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IMPLEMENTATION OF CLEANER PRODUCTION STRATEGIES TOWARDS A SUSTAINABLE CITY

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ABSTRACT: Rapid urbanization and growing size of cities will have an increasing impact on the global environment in the 21st century. As an engine of urban development to drive economic growth and technological innovations, industry has moved its focus from controlling environmental hazards to stimulating sustainable industrial development throughout the entire product lifecycle. These process- and technology-driven innovations for industrial production are prerequisites for enhancement of urban environment and sustainable development of cities. In this review, problems of environment and resources scarcity associated with rapid urbanization are demonstrated. And, on the basis of expatiations on the concepts and policies of the cleaner production (CP) and other similar initiatives with the goal of preventing pollution at the source and of managing the raw material more efficiently, two different ways to link the practice of cleaner production in industrial sector with performance of urban environment are discussed in detail. Then, the introduction, practice and legislation of CP strategies in China are outlined, and possibility for China to develop CPC (Cleaner Practices for Cities) approaches in the demonstration cities is discussed. Finally, some suggestions on implementation of CPC strategies are put forward.
KEY WORDS: urbanization; urban environment; cleaner production; cleaner practices for cities; sustainable cities

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1 INTRODUCTION

Worldwide urbanization at an unprecedented speed is becoming one of the greatest environmental and economic challenges in the 21st century. In 1900, only 160×10^6 persons, one tenth of the world′s population, were city dwellers. By 2006, in contrast, half (3.2×10^9 persons) will be living in urban areas—20-time increase (O′MEARA, 1999; UNPD, 2000) (Table1).

Cities historically have been centers of industry and commerce and magnets for millions of people. Today it is increasingly evident that, with worldwide rapid urbanization, cities are becoming major drivers of economic activity. Over the last 25 years, Asia and many other countries of the world experienced a dramatic shift in economic activity from rural agriculture to urban production and service. From 1977 to 1997, the fraction of GDP in Asian countries resulting from agricultural activities dropped from 35% to 18% of the total (Asian Development Bank, 2001). The sheer size of cities and the rapid urbanization, however, presents humankind a dilemma. The explosive growth of cities in developing countries will test the capacity of governments to stimulate the investment required to generate jobs and to provide the services, infrastructure, and social supports necessary to sustain livable and stable environments (NIC, 2000). The economic and cultural advantages of cities are impressive in many ways, however, the world, especially developing countries, is facing intensified resources scarcity and environmental problems due to rapid urbanization and increasingly intensive human activities within cities.

2 ENVIRONMENTAL PROBLEMS ASSOCIATED WITH URBAN DEVELOPMENT

There is a rapid increase in the urban environmental problems generated by economic activities. Today, air pollution is a major problem associated with most ur-

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Table 1 Distribution of urban residence in the world in 1950–2030

A. Population size and growth

Major area	Population ($\times 10^9$)				Growth rate (%)		Doubling time (years)	
	1950	1975	2000	2030	1950–2000	2000–2030	1950–2000	2000–2030
Total population								
World	2.52	4.08	6.06	8.11	1.75	0.97	40	71
More developed regions	0.81	1.05	1.19	1.21	0.76	0.06	91	1158
Less developed regions	1.71	3.03	4.87	6.90	2.09	1.16	33	60
Urban population								
World	0.75	1.54	2.85	4.89	2.67	1.80	26	38
More deveoped regions	0.45	0.73	0.90	1.01	1.41	0.37	49	186
Less developed regions	0.30	0.81	1.94	3.88	3.71	2.31	19	30

B. Urban indicators

	Percentage urban (%)				Urbanization rate (%)		Doubling time (years)	
	1950	1975	2000	2030	1950–2000	2000–2030	1950–2000	2000–2030
World	29.7	37.9	47.0	60.3	0.91	0.83	76	83
More developed regions	54.9	70.0	76.0	83.5	0.65	0.31	–	–
Less developed regions	17.8	26.8	39.9	56.2	1.62	1.14	43	61

Source: UNPD, 2000

ban areas. It is believed that more than 1.1×10^9 people reside in cities with extremely poor air quality. Another 2.5×10^9 are at risk from high levels of indoor air pollution (SCHWELA, 1997; ROODMAN, 1998). Indoor and outdoor air pollution together kill nearly 3×10^6 persons each year, about 6% of all deaths annually—and 90% occur in developing countries (WHO, 1997; UNDP, 1998; O′MEARA, 1999). Active and potential sources of air pollution include industrial and vehicle emissions and energy production. The circulation patterns associated with an urban heat island create a dome over the city to trap pollutants. Concentration of pollutants such as suspended particulate matter can be thousands of times greater than that of rural areas.

Water pollution is another serious environmental problem associated with urban areas. The urban development contributes in many ways to the pollution of both surface and ground water. The current volume of wastes is far beyond the capacity of effective dilution and dispersal. Over 220×10^6 urban residents do not have access to clean drinking water. Polluted water is believed as the largest environmental killer around the world, killing some 5×10^6 to 12×10^6 lives a year, depending on the definition of water-related disease (DAVIDSON *et al*., 1992). According to the World Health Organization (WHO), the majority of urban population in developing countries do not have access to proper sanitation facilities—flush toilet, sanitary latrine, or a pit that can be covered over—and about half lack a regular supply of potable water (WHO, 1997).

As cities grow ever larger, more and more natural resources are consumed to meet the rising demand for food, water, energy, goods and services, both from people and industry (WRI, 1998; UNFPA, 1999; HINRICHSEN *et al*., 2001). Cities take up less than 2% of the earth′s total land surface but consume the bulk of key resources. It estimated that roughly 76% of industrial wood use worldwide and 60% of the planet′s fresh water consumption take place in urban areas.

