ISSUES PAPER

Innovation for an Environmentally-Friendly Society

BACKGROUND
This Issues Paper is the sixth in a series started in 2002 to examine key problems in China’s environment and development strategy. The purpose of each paper has been to identify major policy questions and issues associated with the theme of the Annual General Meeting (AGM) of the China Council for International Cooperation on Environment and Development (CCICED). The Council, comprised of senior Chinese and international environmental leaders, provides advice to the Premier and State Council of China based on the work of its task forces and special studies. The November 2007 CCICED AGM is the first meeting of the fourth five-year phase of the Council and therefore will serve as an agenda-setting session for work to be carried out over the coming half-decade. The AGM will examine what it will mean for China to embrace “Innovation for an Environmentally-Friendly Society.”

STRATEGIC TRANSFORMATION AND INNOVATION

2007 – A Year of Environment and Development in China and Globally
The timing of this meeting is especially significant since it comes soon after the 17th National Congress of the Communist Party of China. This Congress firmly embraced scientific development, innovation and the need to address pressing environment and development concerns in China. President Hu Jintao noted the need for “Promoting a conservation culture by basically forming an energy- and resource-efficient and environmentally-friendly structure of industries, pattern of growth and mode of consumption.” During 2007, China introduced its first comprehensive action program to address climate change; established a Leading Group on energy, environment and climate change that is chaired by Premier Wen Jiabao; and took numerous actions to improve performance in meeting the 11th Five Year Plan 20% energy efficiency increase and 10% pollution reduction goals. The OECD released its first ever report on China’s environmental performance, an important benchmarking and institutional analysis.

This year environment has risen to the top level of priorities in many countries, including their businesses and communities, with concern for climate change being most prominent. But many other issues are in the spotlight as well including the need for a better understanding of globalization effects, and of the environmental implications related to fast growing countries such as China and India. The International Energy Agency (IEA) in its 2007 energy outlook reference scenario calculates that these two countries would account for 45% of the global increase in energy demand in 2030. It is now 20 years since the famous report Our Common Future was produced by the World Commission on

1 Issues Papers are prepared by the CCICED Chief Advisors, Professor Shen Guofeng and Dr. Arthur J. Hanson with the assistance of others in the Chief Advisors Group.
Environment and Development. Global progress on sustainable development is still limited, however, and “business as usual” attitudes still persist to an alarming extent.

**China’s Strategic Transformation of Environment and Development**

China is entering a time of strategic transformation towards environment and development. This transformation is focused at present on energy efficiency and pollution control, but with much broader implications on how the world’s most populous nation can rapidly align its economy, environmental protection and harmonious social development policies and actions towards sustainable development. China needs to do this on a much-compressed time frame by comparison to many other countries since its longer target of attaining a “basically well-off society” by 2020 depends not only on continued rapid economic growth but also on quality of life and a stable social system.

Ultimately this strategic transformation will affect how government governs, how all business enterprises operate within China and in their international operations, how the people of China participate in environmental decisions, and how China participates in global and regional environment and sustainable development cooperation. It will demand new approaches of institutional change, improved planning and management, and technological changes far beyond what China has so far seen in its environmental protection and sustainable development efforts. And it will place unprecedented demands on other nations to adjust and improve their own ways of dealing with issues such as environment and trade, climate change, and many other environmental matters. A CCICED Special Policy Study on Strategic Transformation of Environment and Development in China in the context of both national change and globalization will be presented to the AGM.

**Innovation for an Environmentally-Friendly Society**

President Hu Jintao has noted that innovation “is the core of our national development strategy and a crucial link in enhancing the overall national strength.” Internationally there is great interest in determining how best to link innovation and sustainable development. It is difficult to believe that societies anywhere can expect to achieve substantive progress on today’s environment and development problems without commitment to science and technology breakthroughs. Yet innovation must go much deeper—especially into the way decisions are taken, and the strength of institutions to implement these decisions; and into the role and functioning of markets that can either encourage or discourage desirable changes depending on pricing and other signals.

It is encouraging that at the 17th CPC Congress such topics were considered. President Hu noted that “China needs to improve institutions for democracy, diversify its forms and expand its channels, and carry out democratic election, decision-making and administration and oversight in accordance with the law to guarantee the people’s rights to be informed, to participate, to be heard and to oversee.” These are among the most important conditions found in nations such as Germany, The Republic of Korea, and Japan that fostered innovation during their strategic environmental transformation in earlier times.

China is in a remarkable position as it moves to strengthen its science and technology capabilities. The available funding will place it among the very top nations investing in
S&T. A considerable amount of this funding will be earmarked for addressing priority energy, environment and development concerns during China’s new 15-Year Science and Technology Plan. And in the process the existing National Innovation Strategy (NIS) will have to become much more focused on sustainable development priorities and on building independent (indigenous) technology that will fuel future economic growth and well-being in China. Yet there are many barriers to be overcome, and the gap between goals and performance progress is still large. CCICED has initiated a new Task Force on Innovation for China’s Environmentally-Friendly Society that will present its final report at the 2008 AGM. Their Interim Report presented during the current AGM provides a critical examination of this topic in China.

