treatment of marine pollution, accelerate the treatment of water pollution in major river basins, the treatment of air pollution, the treatment of heavy metal pollution in key areas and the comprehensive improvement of the rural environment with focus on pollution from non-point rural sources."

"We will continue to carry out major ecological restoration projects, intensify the protection and management of major functional ecological zones. We will carry on with phase two of the protection of natural forest resources, implement the subsidy and reward policy for grassland ecological conservation, consolidate achievements already made in turning reclaimed farmland into forests and grasslands, as well as grazing land to grasslands. We will carry out afforestation, strengthen wetland protection and recovery, and make progress in comprehensively dealing with desertification and rocky deserts. We will improve contingency plans for preventing and mitigating natural disasters, and accelerate the development of systems for surveying and evaluation, monitoring and early warning, prevention and control, and emergency response in areas prone to geological disasters from mountain torrents."

On September 27, the State Council held a national teleconference on energy saving, aiming at comprehensive mobilization and deployment of energy conservation in the "12th Five-Year Plan". Wen Jiabao pointed out that during the "11th Five-Year Plan", energy conservation, as a strong impetus to industrial restructuring and technological progress, had the made important contributions in response to global climate change. However, at present, the energy conservation situation is still quite grim. Therefore, we must be fully aware of the importance and urgency of energy conservation, and enhance the sense of crisis and responsibility. We must comprehensively put into practice the Comprehensive Work Plan for Conserving Energy and Reducing Emissions under the "12th Five-Year Plan", and aim to achieve the desired results. Premier Wen Jiabao put forward that, on the basis of ensuring safe and efficient development of nuclear power, we should build a safe, stable, economical and clean-energy modern industrial system. Starting with pilot projects, we will establish a carbon emission trading market step by step; improve the statistical accounting and monitoring methods; and establish a sound emission monitoring system at national, provincial and municipal levels. We should promote green, low-carbon consumption, and advocate for energy-saving consumption patterns and lifestyles. At the teleconference, the Minister of Environmental Protection indicated that there was good and bad news about reducing pollutant emissions in the first half of the year. Chemical oxygen demand and sulfur dioxide emissions have continued to decline, but the ammonia emissions have only decreased by 0.73%, while nitrogen oxide emissions have increased by 6.17%, a huge disparity with the annual emission reduction targets and goals set in the "12th Five-Year Plan".

2 Important policy progress in environment and development in the past year related to recommendations to the government of China

(1) *Marine development and environmental protection was highlighted*

The State Council has approved three national strategic marine economic development plans during 2011, including the Development Plan for Shandong Peninsula Blue Economic Zone, Development Plan for Zhejiang Marine Economic Demonstration Zone, and Development Plan for Guangdong Comprehensive Marine Economic Experimental Zone. It also officially approved the establishment of Zhejiang Zhoushan Islands New Development Area on July 7, 2011, a national new development area designated by the CPC Central

Committee and the State Council, following the new development areas of Pudong in Shanghai, Binhai in Tianjin and Liangjiang in Chongqing. It is also China's first national strategic new development area with the theme of marine economy.

With the quick development and utilization of marine resources, marine environmental pollution and sustainable use of marine resources have been put on the agenda. The CCICED established a task force in 2010 on this topic, which pointed out the following in its policy recommendations to the Chinese government:

"China should take full account of the impact of terrestrial, watershed and coastal development on marine ecosystems. With adherence to ecosystem-based principle of land-ocean integration and river-ocean integration, an endeavor should be taken to strike a balance between marine development and environmental protection in order to achieve coordinated eco-social development in coastal areas and river basins. Efforts should be exerted to step up marine and coastal ecosystem protection and restoration, the service capacities of marine and coastal ecosystems, and also international cooperation and exchanges on marine environmental protection at global and regional levels, ensuring the sustainable use of marine resources. Recent attention shall be focused on the Bohai Sea Basin and China's green marine development strategy to realize coordinated social and economic development of marine resources."

Recognizing those problems, the Chinese government has made more efforts to protect marine environment and this is reflected in the "12th Five-Year Plan": "to coordinate marine environmental protection and land-sourced pollution prevention, and strengthen the protection and restoration of marine ecosystems." The State Council also expressed its plan to develop a national marine functional zoning plan according to the National Ecological Zoning Plan.

In addition, relevant government departments have also implemented policies and measures to enhance marine environmental protection since 2010, including:

1) For the purpose of preventing pollution to marine environment from ships and related operations, the Regulations on the Prevention and Control of Marine Pollution from Ships and Ship-related Operations was promulgated by Ministry of Transport (MOT) on November 16, 2010.

2) In order to regulate law enforcement for marine environmental protection, further clarify regional jurisdiction, level management and case investigation of maritime surveillance agencies, and raise the overall efficiency and level of marine environmental protection law enforcement, the Implementation Measures for Marine Environmental Protection Law Enforcement of China Maritime Surveillance was issued by State Oceanic

Administration (SOA) on December 22, 2010.

3) In view of the random and excessive land reclamation from the oceans and the consequent destruction of marine resources and environment, Ministry of Land and Resources and SOA jointly issued the Circular on Strengthening the Management of Land Reclamation from the Oceans on December 31, 2010.

4) For the purpose of improving emergency response capacity towards ship pollution accidents, and controlling, reducing and eliminating damages caused by marine pollution incidents, the Regulations on Marine Emergency Preparedness and Emergency Response towards Marine Environmental Pollution from Ships was promulgated by MOT on January 27, 2011.

5) In order to guide and promote the preparation of provincial island protection plan, the Comments of State Oceanic Administration on the Preparation of Provincial Island Protection Plan was issued on January 28, 2011.

6) To effectively prevent and curb serious accidents and promote continuous and steady improvement of safe operation of offshore oil production, State Administration of Work Safety (SAWS) issued the Notice on Special Supervision and Inspection of Offshore Oil Production Safety on April 12, 2011, with an enforcement schedule for late April to early July, 2011.

7） Dynamic ocean surveillance and monitoring is an important established system in the Sea Area Use Management Law, it is also a major means for “informationized”, standardized and scientific sea area management. For better operation and application of national marine monitoring and management system, the Comments on Advancing Dynamic Surveillance and Monitoring of Marine Waters was issued by SOA on April 18, 2011.

8）In order to regulate operations in inspection and acceptance of ship-induced marine pollution, prevention capacities of ports, terminals, loading and unloading stations, as well as operating units engaged in ship repair, salvage and dismantlement, the Implementation Rules for the Special Inspection and Acceptance of Capacities in Ship-induced Marine Pollution Prevention and Control was promulgated by China Maritime Safety Administration (CMSA) on June 9, 2011.

While Chinese government departments began to pay attention to marine environmental protection, two severe oil spill incidents in the Bohai Sea have once again sounded the alarm. A serious oil spill at sea in Dalian in July 2010 shocked the world following the BP oil spill in the Gulf of Mexico, and caused very serious ecological damage to the sea area near Dalian. However, relevant government departments still do not have a clear view on the compensation for damages to the marine ecosystem. The Penglai 19-3 oil spill that occurred in June 2011 was not made public until two weeks later and sparked public outcry. The Conoco Phillips enterprise responsible for the accident is slow in action, and has not yet completely cleaned up the oil spill as required by the national regulatory authorities.

Two severe oil spills at sea within a year have forced the Chinese government to take marine environmental protection seriously. Such events once again have exposed many problems for China in handling marine pollution incidents, including weak awareness of corporate responsibility, delayed information disclosure, light punishment for the responsible party, low-level government emergency response capability, and lack of effective damage compensation mechanism and system. Fundamentally, China's marine environmental management system still needs fundamental reform.

(2) *Heavy metal pollution prevention plan approved*

Heavy metal pollution is a major environmental problem attracting attention during the "11th Five-Year Plan" period, and has aroused wide concern from decision-makers to the general public. According to the CCICED special report on soil protection strategy in 2010, "the severe soil pollution in some areas has become a hazard to ecological environment and food safety, which poses a serious threat to public health." The Task Force recommended measures including improving regulations and standards, introducing plans, enhancing prevention, rehabilitation and technological innovation, setting up a regulatory system, improving fund-raising mechanisms, and so on. Since 90% of soil contamination in China is associated with heavy metals, enhanced prevention of heavy metal contamination is of vital significance in addressing the current soil pollution in China.

In early 2011, the State Council approved the "12th Five-Year Plan" for the Comprehensive Prevention and Control of Heavy Metal Pollution, the first thematic plan that underlines the high national attention to soil pollution prevention and control.

The "12th Five-Year Plan" embraces a series of actions to enhance heavy metal pollution prevention and control. It includes the introduction of technological standards, policy measures and management regulations on heavy metal pollution prevention and control related with lead, mercury, cadmium, chromium, arsenic, etc.; the preparation of a directory on products causing high pollution and posing high environmental risks; the comprehensive investigation and remediation of heavy metals polluting industries; optimization of heavy metal-related industrial structure; the improvement of the three major regulatory systems, namely heavy metal pollution prevention and control system, emergency response system, and environmental and health risk assessment system, all of which will lay a solid foundation for the effective control of heavy metal pollution. It is stipulated in the "12th Five-Year Plan" that, by 2015, the discharge of main heavy metals in key regions, such as lead, mercury, chromium, cadmium and arsenic, will be reduced by 15% from the 2007 levels. Heavy metal pollution prevention and control is prioritized in the thematic environmental protection action jointly conducted by nine departments in 2011.

