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Perspective in development of environmental technology in China

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Abstract—Environmental technology (ET) refers to the processes and techniques for environmental prevention, reduction, recycling, reuse and rehabilitation. Since 1978, China has launched a series of R&D programs in promoting environmental science and technology development. Uneven spatial distribution and sectoral structure give us a profile of the present status of ET in China. Both opportunities and constraints are analyzed for the development of ET, and strategies for its future development are presented in this paper.

Keywords: environmental technology, R&D, technology development, China.

1 Increasing environmental problems call for technological solutions

With the rapid economic growth in the past two decades, all the major environmental problems of world wide concern have appeared in China in one way or another. They are mainly reflected in soil erosion, desertification, bio-diversity reduction, water quality deterioration, acid rain deposition, air pollution, hazardous and solid waste pollution, frequent natural disasters, and so on.

According to the World Watch Institute (1997), as a result of the energy structure heavily dependent on fossil fuel, China has replaced Russia as the second largest country in greenhouse gas emission, with a very high growth rate (27.5%) between 1990—1995, as shown in Table 1.

Table 1 The "Eight Environmental Heavy Weight" in greenhouse gas emission in 1995

Order	Country	Percentage	Growth rate 1990—1995, %
1	USA	22.9	6.2
2	China	13.3	27.5
3	Russia	7.2	27.5
4	Japan	5.0	8.7
5	India	3.8	27.7
6	Germany	3.8	10.2
7	Brazil	1.01	9.8
8	Indonesia	0.93	8.8

Source: World Watch Institute Report 1997, P.8.

China boasts a great number of mountain and hilly land, accounting for 2/3 at the total area; the stability of soil is poor; rain falls in a certain limited period due to the influence of monsoon climate; the population is large; the exploration history is long with strong exploration intensity; the forest is sparse. Such factors make China one of the countries with the most serious soil erosion. Although since the 1950's, water and soil conservation has been paid much attention and 500 thousand square kilometers of land suffering from soil erosion has been brought under control, the area of soil erosion (water erosion) is still expanded from 1.5 million square kilometers in the

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1950's to 1.79 million square kilometers at present, and annual amount of soil lost is up to 5 billion tons. Serious soil erosion results in soil degradation or even complete loss of soil, and reservoirs, lakes and rivers are choked with silt, therefore, natural calamities are getting serious with great economic loss (Shan, 1995). Continuing deforestation, if without restrictions, will make the situation even worse.

China has a large arid or semi-arid area with less precipitation, and the desert is widely distributed in northern China. It is estimated that the direct economic loss is up to 1 billion US dollars and indirect loss reaches 2—10 billion US dollars each year, due to the damage caused by desertification to croplands, grasslands, water conservancy facilities and communication facilities.

Water pollution affects almost all the major river systems and lakes. Many sections of the Yangtze and Yellow rivers and the main streams of Huaihe, Luanhe, Liaohe and Songhuajiang are seriously polluted. Eutrophication level is very high in such big lakes as Chaohu, Dianchi and Taihu.

Acid deposition stretches from central and south-western China to the northern part of China due to the widespread use of coal with high content of sulfur in most parts of China. It has made China become one of the three major regions of acid deposition in the world.

Piling up trash in cities and towns has become a headache with the rapid urbanization. China needs to upgrade its capability to manage solid waste, which provides a space for importing new technology to accomplish this goal. With the improvement in living standards of the people, more and more people have paid their attention to indoor environmental quality in which China lags far behind the developed countries.

The above-mentioned environmental problems bring us not only great challenges but also great opportunities for the development and applications of new, appropriate and advanced technologies. In combination with other approaches such as legal enforcement and economic instruments, cost-effective technological solutions are necessary for environmental prevention, reduction, recycling, reuse and remediation.

2 The state-of-art of environmental technology in China

2.1 Focal points of R&D

Research and development (R&D) of environmental technology were begun with water pollution prevention and treatment in the late 1960's in China. Since then, all the R&D activities have been focused on the pressing problems of air pollution, water pollution and solid wastes occurred in the process of rapid economic development. Great progress in technology development has been made in high content organic waste water treatment for paper making, printing and dyeing industries, treatment and reuse of urban sewage, integrated treatment of eutrophic lakes, high efficiency dust removal, moulded coal, circular fluidized bed combustion process, desulphurization for small and medium-sized furnaces, treatment and comprehensive utilization of chromate scum, treatment and reuse of electroplating waste water and scum, incineration and safe landfill of solid wastes, and so on. But China lags behind some advanced countries for ten to twenty years in pollution control and treatment, while taking the lead in the developing world.