The difficulties of implementing current environmental goals will be reported during the meeting, based primarily on the work of the CCICED Task Force on Policy Mechanisms towards Successful Achievement of the 11th Five Year Plan Environmental Targets. It is likely impossible to meeting the targets without substantial commitment to innovative approaches that are not yet in place. Furthermore the challenge will become greater over time, especially during later Five Year Plans, since more types of pollutants will have to be addressed, and since absolute levels of some contaminants are continuing to increase.

Since the dawn of the new Century China has been in an industrialization phase of heavy industry and chemical production. The rash of serious incidents involving chemical spills and contaminations suggests that a stronger approach to chemical management is needed within China. Such an approach has ramifications for large and small domestic producers, multinational chemical firms operating in China, and for China’s participation in overseas chemical markets. Fortunately, this is a subject where it is possible to draw upon innovation experience from a number of other countries such as Germany. A CCICED Special Policy Study on Environmentally Sound and Strategic Management of Chemicals in China will provide recommendations at this AGM.

Looking Ahead – Global Problems and China’s Needs

China is entering into an era when its impacts on the world will be considerable, and therefore its actions will be monitored closely and judgements made on its contribution to global environmental security and as a “global citizen.” The extensive past work of CCICED on Trade and Environment, and recent efforts to understand how the effects of globalization affect China’s environment and China’s impacts on other countries suggest that international cooperation will become of increasing significance. It is a topic well suited to CCICED, of course, but now one that may need to be examined in ways that recognize both China’s very legitimate development needs and interests, but also in terms of how other nations should cooperate to provide the environmental space for this to happen.

Therefore several exploratory initiatives were undertaken in preparation for this meeting. One is a new partnership of CCICED with WWF China to examine China’s Ecological Footprint, with an Interim Report presented during this meeting, revealing how China’s very low per capita demands on the world’s ecological systems are increasing. This is a relatively new way of examining the effect a country may have on the resources and environments of other nations and regions through market supply chains and other ways.
This information casts a very different perspective than standard economic analysis of trade and identifies the nature of ecological deficits and surpluses around the world.

CCICED’s long-standing interest in Energy and Environment has always been tied to innovation, and specifically to alternative sources and approaches to energy use. Some of these ideas are now in use such as wind power, and it is clear that energy innovation will be one of the most significant areas determining China and the world’s success with sustainable development. Climate change adds to the urgency of finding new ways to improve energy efficiency, sustainable use of coal, and of alternatives that will reduce greenhouse gas emission and other harmful pollutants. These topics are being proposed as important elements within the overall context of Energy and Environment for CCICED work over the next two years. In April 2007 CCICED held an exploratory meeting on “A Low Carbon Economy for China.” The key points arising from this meeting will be made available at this AGM.

Clearly the coming years will not be a time of “business as usual” for China’s environment and development situation. Nor is it a time when any one nation can expect to achieve its own environmental objectives in isolation from global environment issues, or without consideration of the environment and development actions of other nations. As China’s President and Premier have both pointed out, the environmental burden on China is heavy and the situation is grave. It will require sustained effort, participation of all sectors and regions of the country, and new approaches that build on science, management and institutional approaches. What is called for is a broad base of investment in eco-innovation. This long-term commitment will become of ever-growing significance starting with the 11th Five Year Plan (FYP), and certainly extending into the 12th and 13th Five Year Plans.

The Government of China has made it quite clear that innovation rather than minor tinkering will drive the new relationship of environment and development. Perhaps the clearest vision is from statements by Premier Wen Jiabao concerning this relationship in which three principles (“Three Transitions”) have been laid out: (1) environment and economic growth should be given equal status; (2) environmental problems should be considered concurrently, not after economic growth is achieved; and (3) instead of the current focus on administrative initiatives, environmental action should be broadened to include legal, economic, institutional and other approaches.

**CHINA’s 11th FIVE YEAR PLAN ENVIRONMENTAL PERFORMANCE**

The inability of China to meet fully the environmental objectives of the 10th FYP, and the more stringent pollution reduction and energy efficiency goals during the first year of the 11th FYP, reflect systemic problems that are described in the CCICED Task Force Report to the AGM. The key point is that only by addressing such matters as institutional strengthening, and substantial upgrading of the environmental management administrative structure can real progress be expected. There is no single approach that can be implemented in isolation. This point has significant implications for success of environmental technology innovation.
While there is considerable investment in introduced technologies, and also evidence of success in their application, there also are observations that much of the investment has not been well spent in terms of improved environmental performance. The reasons vary but include lack of training, poor environmental monitoring and enforcement, and inappropriate choices.

The 11th FYP will be a time of learning and transition in relation to discovering the best combinations of technological, institutional and management innovations for environmental improvement. It should set the stage for major longer-term investments that will see their full benefits expressed in the decade after, and, in the case of some initiatives, much further in the future, for example, the ITER Project on fusion in which China is a partner. The time available between now and 2010 can be used to put in place a more functional governance system to support environmental innovation, including a much stronger participation by industry, and awareness-raising of communities and people. Fortunately, the necessary investment capital may be much easier to find in China than some other countries.

SOME GLOBAL ISSUES LIMITING PROGRESS

Of the many issues limiting progress on building a better relationship on environment and development in countries around the world, a handful are particularly significant at this time of innovation and transition for China.