(3) *Keeping a balance between speed and safety supervision of nuclear power development*

With the accelerated development of nuclear energy, nuclear safety regulatory capacity building has also been strengthened. In recent years, seeing the boom of low-carbon economy and new energy development, CCICED has been reminding the Chinese government of the safety issue. Especially in 2009, CCICED warned in the policy recommendations to the government that, "the policy to actively promote nuclear power development is beneficial to improving environmental quality, reducing greenhouse gas emissions and addressing global climate change. However, the government should ensure nuclear energy be developed with the consideration of safety, stability and health".

In 2010, the technical support unit of the national nuclear safety regulatory authorities recruited more than 600 people. After the Fukushima nuclear accident in Japan, the state has paid a lot of attention to capacity building, and the number of relevant divisions under the Ministry of Environmental Protection has expanded from one to three, adding dozens of administrative staff. The nuclear leakage after the Fukushima earthquake on March 11 has caused public concerns about the hidden high risks of vigorous nuclear power development.

The government has also turned its attention to the balance between speed and safety supervision of nuclear energy development. Five days after the nuclear accident, Premier Wen Jiabao chaired a State Council executive meeting and decided to suspend the approval of new nuclear power projects, to expedite the preparation of nuclear safety plan, and to undertake the adjustment and improvement of medium and long-term nuclear power development plan. The State Council has also called for the immediate overall safety inspection of nuclear facilities, and strengthening safety management of nuclear facility operations. China is taking a more cautious attitude at the national strategic level towards the development of nuclear power.

Previously, MEP and the General Administration of Quality Supervision, Inspection and Quarantine jointly issued the Regulations for Environmental Radiation Protection of Nuclear Power Plant (February 18, 2011). It made explicit requirements on the siting of nuclear power plants. Geological and seismic features, and other possible natural or man-made factors within the area that could affect the safety of nuclear power plants, must be taken into consideration. In addition to natural factors, such as earthquakes, the Regulations suggest that, non-residential and restricted areas should be established around the nuclear power plant, with delineation taking into account the radiological consequences of hypothetical accidents. By the end of August, the inspection report on China's nuclear power operation safety was finalized and submitted to the State Council. The Nuclear Safety Plan is still under preparation and a draft will be released before the end of the year for comments.

(4) *Strategic emerging industries vigorously promoted, such as energy saving and new energy*

The Decision on Accelerating the Cultivation and Development of Strategic New Industries, issued by the State Council on October 10, 2010, pointed out that strategic new industries are an important force to guide the future economic and social development. Speeding up the cultivation and development of strategic new industries is the inevitable choice for building a moderately prosperous society and sustaining development, and also an important indicator of China's economic restructuring.

The "12^{th} Five-Year Plan" has clarified the positioning of strategic new industries and relevant development strategies, devoting Chapter 10 in Volume 3 to "fostering seven strategic emerging industries", among which are "energy saving and environment protective" industries and "new energy" industries as pillar industries. The energy saving and environment protective industries will focus on key technologies and equipment, products and services that are energy efficient, advanced, environmentally-friendly, and resource recycling. New energy industries will prioritize the development of next generation nuclear energy, solar thermal power, photovoltaic or solar thermal power generation, wind power technology and equipment, smart grid and biomass energy. Major government departments have also introduced development plans targeted at the two sectors.

As a complementary measure, the National Plan on Science and Technology Development during the "12^{th} Five-Year Plan" Period (MOST [2011] No. 270) released by MOST states that, as far as the energy saving and environment protective sector is concerned, great efforts will be made to boost the development of critical technologies, equipment and systems that are energy efficient, advanced, environmentally-friendly and resource recycling. Programs on semiconductor lighting, clean and efficient use of coal, waste recycling, as well as the "Blue Sky" project will be implemented. Also, technology integration and promotion will be enhanced to rapidly raise China's overall technological competence and industrial competitiveness in the field of energy-saving environmental protection. The new energy industries are encouraged to develop key technologies, equipment and systems, such as wind power, solar photovoltaic, solar thermal, next generation biomass energy, ocean energy, geothermal energy, hydrogen energy, next generation nuclear energy, smart grid and energy storage systems. A new energy technology innovation system will be established to step up the research and development of advanced technologies and models conducive to new energy application, and moreover, effective convergence of new energy production, transportation and consumption should be realized to sustain rapid industrial development.

MEP has outlined the important development direction of environmental protection during the “12^{th} Five-Year Plan” in its Guidance on Further Pushing Ahead Energy Saving and Environment Protective Industrial Development within the Environmental Protection System (MEP [2011] No. 36).

Prioritized areas for development during the “12^{th} Five-Year Plan” include nitrogen and phosphorus facilities upgrading in sewage treatment plants, sewage treatment in medium and small towns, treatment of concentrated non-biodegradable industrial wastewater, nitrogen oxides, submicron particulate matter and air pollution control, sludge disposal, heavy metal pollution prevention and control, large-scale municipal waste incineration, hazardous waste treatment, electronic waste dismantlement and disposal, integrated control of rural and agricultural nonpoint source pollution, contaminated sites and ecological restoration, environmental monitoring and early warning, etc. The overall package of environmental services, specialized services on operations, consultation and engineering are also highlighted.

Meanwhile, MEP has called for environmental protection departments at all levels to serve the transformation of economic and social development, vigorously develop circular economy and clean production, and promote green development. Efforts shall also be made to control greenhouse gas emissions and develop low-carbon technologies, provide support for compliance of environmental conventions, improve people’s livelihood and raise scientific awareness of the public, advocate green consumption and green procurement, promote equality in basic environmental public services, and achieve and share the balanced development of regional, urban and rural environmental infrastructure.

“Develop environmental economic policies to guide the green transformation of traditional enterprises and nurture emerging and environmental protection industries” is an important recommendation provided by CCICED to the Chinese government on advancing the green transformation of economic development mode. Judging from the formulation and implementation of above environmental policies, the Chinese government has determined to expedite the development of strategic emerging industries, such as energy saving and environmentally friendly industry and new energy industry, and has accomplished great achievements. Industrial associations and experts have predicted that, by 2015, the total output value of energy-saving and environmentally friendly industry is expected to exceed RMB 3 trillion, accounting for 8% of GDP. By 2020, the installed capacity of new energy power generation in China will reach 290 million kW, accounting for 17% of the total installed capacity. To break it down, wind power, solar power and biomass power will contribute an installed capacity of 150 million, 20 million and 30 million kW respectively. The above prediction has demonstrated a very bright prospect for the two strategic emerging sectors, which will give confidence to future investors.

(5) *"Energy saving and emission reduction" had a good start in the first year of the "12th five-year plan" with efforts from all departments*

"Energy saving and emission reduction", a major task in the "11th Five-Year Plan", demonstrates the government's determination to practice "green development". Its emission reduction targets had exceeded the expectation while energy saving targets reached the set targets. The "12th Five-Year Plan" has included more specific binding targets for energy saving and emission reduction, a "top priority" in environmental protection. According to the Plan, the emissions of four major pollutants (sulfur dioxide, chemical oxygen demand, nitrogen oxides and ammonia) in 2011 shall be reduced by 1.5% over the 2010 levels.

On the morning of July 19, 2011, Premier Wen Jiabao, also the leader of National Leading Working Group on Addressing Climate Change, Energy Saving, and Emission Reduction (NLWGACC), chaired a leading group meeting, at which the participants reviewed and agreed in principle a comprehensive program for energy saving and emission reduction during the "12th Five-Year Plan".

The meeting determined that, the priority for energy saving and emission reduction during the "12th Five-Year Plan" includes:

① Promote energy saving and emission reduction in key fields. Specifically, the industrial sector should focus on the replacement of backward production capacity with advanced energy production capacity. The transportation sector should emphasize the development of public transport and optimize the use of multi-mode transport. In the field of building construction, efforts should be made to modify existing buildings, develop green buildings and smart buildings, while saving energy, land, water and materials to the largest extent. In daily life, cost-effective energy efficient products are recommended, and energy saving and environmentally friendly consumption patterns and lifestyles shall be cultivated.

② Further adjust and optimize industrial structure, develop a modern industrial system, encourage the tertiary industry and strategic emerging industries to use advanced technologies to transform traditional industries. Energy production and use patterns shall be adjusted for a safe, stable, economical, clean and modern energy industry system. ③ Implement major energy saving projects. Focus should be placed on projects concerning energy, environmental governance and circular economy. ④ Promote the use of advanced technologies. A proper mechanism to select, evaluate and promote energy saving technologies should be established, while foreign advanced technologies should be actively introduced, digested and absorbed; and technology development, demonstration and application expedited, so as to effectively improve energy efficiency and reduce emissions. ⑤ Strengthen energy conservation management. The energy efficiency assessment review system shall be improved and national standards for energy-consuming equipment developed and implemented. Enterprises are encouraged to establish energy-saving measures, ledger and statistical systems and implement various management approaches, such as demand-side management, energy efficiency labeling, and government procurement for energy-saving products. ⑥ Improve long-term energy saving and emission reduction mechanism. Tax incentives shall be introduced, resource taxes and environmental tax reform expedited, import and export tariffs adjusted, as well as high energy consuming and high emitting exports curbed.

The meeting also highlighted the need to actively carry out international cooperation on climate change. On the basis of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, with the principle of “common but differentiated responsibilities” and the principle of fairness, efforts should be made according to the Bali Roadmap to constructively push ahead international negotiations on climate change based on Copenhagen Agreement and Cancun Agreement to achieve further positive results in Durban Conference on UNFCCC, and the comprehensive, effective and sustained implementation of the Kyoto Protocol.

Central government departments have also put forward a series of energy saving policies to facilitate the realization of the goals set in the “12^{th} Five-Year Plan”.