Since 1990, the focus of the R&D on technologies for treatment at sink has been transferred to prevention at source, such as cleaner production, low or no waste processes, and new technologies for water and energy saving. The following R&D programs are in the process of being undertaken: (1) integrative cleaner production technology; (2) control and prevention of air pollution as a result of coal combustion; (3) water resource conservation and pollution prevention;

(4) automobile emissions prevention and control; (5) radiation and noise pollution prevention; and (6) real time monitoring and emergency response.

2.2 Spatial distribution

The spatial distribution of environmental technology development and application corresponds with the spatial distribution of economic development in China. In industrially advanced regions, there are generally more pollution problems and comparatively stronger technical and human resources than that in the undeveloped regions, which makes it possible for these regions to take the lead in developing and using environmental prevention and control technologies. Except for Tibet, environmental technologies are developed and applied in other 30 provinces, municipalities and autonomous regions. Environmental industry distributes unevenly with the focus on the coastal regions or the regions along the Yangtze River. In terms of the number of environmental firms, employees, annual production and profits, Jiangsu Province takes the first position, followed by Zhejiang, Liaoning, Tianjin, Guangdong, Shanghai, Anhui, Hubei, Sichuan, Heilongjiang provinces, municipalities and autonomous regions, while slow development in environmental technology has taken place in such provinces and autonomous regions as Qinghai, Ningxia, Hainan, Yunnan, Shaanxi, Inner Mogolia, Gansu, Guangxi and Guizhou.

There are five geographic regions with promising perspective in development of environmental technology: (1) the most advanced region in east China, including Jiangsu, Zhejiang and Shanghai; (2) the past heavy industry region in northeast China, including Liaoning and Heilongjiang; (3) the north China economic region, including Beijing, Tianjin and Hebei; (4) the watershed along the Yangtze River, including Hubei, Hunan and Sichuan; and (5) Guangdong, the future environmental industry development base in south China.

2.3 Sectoral structure

A complete system of research, development and production of environmental technology and equipment has been set up in China. Main focus is put on the research, development and manufacturing of facilities for water pollution prevention and disposal, air pollution control, solid waste disposal, noise and vibration control, radiation and magnetic pollution prevention and maintenance, and environmental monitoring. The sectoral structure is listed in Table 2 in terms of the number of firms and profits, employees and annual production.

Table 2 Sectoral structure of environmental industry(%)

Facilities	Firm	Employee	Annual production	Annual profit
Water pollution prevention and disposal	38.0	36.5	36.8	35.9
Air pollution control	37.6	32.9	43.5	37.9
Solid waste disposal	2.9	4.4	2.3	2.8
Noise and vibration control	11.2	14.2	6.0	5.9
Radiation and magnetic pollution prevention and maintenance	0.1	0.8	0.2	0.2
Environmental monitoring	3.8	4.8	2.2	2.2
Others	6.5	6.2	9.1	1.5

Note: Computed from basic conditions of environmental industry in China, NEPA, 1997, p11.

It is shown in Table 2 that the facilities for air pollution control and water pollution treatment are the two major components of environmental technology research and development in China, while noise control, solid waste management and environmental monitoring still take a small percentage.

3 Opportunities and constraints for ET development

3.1 Opportunities

Environmental protection has long been a national policy, and recently sustainable development and developing China through science and education have been set up as long-term national strategies, which lay an institutional and political basis for development and applications of environmental technology.

"Rule by law" was recently written into the Constitution of the People's Republic of China. With the improvement and strict enforcement of environmental laws and regulations, the Chinese enterprises, large or small, are forced to adopt technical measures for prevention, reduction, mitigation and remediation of environmental emissions, which creates a big potential demand for new and advanced or appropriate environmental technology.

ISO 14000, or environmental management system, has been taken by more and more enterprises as a criterion for entering international market for their products. ISO 14000 requests the enterprises to prevent pollution at source, to carry out environmental management "from cradle to grave", and to be responsible for any emissions in all the processes and operations. This requires the enterprises to reform their production processes, and to conduct an innovative cleaner production which needs support of environmentally sound technologies.

China is now in the process of conducting a national science and technical innovation system in which environmental science and technology are included. For so doing, an increase in investment is foreseen in research and development of innovative environmental technology.

The public is increasingly aware of the importance of improvement of environmental quality. There will be more pressure from the public for taking technical measures for environmental enhancement.

3.2 Constraints

Research has been traditionally separated from applications in China. Researchers do their research out of curiosity with no or little notice of the needs from industry, while industry does not care about research achievements or is not willing to use them without accurate and complete information. There is a lack of linkage between research and applications which can bring research results into applications, obtain research requirements or even funding from industry, and bring industry involvement in the R&D processes.

Inadequate financing mechanisms have become major barrier to the research and development of environmental technology. At present, the main financing channels for R&D of environmental technology are from governmental organizations, very few industries and venture funds are involved in investment in this undertaking.