- An export-driven high growth strategy, with its emphasis on continuous price reduction and mass production of consumer goods, has significant benefits both for the manufacturing country, in this case China, and the consuming countries, whether rich or poor. The reality however is that environmental conditions are being compromised in the manufacturing country, and in some of the countries supplying raw materials. And in the richer consuming countries where cheaper imported goods contribute to ever-increasing demand and over-consumption. It is hard to see how this model can ever truly be sustainable.

- Stimulating domestic consumption in China or other large developing countries from their current low per capita levels could lead to an impossible future global environmental situation if consumption levels rise anywhere close to those of the richer countries today because ecological capacity will be exceeded even with stringent eco-efficiency measures. Ecological footprints continue to rise with economic wealth; already the global resource and environmental situation may be beyond earth’s longer-term carrying capacity. Thus new pathways are needed that lead to high quality of life in China and elsewhere, but with relatively limited per capita consumption increases, while richer countries must become much more serious about their own transformative needs for environment and development and on sustainable consumption.

- Declining resource and environmental intensity (e.g., use of energy or material per capita or per unit of GDP) is a misleading measure of environmental progress in situations where economic or resource exploitation growth rates are very high. Absolute pollution amounts, or of resource decline, may continue to rise even though utilization efficiency increases. This is particularly important in the debate
about greenhouse gas reductions, but also for many other of the pollutants that China and other countries are producing, and for ecological and resource decline globally and regionally.

- Social considerations of poverty reduction, equity in access to education and health care, sustainable cities and towns, sustainable rural development, and creation of new employment opportunities will continue to be drivers of sustainable development innovation in all countries. Yet this type of innovation is still often separated from environmental considerations. China, more than many other countries, is making a serious effort to make the linkages and take an integrated approach. China’s success and experience will therefore be of value to many other nations.

- Corporate social responsibility is taken seriously by many large multinational corporations in particular, yet it has not taken hold to the extent that it should anywhere in the world, and certainly not in most parts of Asia, including China.

- The framework for addressing global environmental protection, and for regulation of market-driven globalization matters, including technology sharing, intellectual property rights, and international trade and investment, is still weak and incomplete. As well, new issues are appearing each year, including many health and environment problems, and new mechanisms such as carbon trading. China’s own strategic transformation on environment and development will depend to a considerable extent on improvements for international action.

- Innovation in the form of new or improved scientific and technology applications, investment, management and institutional change is needed both nationally and internationally, but often the changes occur much more slowly than desired and with a limited distribution of benefits.

China has now become an “indispensable” economic partner, stabilizing the world economy, fueling international economic “booms”, and raising the level of incomes for many developing countries. This success needs to be tempered with the difficult issues of declining environmental conditions. Global attention in recent months has been focused on a range of quality issues, including the efforts to improve the air quality in Beijing and the Olympic Games, to solve the problems of market supply chains and product quality, and how China will respond to climate change. China needs to understand how it can balance its environment and economy relationship in the context of globalization effects.

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INNOVATION FOR ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

There are a number of specific characteristics about environment and sustainable development innovation worth bearing in mind, since these are as likely to be as applicable in China as elsewhere.\(^3\)

- The need for innovation increases as the commitment by governments and the private sector shifts from an emphasis on cost-driven regulatory compliance to an emphasis on broader economic/financial, social and environmental benefits.

- Many environmental innovations will arise from industrial innovation not primarily oriented to environmental improvement, for example, energy efficiency and product improvement. The potential for co-benefits is large.

- Environmental innovation is often directed to maintaining public goods, which means that incentive for private investment and return on investment can be limited, especially in relation to alternatives. Market value is needed for technologies to thrive.

- Bringing environmental innovations to full commercialization can be difficult due to market imperfections and failure, or perverse incentives such as inadequate pricing.

- Technology “lock-in” is a formidable problem for environment and sustainable development innovation, affecting institutional and financing responses even when R&D suggests better technologies are available or could be developed.

- Co-evolution of technologies is often needed, for example, in the relationship of battery technology and hybrid automobile engine development.

- Flexible instruments such as economic incentives and performance standards foster environmental technology innovation more than prescriptive measures (e.g., ‘best available technology’ regulation), especially if the desired outcome is integrated changes in production or other processes rather than end-of-pipe pollution control.

- Globalization, with its fragmented supply chains, may generate considerable international demand for accelerated development of environment and sustainable development technologies and their rapid deployment, including pressure for suppliers along the value chain to conform to consumer-driven environmental demands.

- Some key environment and sustainable development technologies (e.g., for clean coal use, nuclear fusion, and sustainable transportation) are beyond the capacity of any one country, no matter how technologically-advanced, and therefore international partnerships and joint venture activities are desirable).

Governmental intervention in choosing technology “winners” can be highly controversial. One view is that governments should concentrate on defining clear environmental goals and a framework to address them, while being “technology-neutral” on how they are addressed.

CHINA’S INNOVATION STRATEGY AND KEY LINKS TO ENVIRONMENT AND DEVELOPMENT

Scientifically-based development, wealth shared fairly among all citizens, harmonious and sustainable development that provides for environmental protection, continued rapid economic growth and improved social services and greater social equity are cornerstones of current Chinese policy. These elements therefore are reflected in many of the approaches for innovation generally, and science and technology (S&T) strategies in particular.