Firstly, energy saving and emission reduction should be intensified in key industries and key fields. ① Energy saving and emission reduction should be extended to rural areas and small towns. To speed up the development and utilization of renewable energy in rural areas, optimize rural energy structure, promote clean energy and energy modernization in rural areas, Ministry of Finance (MOF), National Energy Bureau (NEB), and Ministry of Agriculture (MOA) jointly issued the Interim Measures for Managing Subsidies for Building

Green Energy Demonstration Counties on April 6, 2011. In addition, in order to promote a healthy, coordinated and sustainable development of China's small cities and towns, MOF and Ministry of Housing and Urban-Rural Development (MOHRUD) jointly issued the Implementation Opinions on the Pilot Demonstration of Small Green Cities and Towns on June 3, 2011. ② Energy saving should be further promoted in public buildings and public transportation. In order to fully tap energy saving potential of public buildings and apply energy saving service mechanisms, such as energy efficiency transaction, contract energy management in the field of building energy saving, MOF and MOHRUD jointly released the Circular on Further Promoting Energy Saving in Public Buildings on May 4, 2011, aiming to reduce energy consumption per unit area of public buildings by 10% during the "12th Five-Year Plan", and by 15% in large public buildings. MOT released the "12th Five-Year Plan" for Energy Saving and Emission Reduction in Highway and Waterway Transportation on June 27, 2011. Approved by the State Council, the Central Finance will allocate appropriate funds from the general budget and special transportation fund from vehicle purchase tax to support energy saving and emission reduction in highway and waterway transportation during the "12th Five-Year Plan". To regulate financial management and improve capital efficiency, MOF and MOT jointly issued the Interim Measures for Special Fund Management for Energy Saving and Emission Reduction in Transportation (CJ [2011] No. 374). ③ Guidelines for energy saving in key sectors are published. Cement industry is an important sector for China's economic development, but also a major energy resource consumer and pollutant emitter. In order to improve energy efficiency and reduce emissions in the cement industry, Ministry of Industry and Information Technology (MIIT) issued the Guidance on Energy Saving and Emission Reduction in the Cement Industry on November 25, 2010, as well as Circular on the Establishment of Industrial Energy Efficiency Monitoring System on May 18, 2011.

Secondly, efforts in energy saving technology research and development, governance tools and pilot demonstration are enhanced. MEP issued the Science and Technology Development Plan for National Environmental Protection during the "12th Five-Year Plan" on June 9, 2011. It intends to invest RMB 22 billion at the national level for key technology in 12 fields. Among them, water pollution control will receive the largest amount of input, at RMB 5.0 billion, followed by air pollution control, and solid waste and soil pollution prevention and control with an investment of RMB 3.0 billion and RMB 2 billion respectively. MOF and NDRC jointly issued the Circular on Carrying out Comprehensive Demonstration for Energy Saving and Emission Reduction Fiscal Policy on June 22, 2011. According to the circular, Beijing, Shenzhen, Chongqing, Hangzhou, Changsha, Guiyang, Jilin and Xinyu are included in the first 8 cities to carry out comprehensive energy saving and emission reduction demonstrations in low carbon industry, clean transportation, green building, intensive services, reduction of main pollutants, and large-scale utilization of renewable energy. Existing policies in support of energy saving, emission reduction and renewable energy development will give priority to the pilot cities. To effectively solve the problem of water pollution in key river basins, a special fund of RMB 5.0 billion will be earmarked from the Central Finance in 2011 for water pollution control in the three rivers (Huaihe River, Haihe River and Liaohe River), three lakes (Taihu Lake, Chaohu Lake and Dianchi Lake) and the Songhua River Basin. Meanwhile, incentives will fully replace subsidies.

Thirdly, the supervision and implementation of energy saving and emission reduction shall be strengthened. MEP issued the Supervision and Inspection Program for the Implementation of Environmental Protection and Pollution Reduction Policy on June 29, 2011, and demanded 14 provinces (regions) including Inner Mongolia, Jiangsu, Zhejiang and Jiangxi, to submit a self-examination report to MEP no later than August 31, 2011. MEP and member units sent an inspection team to carry out the annual supervision and inspection in September 2011.

(6) *National major function zoning plan implemented*

CCICED's recommendations in 2010 stated that the government needs to: "Implement green regional development strategies by taking into account resources and environmental capacity, biodiversity conservation needs, and establish within China regional cooperation mechanisms for ecological protection. It is equally pivotal, however, to strike a balance between regional rejuvenation and green transformation: ① regional strategies and plans should conform to the National Ecological Zoning Plan, and the development direction of a region should be determined by its resource and environmental capacity so that pollution and ecological damage will not come together with the industries that gradually transfer to these regions; ② in the richer eastern region, ecological preservation should be prioritized and optimized development strategy should be implemented; while in the ecologically vulnerable west, a green development strategy should be introduced, focusing on ecological innovation and giving greater attention to biodiversity conservation. These strategies will help build a resource-conserving and environment-friendly society; ③ coordination and cooperation among the localities is needed. It is desirable to establish a comprehensive cooperative mechanism on regional ecological protection and joint pollution prevention, control and treatment."

The State Council released the Circular on National Ecological Zoning Plan (GF [2010] No. 46) on December 21, 2010, which is a regulatory planning document on the strategic land spatial development. In the process of building ecological zones, one needs to take full account of population distribution, economic layout, land use and urbanization pattern, and to identify ecological zones in relation to their resources and environmental carrying capacity, existing development intensity and development potential in order to control development intensity and regulate development sequences.

The National Ecological Zoning Plan will divide national land space into zones for optimized development, key development, restricted development and prohibited development.

Optimized development zones are economically advanced, densely populated and intensively developed, but face more prominent resources and environmental issues. For these zones, industrialization and urbanization should be optimized.

Key development zones have a moderate economic base, strong resources and environmental capacity, and sound conditions for population and economic concentration, with great development potential, so the development of industrialization and urbanization should be prioritized in these areas.

Restricted development zones fall into two categories. ① Main producing areas of agricultural products. Being arable land and in good condition for agricultural development, although these areas are suitable for industrialization and urbanization, large-scale and intensive development towards industrialization and urbanization is restrained in those areas due to issues with national agricultural security and sustainable development. The priority for these areas is the improvement of overall agricultural production capacity. ② Key ecological functional zones. Given the fragile ecosystems or important ecological functions, and low resources and environmental capacity, such regions are not suitable for large-scale intensive development.

Prohibited development zones refer to a variety of protected areas for their natural and cultural values by law, as well as critical ecological functional areas banned from industrialization and urbanization development. At the national level, national nature reserves, the world cultural and natural heritage, national scenic areas, national forest parks and national geological parks are all prevented from such development. At the provincial level, industrial and urbanized development is prohibited in a variety of natural and cultural resource protected areas and important water source sites, as well as other areas identified by provincial governments as needed.

The National Ecological Zoning Plan highlights the principle of “natural conservation”.

The Plan is based on the following concepts:

① It is equally important to protect waters, wetlands, woodlands and grasslands as well as arable land. ② Industrial and urban development should be based on comprehensive evaluations of resources and environment carrying capacity in the region and be strictly confined within such capacity. Regional planning should also undergo the same evaluation process. ③ In areas with fragile eco-systems, water shortages, small environment capacity and prone to geological disasters such as earthquakes and natural disasters, the industrial and urban development should be rigidly restricted, while other development activities may be subject to appropriate control, in order to ease the pressure on natural ecology. ④ All kinds of development activities harmful to the environment are prohibited. Energy and mineral resource development shall not compromise the environment, and they should restore the original ecological environment the best they can. ⑤ Original river ecological protection shall be fortified through the transition from post-treatment to beforehand protection. A strict water management system will be put into practice, which specifies indexes for the development and utilization of water resources, limits of pollutants in water functional areas and water efficiency. Water resources shall be developed in an orderly manner on the basis of river ecosystem protection, while groundwater exploitation is subject to strict control. Comprehensive treatment and prevention monitoring of soil erosion will also be enhanced. ⑥ Infrastructure construction, such as transportation and transmission facilities should not be allowed to go through important natural landscape and ecosystems, and their passage will be strictly controlled. ⑦ Agricultural development shall be considered with its impact on natural ecosystems. Agricultural development activities, such as land reclamation, the occupation of waters, wetlands, woodlands and grassland, are prohibited, if harmful to natural ecosystems. ⑧ On the premise of no decrease in cultivated land and farmland within the provincial territory, it is encouraged to turn farmland to forest, pasture to grassland, and land to lakes in relevant regions, especially to turn farmland to lakes where agricultural water use far surpasses the regional water capacity. ⑨ Ecological debts due to eco-damage should be repaid as soon as possible. Ecological restoration actions should be conducive to building ecological corridors and ecological networks. ⑩ Natural spaces, such as natural grassland, marsh, reed bed, beach, permafrost, glacier and permanent snow, are all under protection.

Requirements for national main functional zones are included in the "12th Five-Year Plan" (Chapter 19). These requirements are specified below.

In accordance with laws, regulations and policies on main ecological functional zones, the compensation mechanism shall be improved during the "12th Five-Year Plan". Central

Finance will step up transfer payments in main agricultural production areas and key ecological functional areas, particularly in central-western regions, and enhance essential public services and environmental protection capabilities. Provincial finance shall improve transfer payment policies. Government investment shall be allocated according to ecological functional zones and fields, with the focus on key ecological functional zones and main agricultural production areas, while the investment by fields shall conform to the positioning and development direction of ecological functional zones. The existing Industrial Guidance Catalogue shall be revised and improved to identify industries encouraged, restricted and prohibited in ecological functional zones. In addition, it is necessary to implement differential land management policies based on scientific evidence on land use scale and control, enforce different pollutant emission control and environmental standards in different ecological functional zones, as well as improve the corresponding agricultural, population, ethnic, and climate policies, etc.