Low cost-effectiveness for enterprises to use environmental technology is another constraint for its applications. For an enterprises itself, it may be more cost effective to transfer the external costs of environmental pollution to its surroundings than to use environmental technology for treating the pollution, given the lack of strict enforcement of environmental laws, regulations and monitoring standards.

Lack of an innovative system in environmental R&D institutions has caused the backwardness of environmental technologies. Introduced technology or equipment may not be suitable for the specific conditions in China, and should be locally customized, which also requires the R&D institutions to be innovative and adaptive.

Shortage of skillful environmental technicians and management personnel in enterprises and

administrations has made the R&D results unacceptable by the potential users or mistakenly used by the users, as there is a lake of professional channels for communications between researchers, developers and their clients.

4 Strategies for future development of environmental technology

4.1 Implementing policies for promoting environmental industry development

Environmental industry should be regarded as a new growth sector, more importance should be given to its development. A series of preferential policies should be set up for promoting environmental industry development in China, such as credit priority and tax reduction for those firms that make a progress in emissions control through technical measures, which may create a greater demand for environmental technology and equipment.

4.2 Strengthening interlinkages between research and applications

For bridging the gap between research and applications, a mechanism should be established for bringing early involvement of industry in the research and development process of environmental technology. More R&D programs and projects should come directly from industrial contracts not only from governmental assignments. Both national and local information systems on supply of and demand for environmental technology and equipment should be established and networked for both the R&D parties and end users to share and communicate information. The evaluation criteria on the performance of researchers should also be changed from traditional emphasis on their academic publications into the focus on their technical innovation capability and intellectual property.

4.3 Expanding financing channels

First of all, governmental investment in environmental industry should be increased to a higher percentage of national GDP. All the possible channels for financing environmental technology should then be considered, including domestic and international bank loans, technical assistance grants, charitable or governmental donations. Industry should be encouraged to take an active role in investing in R&D of environmental technology for sharing either the intellectual property rights or economic returns of the final product. Venture funds or mutual funds should also be introduced to promote the development of environmental technology and other advanced technologies with both high potential returns and big risk.

4.4 Establishing environmental technology assessment system

There is a shortage of suitable environmental technology assessment system in China. Environmental technology assessment (ETA) is taken to be a class of studies that systematically examines the effects on society and environment that may occur when a technology is introduced, extended, or modified. It emphasizes those consequences that are usually unintended, indirect, or delayed. Through ETA, some actions might be taken: (1) modify the project to reduce disbenefit and /or to increase benefits; (2) identify regulatory or other control needs; (3) define a surveillance program for the technology as it becomes operational; (4) stimulate R&D to: (a) define risks more reliably; (b) forestall anticipated negative effects; (c) identify alternative methods for achieving goals of technology; (d) identify corrective measures for reducing or eliminating negative effects; (e) identify experiments to clarify uncertainties; (f) identify needed institutional changes; (g) provide sound information to all interested parties; (h) identify new benefits; (i) delay the project; (j) identify partial or incremental implementation strategies and (k) prevent the technology from developing or being used (T. O'Riordan, 1995). For so doing, an ETA system should be established in China, with the assessment organizations independent of governmental interventions. The assessment organizations should be neutral without any bias in the

assessment process. The assessment criteria should be comprehensive, scientific and just, and evaluated and monitored by the researchers, end-users, brokers, officers and other parties involved. And the assessment procedures should be open and transparent.

4.5 Developing human resources

Human capital is the most important factor in the development of environmental technology. This should become a commonsense in this field. Technical personnel of critical shortage at the present time are the in-situ environmental technicians at grassroots level, environmental management personnel at operations procedures, and environmental intermediary agents who know application requirements and technology itself. Immediate solution to the problem is to set up short-term education curricula and regular training programs, and make them available to and acceptable by the grassroots people. The most important is the firms' awareness of the importance of having this king of education/training program in their firms.

4.6 Strengthening supervision mechanisms for environmental management

To spur the internal demand from industry for environmental technology, the most effective measure is to strengthen the enforcement of environmental laws, regulations and standards. For this purpose, not only legal, administrative and economic penalties should be imposed on the firms that are not in compliance with environmental laws, regulations and standards, but monitoring and supervision systems should be established and maintained for the public, community and media to be informed of or involved in the environmental management of the firms.

4.7 Enhancing international collaboration and exchange

China lags behind the advanced countries in environmental technology for about ten to twenty years, for some areas even longer. In keeping abreast with the international advancement in environmental technology, the Chinese R&D institutions should continue to extend the collaboration with the counterparts in the world in both theoretical research, technology development and facility manufacturing. Attention should also be paid to collaborating with scientists and engineers with other academic backgrounds from different countries, as contemporary environmental technological innovation concerns with not a single discipline but interdisciplinary or multidisciplinary efforts.

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