The context for innovation has been set broadly, as explained by Vice-Premier Zeng Peiyan in a speech to the China Business Summit:4

“…Innovation is the soul of a nation’s advancement, as well as the everlasting driving force for national prosperity…Problems often occur when people tend to pay attention to quantitative expansion and speed while ignoring quality…We have to upgrade our development strategies, transforming our growth pattern and optimizing the industrial structure…The objectives of reform are to bring economic and social development on the track of comprehensive, balanced and sustainable development.”

He pointed out that this effort offers the potential for technological and innovation innovations that could enhance productivity and increase competitiveness for China. The focus on institutional innovation should include reforming the administrative system, accelerating corporate reform, and establishing modern market systems.

Innovation must be linked to improved governance. As noted in a review of China’s S&T Strategy:5

“the path to creating the overall well-off society will necessarily be characterized by technology innovations supporting greater efficiency and productivity, and institutional innovations supporting improvements in governance—greater market discipline and integrity, less government corruption, and greater administrative accountability.”

OECD countries are passing through a transition where stand-alone S&T strategies are now being viewed within a broader context of a National Innovation System (NIS) that can take into account many factors beyond specific S&T plans or strategy. In particular, a NIS must consider the role of the business and financial community not only for participation in research but also in linking to the demand side and in providing clear

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4 China Daily. 11 Sept 2006. *Innovation is the Soul of Nation’s Advancement: Vice-Premier.*
www.china.org.cn/english/BAT/180675.htm

pathways to commercialization. A NIS also must take into account the development of innovation clusters with appropriate capacity building and scientific and physical infrastructure development, enabling frameworks and regulatory systems, and help with fundamental matters such as the selection of priority areas of innovation in which to initiate substantial programs.

The NIS approach, however, is that it has evolved relatively independent of sustainable development. Thus, while some environmental concerns may be addressed in specific cases, this is by no means a central element. Rather, NIS tends to focus on building competitive advantage of a country through new technologies. Sustainable development is its own form of innovation, with some specific characteristics. It is mainly in the last 5 years that NIS and sustainable development have become more closely aligned in OECD nations, stimulated particularly through concerns such as alternative energy and climate change, industrial eco-efficiency, sustainable infrastructure development and some aspects of natural resource and environmental management.

**China’s National Innovation System (NIS)**

China is following somewhat the same pathway as other nations in creating its approach to a NIS—with a very impressive level of S&T investment, and considerable experience with what may best be described as an adaptive approach to its NIS. This system has a number of key characteristics which have evolved over the past 25 years. What sets China apart from others is the magnitude of commitment and the rapidity of transition. And China has placed development concerns front and centre in its innovation goals, with a strong commitment for environmental protection.

The public governance of S&T and innovation is relatively complex, as noted in the diagram on the following page (from OECD 2007. Synthesis Report). There are many challenges to be faced, as noted below (from OECD 2007. Synthesis Report).

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A strong recognition exists of the need to make the NIS enterprise-based. There are numerous mechanisms to involve the private sector, and to transform state-owned enterprises. Yet the reality is that most Chinese businesses invest little in R&D, and it is a challenge to get adequate R&D investment as part of FDI initiatives.

From another perspective, China may be able to tailor its growing innovation capacity to competitive advantage as part of a “global innovation system.” As noted by OECD:

“China can make a significant contribution to the world’s knowledge pool and help to solve global problems. Among these are those relating to the strong demand for energy and natural resources and the environmental pressures associated with the rapid economic growth both of China and other emerging economies. China and OECD member countries have a shared interest in solving these problems.”

There could be multiple advantages to China of participating extensively in such a system. It is a means of sharing the burden and drawing upon a wider range of experience on complex technologies such as those involved in new energy technologies. China can draw upon its advantages as a low cost producer to commercialize innovation technologies and sell these abroad. And China will gain credibility internationally for its science and technology contributions.

A number of strategic tasks have been identified by OECD as possible means for enhancing the efficiency and effectiveness of China’s NIS. These include: (1) Adjusting the role of government to enhance provision of public goods through science and innovation; (2) Improving the framework conditions for innovation, such as enforcement of intellectual property rights (IPR), fostering competition, improving corporate governance, fostering open and competitive markets, careful use of public procurement, and promoting technology standards appropriately; (3) Increasing research quality and efficiency by sustaining the growth of human resource for S&T; (4) Improving governance of science and innovation policy, including a focus on central and sub-national division of labour and responsibility, and improving inter-agency coordination; (5) Adjusting the set of policy instruments in order to develop the most appropriate types of R&D initiatives and programs; (6) Maintain adequate support or public R&D, especially for public good priorities such as environmental protection; and (7) Strengthening the linkages between industry and science.