In order to guarantee the implementation of the National Ecological Zoning Plan, both National Ecological Zoning Plan and the "12th Five-Year Plan" have provided an innovative assessment mechanism for differentiated evaluation and examination according to different ecological functional zones. The assessment will look at economic structure, technological innovation, resource utilization and environmental protection in optimized development zones, and a comprehensive assessment will look at economic growth, industrial structure, quality and efficiency, energy saving, environmental protection and population absorption in key development zones. In restricted development zones, like major ecological functional zones and main agricultural production areas, performance evaluation will be conducted, with priority given to agricultural development and ecological conservation, regardless of regional GDP and industrial index. In areas prohibited from development, a comprehensive evaluation of natural and cultural resources' authenticity and integrity will be conducted.

Ecological functional zoning is a major initiative for the Scientific Outlook of Development. It will help economic restructuring accelerate the transformation of economic development mode and realize scientific development. It will enhance regional development, bridge gaps in regional basic public services and raise people's living standards. It is also instrumental in terms of rationalizing distribution of population and economic layout based on resources and environment carrying capacity. It is conducive to reversing the ecological deterioration trend from the source, enhancing resource conservation and environmental protection, facilitating adaptation to and mitigation of climate change, and realizing sustainable development. It will help to break the boundaries of administrative divisions and develop more targeted regional policies and performance evaluation system for improved regional control.

(7) *Attention paid to eco-environment protection and restoration*

"Ecological conservation" is a core recommendation CCICED put forward to the Chinese government in 2010. Continuous high economic growth and domestic consumption has imposed imminent pressure on ecosystems, which needs our attention. The "12th Five-Year Plan" dedicates a chapter to "promoting ecological conservation and restoration".

According to the "12th Five-Year Plan", protection and natural restoration are given priority in the effort to enhance ecological protection and construction, so as to reverse the ecological deterioration trend from the source. An ecological security barrier shall be established to reinforce the conservation and management of major ecological functional zones. In addition, work should be done to strengthen the supervision of nature reserve construction for elevated management and protection standards; enhance bio-safety management and increase the protection and management of bio-species resources, effectively and proactively preventing the loss of species resources and keeping away alien invasive species; establish an ecological compensation mechanism; increase balanced transfer payments in major ecological functional zones and set up a national ecological compensation special fund. Moreover, the downstream areas, development areas and ecologically beneficial areas are encouraged and guided to implement ecological compensation to the upstream areas, protected areas and ecologically protected areas respectively.

One of the priorities in 2011 has been to strengthen ecological conservation, said Minister of Environmental Protection Zhou Shengxian at the national work conference on environmental protection on January 13, 2011. Specifically, efforts should be made to properly distribute the tasks outlined in China's Strategy and Action Plan for Biodiversity Conservation (2011—2030); to conduct demonstration on biodiversity conservation and restoration, and poverty reduction; to implement the Notice of the State Council on Better Management of Nature Reserves and strengthen the supervision on the development and construction related to nature reserves; and to start the Periodic Remote Sensing Survey and Evaluation on National Eco-environmental Changes (2000—2010). In order to improve the evaluation of ecological impacts during environmental impact assessment, a national environmental protection standard, The Technical Guideline for Environmental Impact Assessment: Ecological Impact (HJ 19—2011) was issued by MEP on April 8, 2011 and became effective as of September 1, 2011.

Since 2010, the government has introduced ecosystem protection regulations targeted at two major ecological zones in China—Greater and Lesser Khingan Ranges and the Qinghai-Tibet Plateau region. National Development and Reform Commission and State Forestry Administration jointly issued the Planning for Ecosystem Conservation and Economic Restructuring in Greater and Lesser Khingan Ranges (2010—2020) on December 16, 2010. It points out that, by 2020, the forest area in Greater and Lesser Khingan Ranges will increase by 1.7 million ha over the 2009 level, with the forest coverage up by 4%. Growing forest stock will see a rise of 400 million m^3 and account for more than 30% of new forest stock volume. On March 30, 2011, the State Council executive meeting passed the Planning for Ecosystem Conservation and Economic Restructuring in Qinghai-Tibetan Plateau Region (2011—2030), according to which the Qinghai-Tibetan Plateau Region is divided into ecologically conservation areas, urban environmental maintenance areas, agricultural and pastoral areas, etc.

Subsidy incentive implementation for grassland ecological protection is being carried out steadily. According to the decision of the State Council executive meeting, a subsidy incentive mechanism started to be established for grassland ecological conservation in 8 major grassland provinces (regions), including Inner Mongolia, Xinjiang, Tibet, Qinghai, Sichuan, Gansu, Ningxia, Yunnan and Xinjiang Production and Construction Corps in 2011, according to which herdsmen are entitled to subsidies for banning grazing and stock raising, as well as to incentives for balancing livestock and grassland. To ensure the conscientious implementation of such policy, MOF and MOA jointly issued the Circular on Better Preliminary Work for Building the Subsidy and Incentive Mechanism for Grassland Ecological Conservation on December 31, 2010.

An “ecological compensation” system is critical to strengthening ecological protection. CCICED has recommended in 2010 to “expedite the process of legislation on ecological compensation, and improve relevant policies and mechanisms”. The Ecological Compensation Ordinance, is still under preparation led by NDRC. It is intended to clarify basic principles, main fields and approaches for ecological compensation; the rights and obligations of stakeholders, and various safeguard measures. Specific regulations shall be introduced to cover waters, forests, grasslands, wetlands, mineral resources etc. According to NDRC and the Ministry of Finance (MOF), China’s first “national comprehensive experimental area for ecological conservation” will be set up in Three Rivers Areas, and China’s first ecological compensation scheme, the Overall Implementation Program for Three Rivers Ecological Compensation Mechanism, is also in the pipeline. China’s ecological compensation proceeds simultaneously in regulations, policies and practices.

(8) *Rural pollution prevention and environmental protection further enhanced*

Rural environmental protection has long been an Achilles heel for environmental protection in China. CCICED has suggested in the 2010 policy recommendations the need for:

"comprehensively improving rural ecological environment and shortening the gap between urban and rural areas in terms of ecological civilization. At present, the acute environmental problems in Chinese rural areas have become the weak link in China's ecological and environmental protection, which directly impacts the quality of life for most of the Chinese population and the equitable sharing of China's development achievements. During the "12^{th} Five-Year Plan", the Chinese government should fully enhance rural ecological environment and strive for a breakthrough."

Rural environmental protection has attracted the CPC and government's attention ever since the "New Socialist Countryside Construction" was initiated in 2005. In July 2008, the national teleconference of the State Council on rural environmental protection was held, marking the official onset of efforts to protect rural environment.

The "12^{th} Five-Year Plan" also includes stipulations on rural environmental protection. According to "promoting the comprehensive improvement of rural environment" (Section 4) in "improving rural production and living conditions" (Chapter 7), efforts should be made to control pollution from non-point sources, such as pesticides, fertilizers and plastic sheeting; comprehensively push forward pollution prevention and control of livestock breeding; strengthen rural drinking water source protection and the comprehensive treatment of rural rivers and water pollution; and enhance supervision and management of soil pollution prevention. In addition, rural sanitation projects shall be implemented to speed up the concentrated treatment of rural garbage and contiguous environment in rural areas. Urban and industrial pollution is strictly prohibited from spreading to rural areas.

According to the Opinions on Further Strengthening the Work of Rural Environmental Protection (MEP [2011] No.29) issued by MEP on March 15, 2011, the general idea of environmental protection in rural areas during the "12^{th} Five-Year Plan" is as follows:

Under the guidance of the Scientific Outlook of Development, with improving rural eco-civilization, protecting and improving people's livelihood as the theme, ecological construction demonstration initiatives, pollution reduction, as well as the responsibility system for integrated environmental management targets shall be carried out in rural areas as the starting point, to enhance treatment while intensifying the "incentives for treatment" policy. An endeavor should be exerted to solve prominent environmental issues undermining public health and sustainable rural development to effectively curb the expansion of urban and industrial pollution to rural regions and to improve environmental quality in rural areas in order to build a moderately prosperous society in rural areas.

The environmental protection targets in rural areas during the "12th Five-Year Plan" are: by 2015, to complete integrated environment treatment in 60,000 administrative villages, targeting prominent environmental problems severely harmful to public health in rural areas; to improve water quality and management in rural drinking water sources; to significantly increase the level of pollution control in rural sewage and garbage disposal, large-scale livestock farms (plots) and densely free range areas; to enhance rural soil environmental protection and agricultural non-point source pollution prevention and control; to preliminarily improve environmental quality in rural areas; and to raise rural environmental monitoring capacity and farmers' environmental awareness.

A national work conference on environmental protection in rural areas was held by MEP on 28–29 March 2011. MEP Vice Minister Li Ganjie attended the conference and pointed out that the work focus of environmental protection in rural areas during the "12th Five-Year Plan" could be summarized as: ① to draft and implement a national "12th Five-Year Plan" for rural environmental protection, ② to start the legislation process for the Livestock Pollution Prevention Regulations and the Law on Soil Environmental Protection urgently, ③ to intensify environmental law enforcement, environmental monitoring, environmental dissemination in rural areas, ④ to promote environmental treatment through incentives, innovation, emission reduction and inspection, and ⑤ to aim for results in protection of drinking water sources, sewage treatment, garbage disposal, pollution prevention and control in livestock breeding and soil environmental protection in rural areas.

China has a large rural area and a big rural population. Effective environmental protection in rural areas touches upon the interest of each individual and decides the results of environmental protection in China. Most severe environmental pollution incidents in recent years have occurred in rural areas. As urban environmental quality gradually improves, the government is shifting the focus of environmental protection to rural areas. The worsening environmental trend in rural areas is expected to be significantly curbed during the "12th Five-Year Plan".

(9) *New progress in China's environmental governance*

1) Resources, energy, and environmental laws and regulations

In terms of legislation concerning environment and natural resource protection, amendments have been made to environmental pollution crime in the Criminal Law, as well as Law for Soil and Water Conservation.

The Amendment (VIII) to the Criminal Law of the People's Republic of China, adopted at the 19th Session of the Standing Committee of the 11th National People's Congress (NPC) on February 25, 2011, has lowered the threshold for environmental crime conviction. The legislative provisions on environmental pollution crimes in China have been modified, which will stipulate sound conditions for the government to step up efforts to combat environmental pollution crimes.

Article 338 of the Criminal Law (Crime of Undermining Protection of Environment or Resources) before the amendment reads: "A person who, in violation of the State's regulations, discharges, dumps or disposes of radioactive wastes, wastes carrying infectious pathogens, poisonous substances or any other dangerous substances to land, water or air, thus causing a severe accident of environmental pollution, shall be sentenced to fixed-term imprisonment of not more than three years or criminal detention, and be concurrently or independently fined, if severe consequences or a great loss of public or private property or bodily injury or death of another person is caused; and if the consequences are especially severe, to fixed-term imprisonment of not less than three years and not more than seven years, and be concurrently fined." Article 338 is amended to read: "A person who, in violation of the State's regulations, discharges, dumps or disposes radioactive wastes, wastes carrying infectious pathogens, poisonous substances or any other hazardous substances, thus causing severe environmental pollution, shall be sentenced to fixed-term imprisonment of not more than three years or criminal detention, and be concurrently or separately fined; If the consequences are especially severe, to fixed-term imprisonment of not less than three years but not more than seven years and be concurrently fined."

Amendments are as follows: ① "thus causing a severe accident of environmental pollution, and if severe consequences or a great loss of public or private property or bodily injury or death of another person is caused" is amended to be "severe environmental pollution". The most important change gives more prominence to environmental protection itself, rather than environmental interests attached to personal interests and property interests. Accordingly, the charge is amended from "crime of major environmental pollution accident" to "crime of undermining protection of environment and resources". ② "Dangerous substances" discharged, dumped or disposed is amended to be "hazardous substances", and "to land, water, or air" is deleted. It greatly lowers the threshold for crime conviction.

Law of the People's Republic of China for Water and Soil Conservation (Amendment) adopted at the session of NPC Standing Committee on December 25, 2010 includes the guiding principle of protection first, highlighting priority and scientific management. It further strengthens the legal status of soil and water conservation planning, improves measures on soil erosion prevention and control, and enhances monitoring systems and supervision measures for soil and water conservation. It also increases penalties for violations of soil and water conservation, with the maximum fine raised from RMB 10 000 to RMB 500 000.

The State Council formulated Land Reclamation Regulations and amended Regulations on the Safe Management of Hazardous Chemicals from October 2010 to July 2011. The Administrative Regulations for the Recovery and Disposal of Waste Electrical and Electronic Products, which was adopted at the 23rd Executive Meeting of the State Council on August 20, 2008, has become effective on January 1, 2011. As a supporting document, the Administrative Measures on the License for the Disposal of Waste Electrical and Electronic Products, was promulgated by MEP on December 15, 2010.

In addition, MEP and other departments have also developed and revised the Administrative Measures for the Import of Solid Waste, the Regulation on the Safety and Protection of Radioisotopes and Radiation Devices, the Measures for Information Report of Environmental Emergencies Administrative Measures for the Tip-off Hotline for Environmental Protection and the Measures for the Ex-post Supervision of Environmental Administrative Law Enforcement.

2) Judicially-driven environmental protection

Encouraging progress has been achieved in the field of environmental justice over the past year. Environmental protection courts have been set up in some places, e.g. in Hainan, and some will be set up, e.g. in Chongqing. Public interest litigation cases and the amount of compensation have gradually increased.

The Xinyi municipal government brought an action against Zijin Mining in October 2010 for damages as a result of gangue dam collapse, and demanded RMB 19.5 million in compensation. The guilty verdict was received on January 30, 2011 that the defendant was guilty of the major environmental pollution accident and sentenced to a fine of RMB 30 million. With an already paid administrative fine of RMB 9,563,100, the defendant still needs to pay RMB 20,436,900. It is the most severe sentence against the violation of environmental laws in Chinese history.

Meanwhile, two public interest litigation cases in China’s southwest provinces marked the beginning of public interest litigation in China. One involved a paper mill in Guizhou Province and the other a company dealing with livestock farming in Yunnan Province. Both cases were brought to the justice system by the local government and environmental protection departments against polluters for damages on behalf of the public. It can be expected that, with the growing number of cases like these, polluters will pay higher costs for the violation of laws. The cases like these will play a positive role in curbing the frequent environmental violations.

3) Information disclosure and public participation

Information disclosure and public participation in China's environmental protection is still mingled with feelings of hope and fear. Environmental Open Information: between Advance and Retreat, an open report on pollution information transparency index in 113 cities during 2009—2010, released by private environmental organizations on December 28, 2010, shows that in 2009—2010, China's environmental information disclosure continued to improve overall, and some cities even saw large improvements. However, progress was unevenly distributed. Information disclosure remains at a low level in some cities.

The recent oil pollution incident in the Bohai Sea makes environmental information disclosure and public knowledge a public focus. The oil spills in CNOOC's oil field in Bohai Sea in June 2011 was not announced to the public until two weeks later, which aroused strong public outcry. The incident has once again sparked public concern for environmental information and indicates there is still a long way to go for environmental information disclosure in China. Nevertheless, the incident was first exposed to the public through the micro-blog, which demonstrates that public participation in new ways of information dissemination will enhance environmental information disclosure and thereby step up public supervision.

In terms of public participation, without a doubt, the adjustment to the Upper Yangtze National Nature Reserve for Rare and Endemic Fish Species and Chinese parasol tree in Nanjing are the most famous events in the past year. In both cases, the "public gatekeeper" played an important role of keeping the public informed of government actions and their environmental implications.

China's information disclosure and public participation in environmental protection have strived forward though still faces difficulties. These are topics concerning which CCICED has made a number of recommendations over the past half-decade.

3 Conclusion

In the face of an extremely complex domestic and international environment, China successfully achieved the targets in the "11th Five-Year Plan" for energy conservation and emissions reduction. The Chinese government is determined to transform economic development mode, to build a resource-saving and environmentally friendly society and to pursue a new path for environmental protection. The government has learned a lesson from the “10th Five-Year Plan”, surpassed most of the environmental targets in the “11th Five-Year Plan” and has accumulated valuable experience for reaching the new targets set for the “12th Five-Year Plan”.

Looking back at the Chinese government’s environmental and development policies in the past year, we need to pay special attention to some signs of important policy development:

(1) Ecological protection has escalated to equal importance with energy conservation and emission reduction.

(2) Some “strategic emerging industries” as energy saving, environmental protection and new energy industries have become drivers for environmental protection and economic development, but we must be vigilant about their potential environmental impacts on the development process.

(3) The era of balanced environmental protection between urban and rural areas has begun.

(4) The environmental legislation has been further strengthened, and the awareness of and public participation in legal actions for environmental issues are enhanced.

The year 2011 is the first year of China’s “12th Five-Year Plan”, and it is also the last year of CCICED Phase IV. In the past five years, the CCICED has focused on building a well-off society, closely linked with the policy demands of the Chinese government for environment and development, and conducted a large number of early warning and forward-looking policy studies in a planned and systematic way. Some of these studies have formed the leading edge in China and stimulated a wave of domestic research (including low-carbon economy, green economy, green administration).

During the period of CCICED Phase IV, China’s development has been closely integrated into the economic globalization process. The CCICED has made important contributions to promoting China’s sustainable development as an important part of global sustainable development, and has fulfilled its mission of propelling China to establish a new relationship between economic development and environmental protection, and of exploring a new road of environmental protection while pursuing economic development. In addition to providing direct support for some major domestic issues, CCICED has also responded to a number of urgent and difficult topics, carrying out early-warning and forward-looking studies on issues such as management of chemicals, soil environmental protection, environment and health, climate change, and China’s outgoing direct investment (ODI). The CCICED Phase IV has reached a higher elevation in terms of policy research topics, content, methods, and policy recommendations, enhancing its role as a high-level advisory body to the Chinese government.

Part II CCICED 2010 AGM Recommendations to the Government of China

This section is reproduced from the Proceedings of the 2010 CCICED Annual General Meeting. It is included in this report for the convenience of CCICED members and others interested in forming their own opinions on the impacts and congruence of CCICED recommendations with the many policy shifts described above.

The 4th Annual General Meeting of the China Council for International Cooperation on Environment and Development (CCICED) Phase IV was held from November 10th to 12th 2010 in Beijing. The theme of the meeting was "Ecosystem Management and Green Development."

The council members note that, despite the plethora of approaches to promoting green development, one issue in this context has not gained as much attention as it deserves, either within China or elsewhere: the protection of ecosystems and enhancing their ecological function and services. Certainly China has undertaken major initiatives to restore forests, grasslands, wetlands and to designate nature reserves and protect species and other components of the country's natural capital. Yet much more remains to be done and the situation will grow more urgent with rising domestic consumption and continuing high rates of economic growth. The council members voice their special concern over the frequent natural disasters that have plagued China this year, such as droughts, floods, landslides, typhoons and earthquakes. These disasters have rung alarm bells. They have exposed the fragility of the country's ecosystems and, in some instances, the desperate need for enhanced eco-services. In the future, climate change will place even more pressure on already overworked ecosystems.