**China’s 15 Year Science and Technology Strategy**

China is poised to become one of the world’s leaders in S&T investment. The 2006 15-Year S&T Plan emphasizes “indigenous innovation” and technology leapfrogging so that some 60% of contributions for economic growth will come from technology advances, with dependence on imported technology no greater than 30%. China aims to be among the top 5 countries in terms of invention patents and also in terms of overall S&T expenditure—a “global scientific centre.” OECD believes that China is already the world’s second highest investor in R&D, spending slightly more than Japan’s USD 130

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billion in 2006, but far lower than the US investment of USD 330 billion. This represents an increase from 0.6% of GDP in 1995 to more than 1.2%.\(^9\)

The meaning of “indigenous innovation” is somewhat complex: original innovation, integrated innovation relying upon linking of existing technologies for new uses (e.g. application of medical biotechnology for diagnostic testing of the environment), and “re-innovation” involving improvement of imported technology. All three approaches are of value in relation to environment and development innovation. It also should be noted that emphasis on institutional and management innovation is a crucial component for all three approaches—in order to improve implementation success of off-the-shelf technologies as well as innovative technologies.

A likely transition for China is towards greater ownership of intellectual property rights and possibly to industrial standard-setting as part of its effort to become an innovation-based society. This has important implications for environment and SD technology development for use domestically and also for applications internationally. The potential dilemma is the length of time to develop new intellectual property, and therefore the uncertainty and lengthy process to bring new technologies into the marketplace.

Another view is that gaining access to sophisticated available environment and sustainable development technology from abroad is essential for the near-term, especially during the 11th and 12th FYP periods. While such an approach is appealing and in fact occurring, there are cost issues and also issues that relate to reluctance of some companies to share their most advanced features with Chinese operations. The role of China’s government in setting appropriate regulations (e.g. auto emission standards) and IPR safeguards is important.

Chinese-international partnership for development and implementation of new technologies is a hybrid approach to innovation that is likely to be of increasing significance in coming years, and seems particularly important for alternative energy sources, and perhaps for water pollution control technology, hazardous waste management and prevention, etc. Many of these activities can be managed through foreign direct investment strategies but some might also be done through government-to-government arrangements. Models for the latter exist (EU, USA, etc.)

Almost all of the 20 strategic research topics noted in the S&T Plan are relevant in some way to environment and development, but several are critical including: agricultural S&T, culture for innovation and S&T popularization, ecology, environment protection and circular economy S&T, energy, resources and ocean S&T, human resources for S&T, modern manufacturing development S&T, population and health S&T, regional innovation system, strategic high technology and industrialization of high and new technology, transportation S&T, and urban development and urbanization S&T.

Environment and development innovation may be less in need of S&T megaprojects than some other aspects of the strategy, but require greater attention to accelerating the pace of development of promising initiatives, and to the need for funding related to those initiatives where the marketplace has not yet caught up with the societal need (e.g., low

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cost sanitation and water treatment, brownfield redevelopment, and advanced forms of biorefineries.)

Regional and local S&T innovation and concurrent needs for implementation capacity development are significant, and involve the private sector and communities as well as governments at various levels. This aspect of innovation is critical for ecological initiatives and rural development, as well as industrialization in locations where innovative solutions may be needed to address pollution and other environmental impacts.

A NATIONAL “ECO-INNOVATION SYSTEM” FOR CHINA

The time may be right to propose creation of a national eco-innovation system for China that could address in a comprehensive way the various opportunities and challenges to innovation for an environmentally friendly society. This approach has not been widely tested, although it is being actively explored in Europe particularly. Eco-innovation is defined as any form of innovation focusing on sustainable development through reducing impacts on the environment and achieving more efficient use of energy and natural resources.

A key question would be how taking an eco-innovation system approach might influence outcomes of the 11th FYP environmental efforts? By taking a systemic approach, could performance be improved, and to what extent would the results be related to environmental technology, and to what extent from institutional improvement such as local government strengthening?

The following 10 innovation issues are indicative of the need for policies and action in a systemic approach to achieving an environmentally-friendly society.

1. Create more widespread and effective use of existing environmental technologies that would lead to greater efficiency at a lower cost than developing new technologies, especially for industry and energy pollution control and for new building technology.

There are many environmental technologies available at the present time either within China or elsewhere. Such technologies could be introduced and adapted to specific Chinese development conditions, likely at lower cost and in a more timely way than developing new technologies. And a good part of the challenge in any case is not the technology per se that is a barrier, rather it is the lack of knowledge about its application, inappropriate incentives and regulation, and the need for an improved implementation management system.

It is sensible and necessary in the short run to focus on immediate opportunities even while seeking longer-term, more transformative options. Using existing technologies is a means for the industrial and construction sectors to demonstrate a commitment to corporate social responsibility in an immediate, goal-oriented and measurable way rather than via promises mainly of future, longer-term performance. It is a mechanism to maximize technology transfer by drawing upon multinational experience, especially as part of FDI packages and through cooperation programs, particularly with OECD countries. An additional benefit of maximizing use of existing environmental

14
technologies is that it will further stimulate the rapid development of a robust environmental service sector within China.

The potential downside of embracing existing environmental technologies is that many will be from an earlier generation designed for pollution clean-up rather than prevention, and some will not be as cost-effective or efficient as newer approaches being designed today. In particular, the move towards elimination of serious pollutants through industrial ecology design and environmental planning presents more attractive longer-term options, including synergies for a circular economy, ability to control emissions such as greenhouse gases that were not of such a concern in the design of existing pollution control technology, and perhaps discovering better approaches for China’s situation.