Both theory and practice show that improved ecological management can help protect biodiversity and enhance ecological services. CCICED has two task forces reporting this year. One studied key ecological factors in terrestrial ecosystems (forest, grassland and wetland), and the second examined the sustainable use of China's marine and coastal ecosystems. Other studies were carried out regarding soil pollution, conservation of aquatic ecosystem services, the need for mainstreaming biodiversity conservation, and on the status of China's ecological footprint. Based on the discussions during the Annual General Meeting and the results of the task forces and other studies, the CCICED AGM 2010 proposed the following policy recommendations to China's central government.

1 Changing views and management approaches regarding ecosystem services and management, and updating the national strategy on ecological protection and rehabilitation

China should change its views and approaches regarding the use of natural capital; set healthy ecosystems and highly functional eco-services as a key goal; and take a holistic ecosystem management approach. The council members further recommend that with these changes, key goal and management approach in mind, China should update the national strategy on ecological conservation and development in an effort to enhance the overall economic and social value of China's natural capital.

(1) Change views and recognize the holistic and multi-functional nature of China's ecosystems from a scientific development point of view. Scientific research and public education about ecosystems should be strengthened to raise the awareness of both policy makers and the general public about the multiple services and high value that ecosystems and their biodiversity can provide. This should lead to greater public participation in ecosystem protection. Of critical importance is the introduction of the ideas that improvement of ecosystem management could bring about multiple benefits of economic development, poverty alleviation, as well as job creation. It is of critical importance that both the quantity and quality of ecosystem services are improved at the same time.

In addition, management approaches should place as much attention on the functions of ecological regulatory processes, cultural enjoyment and ecological support as on the supply function of ecosystems. The former functions should be well protected, improved and given long-term attention. The goal for ecological conservation and development should be a healthy and resilient ecosystem with continuously improved eco-services. Biodiversity conservation should be mainstreamed into development strategies, and into the general efforts for ecological protection. A holistic and integrated view of ecosystem management embracing the linkages from China's mountaintops to its seas should be upheld as a basic approach in ecosystem management.

(2) Introduce National Medium and Long Term Strategic Guidelines on Ecological Protection and Development, and establish a coordinated action framework. During a nation's development, science and technology provide the driving force, education is the basis, talents are the key, and natural capital the roots. By drawing upon the modality of national guidelines on science and technology, education and human resources development, and taking into consideration the National Plan for Ecological Development (1998—2050), the National Guidelines on Ecological Conservation (2000—2030), and the results of the

recently completed Macro Environmental Strategy Study, China should draft National Medium to Long Term Strategic Guidelines on Ecological Protection and Development.

The Guidelines can integrate various functions of the ecosystem and help the government to manage the country’s ecosystems holistically. Consequently, the problems brought about by the current separated and jurisdiction-based management system will be resolved. Bearing in mind the National Plan on Ecological Functional Zoning, the Guidelines should incorporate the protection of all ecosystems, including forest, grassland, soil, wetland, rivers, lakes, seas, and groundwater, as well as the endeavors of biodiversity conservation, ecological preservation and pollution control. The umbrella Guidelines should also identify the medium to long term targets and tasks for ecological protection and development in China. Based on the proposed Guidelines, subordinate plans or measures targeting specific types of important ecosystems should be developed.

(3) Establish a more comprehensive cross-sector and trans-regional coordination mechanism and an effective ecosystem management system. For an integrated use and management of ecosystems to be feasible, China should take a long term view and work towards the establishment of an administrative body that holds more fully the powers for regulating ecological conservation and development, with the current need being the establishment of an effective inter-ministerial and trans-regional coordination mechanism. Many problems such as: overlap of mandates; blurred responsibilities, powers and interests; coordination difficulties; and high management costs will have a better chance to be resolved.

At the central government level, a cross-sector and trans-regional coordination mechanism needs to be established that focuses on the entire ecosystem management and trans-regional river basin systems. It is important to streamline the responsibilities between central and local; between different ministries; and between upstream and downstream jurisdictions. At the local level, particularly in middle and western regions of China, it is important to establish an inter-provincial and intra-provincial ecosystem management coordination mechanism that becomes the decision-making body for ecological development, planning and management. This mechanism will facilitate inter-agency coordination and prevent unilateral and uncoordinated decision making.

The responsibility for biodiversity conservation and ecological preservation should not be limited only to national authorities on forestry, environmental protection, land and resources, and water resources, but also should be mainstreamed into the portfolio of the economic, industrial and agricultural agencies.

(4) China should encourage wider participation of the general public, enterprises,

communities and NGOs in ecosystem management. Among other means this can be accomplished through education and awareness raising, market mechanisms such as eco-compensation that links their incomes with ecosystem health. Of critical importance is the creation of incentives, such as eco-product labeling and certifying process, to encourage the private sector to get involved and manage certain ecological services, foster certain new sectors, strengthen enterprises' social responsibilities, and reduce their ecological footprint. It is important to engage communities and individuals, especially those living in and directly exploiting natural ecosystems, to raise their awareness of the importance of the ecosystem health, explore sustainable community action mechanisms, improve information disclosure, and alter their behaviors. Ecosystem service and management should be included into school curriculums and education programs. One critical path is to engage NGOs in ecosystem management and ask them to lead, support, monitor and implement the system themselves. A combination of both top-down and bottom-up approaches would help form a stronger force in ecosystem protection.

2 Strengthen environmental management and allow key terrestrial ecosystems to recover

China should regard the terrestrial ecosystems as a whole; use systematic and coordinated approaches to improve terrestrial ecosystems management; introduce relevant laws and regulations, plans, policies, and measures; and grant more financial support to ensure success of these measures. The measures will help the important terrestrial and their associated aquatic ecosystems to rehabilitate.

(1) Amend or draft protection and recovery plans on important terrestrial ecosystems. In light of the proposed National Medium to Long Term Strategic Guidelines on Ecological Protection and Rehabilitation, sub-plans on specific terrestrial and freshwater aquatic ecosystems should be formulated on the basis of geographical distribution and ecological boundaries. These sub-plans should be mutually supportive and linked. It is important to establish a dedicated prevention, supervision and rehabilitation planning and management system that deals with social and economic activities with possible serious ecological concerns, such as mining and large infrastructure projects.

(2) Strengthen legislation on ecosystem management. The legal system for ecosystem management should be continuously improved. The following actions are needed: ① Revise the more than 20-year old Environmental Protection Law, to better coordinate ecosystem management with pollution control, as well as to update principles, views and provisions. ② During the legislative improvement of related laws and regulation, China should safeguard the holistic nature of ecosystem protection. ③ In the legislative upgrading of

economic laws and regulations, it is important to factor in the requirements of natural systems and "green" such pieces of legislations.④ On the basis of a comprehensive review of existing biodiversity protection laws and regulations, facilitate the convergence between international conventions and domestic regulations. An umbrella law on biodiversity conservation should be mapped out in order to fully implement the National Biodiversity Protection Strategy and Action Plan (2011—2030) and to comply with the Convention on Biological Diversity, thus fulfilling China's international commitment to biological diversity protection. ⑤ Strengthen the enforcement of ecosystem management laws and regulations.

(3) It is important to strengthen the capacity of the society and ecosystem in the event of natural disasters. Natural rehabilitation should be given more priority over human intervention, so as to strengthen the ecosystem's own capacity in coping with natural disasters. Preservation and protection should start from the beginning of social and economic activities. Where appropriate, watersheds, rivers, lakes should be equipped with more capacity in flood control, with reinforced hydraulic infrastructure. It is important to establish various systems in disaster-prone areas, including assessment and monitoring, emergency response and contingency plans, as well as a post-disaster reconstruction process.

(4) Increase long term input for the protection and management of terrestrial ecosystems. The long term nature of ecological preservation and recovery requires long term financial support and stable policies of the government. China should increase long term financial input by exploring and leveraging multiple investment and financing channels, and formulate a stable policy environment. Existing ecological programs need to be continued, including those aimed at converting farmland back to forest/grassland, at preserving virgin forests, at treating the source of sandstorms affecting Beijing and Tianjin, at restoring grasslands from overgrazing, at conserving water and soil and for protecting wetlands, lakes and river aquatic ecosystems. The channels and total sum of financial support should be guaranteed in order to consolidate the progress achieved so far. Greater attention needs to be paid to refining the ecological objectives of each of these program areas, with better guarantees that the stated goals will be fully met.

For the ecologically fragile regions in central and western China, plans should be developed, and new ecological programs introduced to cover river basins and their source water areas, seriously eroded areas, key ecological-function conservation areas, and China's extensive network of nature reserves. These new programs should be planned by the central government, implemented by the provinces, and supported by stable financial resources, such as financial transfers by the central government, specialized funds, and ecological compensation schemes.

In addition, China should foster ecologically-dependent industries and markets, and build an evaluation and auditing system to oversee the collection, distribution and use of ecological funds, ensuring the effectiveness of these funds.

3 Place marine ecosystem management high on the policy agenda and promote sustainable ocean and coasts development

China should take into account the impacts of development in river basins and coastal lands on China's ocean and coastal ecosystems, and of marine effects on cities and terrestrial areas, the government of China should develop mechanisms to reduce the impact of land-based sources of environmental and ecological problems in the seas of China. China should strengthen marine ecological protection and scientific sustainable development as the basis for all present and future economic development in the ocean. China should also strengthen global and regional exchanges and cooperation on marine ecosystem protection. Only in these ways will it be possible to guarantee sustainable ocean use, with continued growth in the contribution of the ocean economy to China's GDP growth. Currently there is no green development strategy for China's seas. The most obvious and immediate case in need of such a strategy is the Bohai Sea.

(1) Set up and improve the legal system of marine management. The central government should initiate the legislation process for a Basic Law of the Sea of the People's Republic of China as soon as possible. This Law should be designed to serve as the basis for marine development and management, marine economy development and ecological protection of the sea. It should be the fundamental law promoting sustainable use and development of the sea. Moreover, there is a need to draft the Coastal Zone Management Law of the People's Republic of China and the Bohai Sea Environmental Management Law of the People's Republic of China. The supporting regulations, methods, rules and standards of the Marine Environmental Protection Law should be formulated or improved at the earliest date. In all laws concerning use of the sea, China should abide by the principle of holistic ecosystem management and set substantial protection and rehabilitation of marine ecosystems as a goal.

(2) Map out a national strategy and plan on marine ecological protection as soon as possible. Drawing upon the China Ocean Agenda 21, China should consider formulating a new China Strategy on Marine and Coastal Sustainable Development. This new strategy will map out the basic principles, guiding philosophy and strategic targets in the next 20 years, and detail the key tasks for coastal and marine economic development, marine

environmental protection and resource preservation. The strategy should prioritize such issues as sea enclosure and land reclamation, addressing marine eutrophication and its impacts such as toxic red tides and green algae blooms, as well as fishery development issues in light of the overfishing pressure.

(3) Establish a coordination mechanism for the marine environment with participation by relevant agencies including those with marine mandates, and some with terrestrial and freshwater mandates. In the near future, there will continue to be multiple players in the field of marine management and it is not yet realistic to set up a unified agency with full powers over marine issues. It is thus necessary and appropriate to set up a National Ocean Committee for the time being, which coordinates and draws upon the powers of relevant authorities in order to facilitate better management of marine and coastal affairs. Considering the current serious marine environmental problems, the main tasks of the Committee should include formulating a national strategy on marine development, promoting communications among relevant agencies, and coordinating major marine affairs that involve different agencies, sectors and regions. Among these tasks, the first priority should be solving the ecological problems in the Bohai Sea.

(4) Introduce an ecosystem-based approach to marine management. The ecosystem should be viewed as a whole, and the following comprehensive measures need to be taken in marine management: ① formulate an ecosystem-based sea zoning plan; ② evaluate ecological safety and environmental capacity of offshore waters, and identify off-limits for sea reclamation, identify ecologically sensitive and fragile areas as well as key regions of ecological safety, and mark the protected areas on the sea; ③ in addition to maintaining existing protected areas of the sea, new marine nature reserves, special protected zones and marine parks should be established for typical and representative ecosystems as well as for protecting rare and endangered species; through this means a network of protected areas on the sea will be formed; ④ in islands and areas rich in typical marine ecosystems, affected by invasive species or sensitive to climate change, ecological recovery programs should be carried out; set up demonstration areas of marine preservation, and recover the capacity of the seas for maintaining biodiversity and strengthening resilience against marine disasters and climate change; ⑤ establish conservation and recovery systems for marine species under the ecosystem-based ocean management framework; ⑥ expand sea farming in an environment-friendly way, promote the carbon sink functions of fishery and improve ecosystem capabilities; ⑦ introduce the approach of determining an inland pollution cap based on the receiving capacity of the sea, and when technically and economically feasible, formulate upstream-river mouth pollution control plans; reducing agricultural and industrial

pollution loads on the ocean should be high priorities; and ⑧ strengthen mud and sand regulation by dams and minimize negative effects of delta erosion caused by sudden decrease of mud and sand volume.

(5) Build up the early warning and emergency response system of serious marine pollution incidents. According to relevant international practices, China should set up and continuously improve the early warning and emergency response system of serious pollution incidents on the sea. Under the proposed National Marine Committee, China could establish a Leading Group on Emergency Response to Major Marine Pollution, with the responsibility for setting up an emergency response mechanism and coordinating actions of relevant agencies in the wake of serious incidents of marine pollution. In the meantime, China should establish mechanisms on notification of major marine pollution, for evaluation of potential environmental risks, and for improving early warning and information sharing issues. China also should improve emergency response mechanisms for regional marine pollution, strengthen supervision and management of potential pollution sources, and ensure the implementation of emergency response measures.

(6) Set up an integrated environmental monitoring and analysis system that covers both the land and the sea. China should combine the work of upstream, river mouth and sea monitoring; set unified monitoring indicators and technical standards; build an integrated monitoring system that covers air, river basins, the sea and coastal areas, and set up an information sharing system. In the short term, China should add NO_x as a new indicator for air monitoring and control, and total nitrogen and phosphorus as new indicators for water monitoring and control over the river basin. In addition, China should carry out scientific research on river basin-ocean linked ecosystems and deepen understanding of the marine ecosystems, laying a sound scientific basis for better marine management. In the populous and economically prosperous coastal areas, China should create an integrated research and monitoring network comprised of environmental monitoring facilities, research institutions, laboratories, outdoor observatories, and ecological recovery demonstration projects.

4 Promote scientific innovation, improve technological support, and strengthen capacity building on ecosystem management

China should set up and continuously improve a measurable, verifiable and reportable monitoring and evaluation system on China's ecosystems to cover the whole country and in particular the key ecological regions. More input should be given to scientific research and capacity building on ecosystem management.

(1) Set up an improved national observation and research network on the ecosystem. The central government should improve the outdoor observation and research network for regional ecosystems and biodiversity studies, support the network by long-term and stable financial resources, unify relevant technical and data standards, and establish a basic database and national digital atlas for biodiversity and ecosystems. These measures will help provide key scientific data, develop key technologies, and improve management of ecosystems and their services.

(2) Carry out regular evaluation on the status of China's ecosystems, and set up monitoring and evaluation systems for adaptive management of ecosystems in key regions. Comprehensive evaluation of China's ecosystems should be carried out every five years in order to illustrate a full picture of the ecosystem and support the formulation of the "Five-Year Plans". These evaluations should utilize the results of various censuses and surveys on forests, grasslands, wetlands, oceans, soil, water and biodiversity; make use of the national observation and research network on ecosystems, and apply remote sensing, modeling and other technologies. By doing these activities, an objective understanding on the changing ecosystems and their eco-services will be gained. Furthermore, China should establish an air to ground monitoring system for key ecosystems and have systematic and non-stop monitoring in these regions. Such monitoring systems will not only help to follow closely the trends of ecosystem change and record the progress China is making, but also to expose existing problems. This monitoring could then be the basis for developing solutions to the problems and contribute to better protection and recovery of ecosystems.

(3) Carry out basic studies on and develop key technologies of ecosystem services and management, and promote the application of the results gained. China should study the features and regional distribution of the main types of degrading ecosystems in order to define the mechanisms and patterns of their degradation. Based on these studies, key technologies for ecological recovery should be developed, and their application promoted. Technologies for recovering different ecosystems and in different regions should be developed. It is important to establish a green accounting system for ecosystem services, link

this system to the national system of accounts, and incorporate relevant indicators into performance evaluation system. Scientific and technological studies should be carried out to study the impact of climate change on ecosystem adaption and mitigation, as well as the impact on ecosystems from new energy exploitation and new technique applications. Meanwhile, it is necessary to review different management models and apply the management systems that suit the localities best. In this way, the country's ecological preservation efforts can be more effective and sustainable.

5 Attach greater importance to weak links, step up efforts in key fields, and help promote the green transformation of economic development pattern during the "12th Five-Year Plan" period

China's core mission in the field of environment and development during the next five years is to integrate environmental protection with the transformation of economic growth pattern; to achieve success in both improving environmental quality and promoting green development; and to explore a new path for environmental protection. To fulfill this mission, it is necessary to not only step up efforts on traditional priorities and strengthen policies and programs that have proved to be effective, including the energy conservation and pollution reduction program, but also give more attention to weak links that require immediate actions, including ecosystem management, rural environmental protection, soil pollution prevention, and the inclusion of climate change mitigation and adaptation targets into ecosystem management initiatives. These actions will help give full play to the role of ecological protection in promoting the green transformation of economic development pattern.

(1) Step up efforts in key fields and promote the green transformation of economic development pattern. Efforts should be made in the following aspects: set up mandatory objectives for improving environmental quality and promote nationwide; carry out environmental impact assessments more strictly and systematically; adjust industrial structure and regional distribution; raise environmental standards, tighten environmental enforcement and force the industrial structure to adjust both by improvements in upstream sectors and end-of–pipeline measures; promote environmental product certification and encourage green consumption; introduce environmental economic instruments, guide the traditional enterprises to "green" themselves and foster emerging and green industries; deepen environmental information disclosure programs and encourage public participation in green development; and provide technical and scientific support to green development through environmental innovation and technological application.

(2) Boost rural environmental protection across the board and bridge the gap between

urban and rural areas in terms of ecological civilization. Currently, rural environmental degradation stands out as a prominent problem. Compared with the urban and industrial areas, rural areas have become a weak link in China's environmental protection work, affecting the living standards and equitable sharing of development results in rural areas.

In the "12th Five-Year Plan" period, the Chinese government must greatly strengthen environmental protection in rural areas and try to make breakthroughs in this regard: ① formulate an environmental protection plan for the rural areas and move rural environmental issues higher on the agenda of national environmental work; ② improve the legal system of rural environmental protection, accelerate the legislative process on animal husbandry pollution control, non-point pollution control, soil pollution control and agricultural waste recycling; ③ step up infrastructure building for rural environmental protection, provide more guidance on environmental management and disseminate pollution control technologies; ④ expand the coverage of "award for treatment" policy (a policy that financially rewards the villages doing a good job in environmental treatment), raise the amount of such awards and study the feasibility of introducing "award for prevention" policy (a policy that financially awards the villages that successfully prevent environmental pollution and degradation); ⑤ set up rural environmental supervision institutions from the central government down to the grassroots level and improve rural management capacity across the board; and ⑥ strengthen education and publicity, raise awareness and recognition of rural environmental issues.