2. Set environment and sustainable development objectives, standards, and incentives at levels that will promote innovative responses, while putting into place regulatory frameworks that will enable innovation solutions to be implemented effectively.

While China has already taken many initiatives for addressing this set of issues, the results are still far from optimal, suggesting the need for further national and local government interventions. The problems seem to be associated with the following matters:

- Inadequate drivers for action towards desired innovations (not only for new technology, but also for institutions, investment and management systems). The weak drivers are reasonably well understood. They include weak enforcement and punitive measures that simply become part of the cost of doing business; the continuing ambivalence of many local governments towards environmental management efforts where GDP growth may be threatened; national laws and regulations that are too general or even work at cross-purposes; etc.
- Limited returns from existing S&T investment in terms of bringing new technology to commercialization and in terms of the relative low number of patents and other indicators of productivity of the S&T system.
- Failure of much of China’s private sector to develop robust environmental management strategies and to undertake the original R&D that would support innovative solutions to pollution control, energy efficiency and other problems that should engage their interest.
- Failure to engage the financial sector fully into environmental innovation strategies. For example, it is only recently that bank lending has started to consider environmental matters.

This list of problems is very significant in terms of China’s future success with innovation for environment and sustainable development. But it is a list that may well grow over time as new technology innovations emerge.

Experience elsewhere suggests that public perception and markets are unlikely to embrace all forms of technology solutions. This may well be true in the future for China as well—in its domestic markets, but also, via market supply chains, for China’s export-driven economy. Choice of biotechnologies for environmental matters, for example, may influence access of final products to foreign markets.
3. Develop environmental, safety, health and life cycle assessments of impacts arising from new technologies (e.g., biotechnology, nanotechnology) at all stages of their development from R&D to full commercialization.

Many assertions will exist concerning the benefits and risks of new technologies, starting with the earliest stage of scientific research. China has engaged domestically and in joint ventures with funding of initiatives and building of expertise covering a wide range of promising technologies. The new S&T strategy offers even more possibilities. How can there be reasonable assurance that the new investments actually will contribute to China’s sustainable development needs in a more effective way? And what safeguards need to be put into place to ensure that the innovations do not create unacceptable health, environmental and safety problems on their own right. The design of existing environmental assessment procedures is not very robust for answering these questions since the assessment system is geared much more to construction and other types of projects. Even policy environmental assessments are likely to be insufficient.

The OECD and some individual nations have started to consider appropriate assessment tools and procedures, for example, to cover innovations such as biotechnology applications for the bio-economy and for nanotechnology and the environment. China will need to place more emphasis on these matters as its S&T strategy unfolds. The time to set in place an innovation environmental assessment system is now, before the new technologies overwhelm regulatory bodies, or before a serious incident occurs that is detrimental domestically and/or internationally.

The issue of whether assertions about the value of the potential S&T application are correct will always be difficult to assess, since the full potential often takes two or more decades in order to be fully realized. The slow unfolding of the hydrogen economy is a highly relevant example. However, the area of technology assessment for environment and development has made considerable progress over the past 5 years, with development of useful tools and scientific dialogue processes that are valuable. China is already engaged in some of these processes, but likely should be doing more to ensure that initial choices are reasonable.

4. Enhance the contribution to environment and sustainable development innovation by multinational corporations, international joint ventures and partnerships for key technology applications.

The environmental role of the international business community investing in China has been highly variable, ranging from negative to highly positive. It would be desirable for international businesses to be in compliance with all relevant Chinese environmental laws, but compliance is not enough to address innovation. Instead, multinational corporations should be prepared to consider the following: environment and sustainable development capacity building of staff in their own business and, sometimes, with other businesses in the same sector; willingness to share cutting edge technology; support for environmental R&D within company operations and via grants or partnerships with Chinese universities and research bodies; participation in certification and other innovative voluntary environmental programs. Some international companies operating in China are already engaged in many of these activities, but certainly many others are not. Furthermore, there are many supply chain issues, including subcontracting and outsourcing within China.
where there seems to be limited consideration of how goods are produced. These problems are exacerbated by the intense competition among provinces for investment and for increased manufacturing opportunities.

The problems go deeper, when investments in supporting infrastructure, such as commercial and factory buildings, transportation and utilities are considered. While some excellent trial efforts for LEED certified buildings have taken place, and many individual companies operating in industrial parks have established facilities that compare well with similar operations in their home countries. But these initiatives appear to represent a small fraction of total investment. Some new industrial operations such as those for steel production tend to be designed at or above international norms. However, there is justifiable concern about the creation of many more facilities that will become brownfield sites or that will become an on-going energy and pollution burden due to the limited initial investment in environmental controls.

What is required is a much greater environmental interest on the part of both Chinese and international investors in China, including those from other parts of Asia. The reality is that only two factors are likely to have a high degree of influence. One factor is strong governmental action of both a regulatory and an enabling nature. The second is the power of markets by rejecting unsustainably-produced items, or demanding certification or other proof of sustainability. Over the coming 5 to 10 years it is quite likely that both domestic and international markets for Chinese goods will feel pressure from environmental concerns. And, especially at the national governmental level, there is an increasingly coherent approach being followed in environmental regulation.