(3) Strengthen soil environment protection and safeguard public and ecosystem health. Soil pollution poses a great threat to food safety, public health and ecosystem integrity. The Chinese government already attaches a great deal of importance to this issue but needs to implement a comprehensive action plan during the "12th Five-Year Plan", including prevention, restoration and remediation, and supervision. There is an urgent need to: ① commission a national soil environmental protection plan; ② issue a law on soil environmental protection and pollution treatment, to introduce standards, and to establish national and local guidelines for soil protection and environmental quality; ③ set up a national monitoring system for soil protection, allocate responsibilities and establish a liability and accountability system; ④ establish a funding mechanism for soil pollution prevention and reclamation; ⑤ strengthen scientific research for soil pollution management and study and develop reclamation techniques and equipments; ⑥ establish a pollutant watch list by regions and food products; ⑦ establish, monitor and evaluate the supply chain for food safety; and ⑧ study and act on the carbon sink and water resource protection potential of soil, and strengthen soil's role in climate mitigation and adaptation.

(4) Focus on priorities, and incorporate the target of improving various ecological services and the principle of holistic ecosystem management into the daily work of ecological protection and development during the “12th Five-Year Plan” period. The approach of holistic ecosystem management is something new; there will be many challenges ahead in ideological, institutional and legal terms to be addressed in order to put it into practice in China. With so much preparatory work to be done in order for integrated management to be successful, it will be a fairly long time before full implementation of this approach takes place. In the coming five years, China should first raise the awareness of this holistic and integrated ecosystem management approach among policy makers and stakeholders, and formulate and promulgate the National Medium to Long Term Strategic Guidelines on Ecological Protection and Development as well as specialized plans on key ecosystems. Then China should implement this approach first in key and vulnerable ecosystems like the soil and the sea. Pilots could be first established in important areas such as Bohai Sea and other priority ecosystems and sub-regions. In addition, China should also strengthen scientific research, technological development, management model demonstration, and monitoring system development in order to better support the holistic approach of ecosystem management.

(5) Expedite the process of legislation on ecological compensation, and improve relevant policies and mechanisms. There are many useful tools that can be introduced in China, but among them ecological compensation, which has been studied and piloted for many years and initiated into legal procedure, is particularly important for both ecological preservation and pollution control. China should issue the State Council Regulation on Ecological Compensation as soon as possible, and promote the widespread establishment of ecological compensation schemes. In light of the current status of the country’s ecosystems, there are several key tasks in this regard: ① establish a non-profit compensation fund for forests, grasslands and wetlands; ② the central government should grant sufficient budget to national nature reserves under the framework of the national ecological compensation scheme; ③ gradually incorporate the forests and grasslands restored from farmlands into the scheme; ④ establish marine ecological compensation mechanisms, carry out compensation demonstration for key marine programs, including sea reclamation projects, as well as for oil spills and protected areas. Compensation should also be piloted in places where inland activities have affected river mouths and seas; ⑤ establish eco-compensation mechanisms for mining projects; and ⑥ an ecological compensation scheme for freshwater ecosystems.

(6) Implement green regional development strategies by taking into account resources

and environmental capacity, biodiversity conservation needs, and establish within-China regional cooperation mechanisms for ecological protection. Over the past two years, China has issued a number of regional development strategies and plans, which will be essential to bridge the development gap among the different regions and to foster new growth engines. It is equally pivotal, however, to strike a balance between regional rejuvenation and green transformation: ① regional strategies and plans should conform to the National Plan on Ecological Zoning, and the development direction of a region should be determined by its resource and environmental capacity so that pollution and ecological damage will not come together with the industries that gradually transfer to these regions; ② in the richer eastern region, ecological preservation should be a priority and optimized development strategy should be implemented; while in the ecologically vulnerable west, a green development strategy should be introduced, focusing on ecological innovation and giving greater attention to biodiversity conservation. These strategies will help build a resource-conserving and environment-friendly society; ③ in light of the current status of the environment, it is not enough for one local government alone to curb the degrading trend of the ecosystem and substantially improve environmental quality, but rather coordination and cooperation among the localities is needed. It is desirable to review experience so far and establish a comprehensive cooperative mechanism on regional ecological protection and joint pollution prevention, control and treatment.

Appendix II Name List of Council Members

Mr. Li Keqiang	Vice Premier, State Council **Chairperson of the Council**
Mr. Zhou Shengxian	Minister, Ministry of Environmental Protection **Executive Vice Chairperson of the Council**
Ms. Margaret Biggs	President, Canadian International Development Agency **Executive Vice Chairperson of the Council**
Mr. Xie Zhenhua	Vice Chairman, National Development and Reform Commission **Vice Chairperson of the Council**
Mr. Klaus Töpfer	Former Executive Director, United Nations Environment Programme **Vice Chairperson of the Council**
Mr. Børge Brende	Managing Director, The World Economic Forum **Vice Chairperson of the Council**
Mr. Li Ganjie	Vice Minister, Ministry of Environmental Protection **Secretary General of the Council**
Ms. Wang Jirong	Vice Chairwoman, Environment Protection and Resources Conservation Committee, National People's Congress
Ms. Jiang Zehui	Vice Chairwoman, Committee of Population, Resources and Environment, National Committee of the Chinese People's Political Consultative Conference
Mr. Wu Hailong	Assistant Minister, Ministry of Foreign Affairs
Mr. Zhang Shaochun	Vice Minister, Ministry of Finance
Mr. Yu Jianhua	Assistant Minister, Ministry of Commerce
Mr. Ning Jizhe	Vice Minister, Research Office, State Council
Mr. Ding Zhongli	Vice President, Chinese Academy of Sciences (CAS); Academician of CAS

Mr. Shen Guofang	Professor, Former Vice President of Chinese Academy of Engineering (CAE); Academician of CAE; Chinese Chief Advisor of the Council
Mr. Liu Shijin	Vice President, Development Research Center, the State Council
Mr. Feng Zhijun	Professor, Counsellor of the State Council
Mr. Li Xingshan	Professor, Former Academician Dean, Central Party School of the Communist Party of China
Mr. Zhou Dadi	Senior Research Fellow and Former President, Energy Research Institute, NDRC
Mr. Lu Yaoru	Professor, Chinese Academy of Geological Sciences, Ministry of Territory and Resources; Academician of CAE
Mr. Zou Deci	Professor and Senior Urban Planner, China Academy of Urban Planning and Design, Ministry of Construction; Academician of CAE
Mr. Zhou Wei	Professor and President, Research Institute of Highway, Ministry of Transport
Mr. Wang Hao	Professor and Director, Department of Water Resources, China Institute of Water Resources and Hydropower Research, Ministry of Water Resources; Academician of CAE
Mr. Ren Tianzhi	Professor and Deputy Director, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Ministry of Agriculture
Mr. Wang Wenxing	Professor and Senior Advisor, Chinese Research Academy of Environmental Sciences; Academician of CAE
Mr. Niu Wenyuan	Professor and Chief Scientist, Institute of Policy and Management, Chinese Academy of Sciences
Mr. Ma Xiangcong	Senior Research Fellow, Institute of Law, Chinese Academy of Social Sciences
Mr. Ding Yihui	Professor and Senior Advisor, China Meteorological Administration; Academician of CAE
Mr. Hao Jiming	Professor and Dean, Department of Environmental Science and Engineering, Tsinghua University; Academician of CAE
Ms. Sarah Liao Sau Tung	Senior Advisor to the Vice-Chancellor of the University of

	Hong Kong on Environmental and Sustainability Matters; Former Secretary to the Environment, Transport and Works of the Hong Kong Special Administrative Region Government
Mr. Roger Beale	Senior Associate, the Allen Consulting Group, Australia; Former Portfolio Secretary, the Department of Environment and Heritage, Australia
Mr. Corrado Clini	Director General of Sustainable Development and Research Department, Ministry for the Environment, Land and Sea, Italy
Mr. Gordon Conway	Professor of International Development Centre for Environmental Policy, Imperial College, London, UK
Mr. Daniel J. Dudek	Chief Economist, Environmental Defense Fund, USA
Mr. John Forgách	Chairman of the Board, the Equator LLC in New York; Brazil
Mr. Arthur Hanson	Distinguished Fellow and Former President, International Institute for Sustainable Development, Canada; International Chief Advisor of the Council
Mr. Stephen B. Heintz	President, Rockefeller Brothers Fund
Mr. James Leape	Director General, World Wildlife Fund
Ms. Julia Marton-Lefevre	Director General, International Union for Conservation of Nature
Mr. Lars-Erik Liljelund	Executive Director of Mistra, Sweden
Mr. Lim Haw Kuang	Executive Chairman, Shell Companies in China
Mr. Timo Makela	Director, International Affairs, DG for Environment, European Commission
Mr. Dirk Messner	Director, German Development Institute
Mr. Mark Moody-Stuart	Chairman, Hermes Equity Ownership Services, UK
Mr. Mohammed Valli Moosa	Chairman of Lereko Investments and Sun International Ltd., South Africa; Former Minister, Ministry of Environmental Affairs and Tourism of the Republic of South Africa
Mr. R.K. Pachauri	Director General, the Energy and Resources Institute, India Chair of UN Intergovernmental Panel on Climate Change
Mr. Achim Steiner	Executive Director, United Nations Environment Programme
Mr. Björn Roland Stigson	President, World Business Council for Sustainable Development
Mr. Hau Sing Tse	Executive Director, Canada, China, Korea & Kuwait,

	African Development Bank
Ms. Laurence Tubiana	Director, Institute of Sustainable Development and International Relations, France
Mr. Hans van der Vlist	Former Vice Minister, Ministry of Housing, Spatial Planning and the Environment, the Netherlands
Mr. Kandeh K. Yumkella	Director General, United Nations Industrial Development Organization