5. Attract much more Chinese and international venture capital and private equity in support of environmental services, and new environment and sustainable development initiatives, especially those at the start-up and scaling-up stages.

At the leading edge of investment is the role that could be played by venture capitalists in support of environmental and sustainable development innovation. Venture capitalists typically are needed in order to move innovations arising from small entrepreneurial companies from a preliminary stage of development to become a commercially viable operation. Use of venture capital in China is still at a stage where there are numerous problems, including an insufficient regulatory framework, and satisfactory relationships between entrepreneurs and the venture capital sources. There are many types of opportunities available and until recent times environment has not been the focus of as much attention as other fields such as information technologies and biotechnology. However, the highlighting of energy efficiency and pollution control as key objectives in the 11th FYP has elevated their significance to such investors.

Environmental services companies will likely prove to be attractive to private equity sources in future years. The conditions to support more private equity investment for environmental protection include: a need for consistent drivers so that there is reasonable assurance of a growing market demand and profits that are at least as good as alternative investments; fair regulatory frameworks that ensure a level playing field for enforcement and therefore interest—on the part of municipalities, the construction sector and various industrial sectors—in purchasing both environmental equipment and services; and knowledge of the opportunities that are likely in the coming years. Government may also
provide some direct stimulus through public procurement policies that favour environmentally friendly products and services. Fortunately, there is a growing understanding of energy efficiency and environmental protection investment opportunities in both the venture capitalist and private equity communities within China.

6. Ensure adequate flow of innovation benefits concerning environment and sustainable development to less wealthy areas of China and to rural areas, especially via the strengthening and support of small and medium-sized enterprises (SMEs) throughout the country.

While most funds for environmental innovation R&D and follow-up commercialization are likely to flow into urban areas where universities, research centres, industry and commercial activities are concentrated, there are many applications that must be developed to meet needs associated with the countryside. And, throughout China, the future strength of entrepreneurship will continue to be expressed largely through the remarkable number and variety of SMEs, including many located in smaller centres.

Megaprojects, including giant water and energy initiatives; some transportation projects such as the Qinghai-Tibet Railroad; regional development in China’s Northeast and in the Pearl Delta; and development of new cities encroaching into rural lands all have the potential to introduce not only a wide array of environment and sustainable development innovation technologies, but also vastly improved planning and management.

While China has undertaken many unique engineering initiatives in terms of scale and complexity, they alone cannot ensure sustainable development nationally or in the various regions of China. It is particularly important that there also is sufficient scientific effort devoted to solving the many problems related to intensive use of landscapes, ecological construction and restoration, development of eco-communities and green buildings at all scales including those in smaller cities and towns, and improvement of environmental quality in coal mining, heavy industry. This need is recognized in the new S&T strategy. The Asian Development Bank has noted that SMEs are “more flexible in meeting the market demand for new technology and are therefore able to achieve rapid growth in the market.” However, more needs to be done to provide an integrative approach that fosters and takes full advantage of small and medium-sized enterprises potential to be local and sometimes national entrepreneurs.

The integrative effort should include not only capacity development within the national innovation system to build local environment and sustainable development S&T competence, but also fostering the necessary private sector and venture capital funding opportunities directed to meet needs of SMEs. In addition, within local and provincial level governance, more emphasis must be placed on building appropriate enabling arrangements for entrepreneurs to work successfully but without creating funding sinkholes.

It is at local and regional levels where considerable effort must be applied in order to create adaptive strategies for environmental problem-solving. This is a key concern for climate change, for addressing problems associated with natural disasters, and for issues

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such as desertification and maintaining ecological services. Adaptive strategies recognize that it is human behaviour that must be modified to successfully address environmental change. Such strategies depend upon a blend of technological application, good environmental planning, innovative economic incentives and a high level of public understanding and input.

7. Seek better solutions to high licensing fees, more timely and reasonable access to advanced technology and, in general, build more proactive approaches to intellectual property rights matters for environment and sustainable development.

The balance between indigenous technology development and the utilization of environmental technology developed elsewhere will be determined by many factors, but certainly issues surrounding intellectual property rights and cost of access rank high. The problem is more complex than monetary factors only, however. Those possessing advanced technology are wary of losing control over rights, or unauthorized copying, acts of industrial espionage, etc. And there is also sometimes a concern about the absorptive capacity, which leads to a staged access rather than leapfrogging.

In the coming years, as Chinese industrial and manufacturing development matures even further, and as the domestic environmental industry sector grows, there should be a much greater capacity and opportunity to assimilate advanced technologies. The value attached to these technologies quite likely will be even greater than today. And there will be new options, especially in alternative energy technology, green chemistry, biorefineries and other applications involving biotechnology and information technology. Energy efficiency, new coal technology and transportation are other areas where major advances are already occurring.

What will be needed are more effective international partnerships and joint ventures aimed at building the levels of trust and understanding, and experimentation with new approaches towards sharing technological experience and advances. In general it should be in the best interests of the rest of the world to accelerate the pace of China’s transformation towards clean and efficient technology. Despite broad agreement about this statement, action has been relatively limited by comparison to the need. This is true for both government-to-government (e.g. EU S&T initiatives) or at the level of enterprises (e.g. the limited innovation efforts by overseas automobile manufacturers operating in China).

It is encouraging that new models are emerging, for example, the recently announced JUCCCE (Joint U.S.-China Cooperation on Clean Energy), a not-for-profit initiative designed “to accelerate 30 years of clean energy development into 10 years.” It will bring together US and Chinese government, business, research and investment interests to address China’s current energy efficiency and pollution control priorities.

Existing, but still evolving international mechanisms such as the CDM (Clean Development Mechanism), and TRIPs (trade related intellectual property rights) present future opportunities for China to make further gains towards more equitable arrangements on terms for technology access.

China also will benefit if it becomes a nation capable of exporting environment and sustainable development technology and expertise. This is already the case with solar
panels, where China is a leader. New export markets for environmental products, taking advantage of China’s comparative advantages such as lower production costs, could help to offset some of the fees paid to license advanced technologies. It also is a means of building economies of scale so that Chinese domestic markets can take advantage of more reasonably priced environmental goods.

8. Develop shared regional policies and practices with key countries and country groups within Asia and in the Asia-Pacific Region in order to create greater demand for environment and sustainable development innovation and to create new markets for Chinese environmental goods and services.

With the rising level of need and interest in environment and sustainable development throughout the Asia-Pacific region, and especially in South, Southeast and East Asia, there are good opportunities for China to build cooperative environment and sustainable development innovation ventures within the region. The advantages are obvious since problems often are shared or of a similar nature, costs of gaining access to appropriate levels of technologies may be less, and a clean environment will benefit all within the region. Also, there are bodies available that promote cooperation, such as ASEAN and APEC.

With huge populations and booming economies, markets for environmental goods and services in South and East Asia will become larger and larger. Yet there is insufficient cooperation to build a truly cutting edge approach that would take best advantage of the opportunities. It is striking that most of the international technology cooperation, venture capital access and capacity building necessary to supply these growing markets adequately is still via North America and Europe (along with considerable Japanese and growing Korean involvement). China and India could change this equation very significantly through cooperation to become regional environmental innovation leaders.

9. Recognize the role of producing and disseminating reliable information on environment and sustainable development as a central component of national innovation strategy.

People and communities need to understand benefits, costs and risks associated with innovation for environment and development and to have direct access to benefits. Otherwise there may be backlash. Fostering a culture of innovation within a country as large and diverse as China depends on education, public awareness, and a sense of opportunity. Environmental decline is now recognized as a matter of high concern by many of China’s citizens, yet relatively few would be able to link problems and solutions to specific modern technologies or other innovations. Certainly the same was true in many western countries until a generation ago. Much of today’s enhanced environmental perception has come about through a much better understanding of pollution science, ecosystem analysis, etc., accompanied by an active media involvement to popularize scientific findings and to interpret environmental changes. The debates accompanying the search process to define the nature of problems and possible solutions have become an important part of democratic processes.

China’s future choices on how and where to engage in scientific innovation for environment and sustainable development one way or another will be influenced by the
voice of its people—whether operating through consumer choice, consultative processes, or in other ways. It is essential that choices be informed by the best available Chinese and international knowledge, and that will require deliberative dialogue on technology, institutional performance, assessment of impacts and other concerns of people.

10. Use China’s comparative advantages to engage in the substantial markets for green products and services both domestically and for export markets.

China’s low labour costs and skilled labour supply, ability to rapidly set up modern, efficient manufacturing plants, and technological design skills can be used to build international leadership in green markets of the future. Part of China’s advantage, of course, is the enormous potential size of domestic markets. Chinese businesses have been able to do this already with solar panels. Another opportunity clearly will be in the manufacture the next generation of lights to replace incandescent bulbs.

China has developed unique capabilities related to implementation of Circular Economy. Utilization of the world’s waste paper is one of the most significant examples of how China can meet its needs while contributing to the solution of a global problem. The idea of a Circular Economy is an important expression of an environmentally-friendly society. It is one of the most concrete ways to address environmental innovation.

CONCLUSION

China’s strategic transformation on environment and development may well be unlike that of any other country. Coming some 30 years later than transitions in the OECD countries, China’s transformation can be informed by many good and bad experiences of others. The challenge is for China’s effort to be more successful than any other nation. Although there are many barriers domestically and internationally, there is also good reason to believe this success could be achieved, so that China becomes a model for others.

Would it be in China’s best interest to do so? And how substantial would be the economic, social, environmental and political benefits to the country? These are questions that will need to be debated. But it is clear enough that the entire world will benefit if China is successful.

Therefore China’s commitment to innovation for an environmentally-friendly society is likely to become one of the great experiments of our time. It needs to be supported in many ways, including accelerated efforts to more rapidly find ways to address such difficult and pressing problems as clean coal combustion and utilization, and mechanisms to properly assess new technologies so that both domestic and international confidence is maintained. The experiment will start to demonstrate its benefits immediately, both to China and outside of its borders. But the greatest payoffs will come in the longer-term, hopefully to China’s society of 2020, and to the world of 2030 where significant transitions in energy use, industrial ecology, Circular Economy and other innovations should be universal.

(Text version is provided by Chief Advisors)