The economic and environmental reach of the city goes far beyond the city limits. Today cities are more and more relying on far-flung resources for food, water, and energy. London, for example, now requires roughly 58 times as much as its land area just to supply its residents with food and timber. Meeting the needs of everyone in the world, in the same way that the needs of Londoners are met, would require at least three more earths (O′MEARA, 1999). On the other hand, through trade and commerce, the generation and disposal of wastes, and the alteration of nature′s cycles, cities exert environmental impacts to the regions beyond urban hinterlands (HINRICHSEN *et al*., 2001).

Urbanization processes and urban activities are dependent on a steady supply of resources including renewable and non-renewable ones. Natural resources scarcity, however, at global level is undeniable. Thus, depletion of non-renewable and degradation of renewable must be minimized in order for cities to be sustainable. The 21st century is the first urban century, with the majority of the world population living in cities. The impacts of this transition challenge all segments of society. The sheer size and reach of cities means that they will have a profound impact on the global environment in the 21st century—or better or worse. One of the guiding principles is

to reform urban systems so that they mimic the metabolism of nature. Rather than devouring water, food, energy, and processed goods without regard for the impact of its ravenous appetites, and then belching out the remains as noxious pollutants, the city could align its consumption with realistic needs, produce more of its own food and energy, and put much more of its waste to reuse (O′MEARA, 1999). Thus, sustainable solutions are needed to produce both for economic and environmental gains, contradicting traditional notions that environmental gains have economic tradeoffs.

3 PROCESS–DRIVEN INNOVATIONS FOR INDUSTRIAL SUSTAINABILITY

3.1 Urban Environmental Consequence Caused by Over-expansion of Industrial Output

As known, historically there has been tight linkage between industry and urban development, and, actually the Industrial Revolution brought the major urban transformation (O′MEARA, 1999). Since the Industrial Revolution, over-expansion of industrial output has brought about intensive resources depletion and serious environmental consequence in the way of profligate energy and material use, extensive air and water pollution, and the generation of hazardous waste and toxic chemicals (ROBINS and TRISOGLIO, 1992; GRUBLER, 1994). Not only have the bulk of these impacts been concentrated in the world′s growing urban areas, but also the burden has been unevenly distributed both within the city and its hinterland (ROBINS and KUMAR, 1999).

3.2 Environmental Protection from ″End-of-pipe Control″ to ″Beyond Compliance″

The speed of producing of wastes and pollutants from industrial sector have been faster than that of the earth absorbing them, and natural resources has been consumed faster than they can be restored. Industry must attend and react to increase economic pressures, global competition and environmental awareness. In the past, industrialized nations responded to pollution and environmental degradation in three characteristic ways: firstly, by ignoring the problem; secondly, by diluting or dispersing the pollution, so that its effects are less harmful or apparent; thirdly, by trying to control the pollution and the wastes (the so-called "end-of-pipe" or pollution control approach). It is obvious that the above-mentioned approaches for environmental protection focus on what to do with wastes and emissions after they have been created. More recently, however, the focus of attention has been moved from controlling environmental hazards to stimulating sustainable industrial development throughout the entire product lifecycle. Indeed, in the 1990s a significant shift have been witnessed among the enlightened sections of the global business community away from denial and resistance to the changes towards a more proactive approach, seeking to go "beyond compliance" and using the sustainability imperative as a driver for innovation (ROBINS and KUMAR, 1999; UNEP and DTIE, 2002) (Fig. 1).

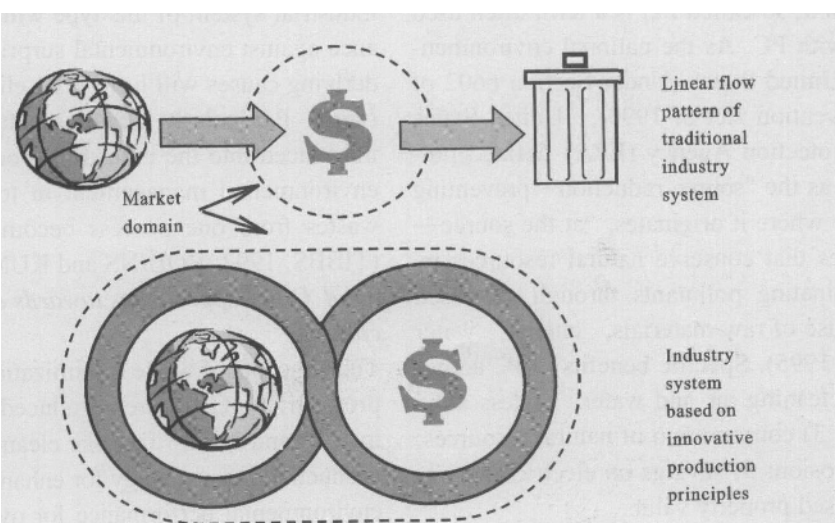

Fig. 1 Differences between traditional industrial mechanisms and cleaner production strategies (after TIBBS, 1992)

3.3 Concept of Cleaner Production and Its Benefits

With the goal of preventing pollution at the source and of managing the raw material (including energy and water) more efficiently, UNEP (United Nations Environment Programme) established its Cleaner Produc-

tion (CP) Programme in 1989. Since the Earth Summit in Rio De Janeiro held in 1992, cleaner production have already got internationally acclaimed and incorporated into *Agenda 21* as a preferred strategy in reconciling the dual needs of environmental protection and economic development. According to UNEP and DTIE (Division of Technology, Industry and Economics), cleaner production is defined as "the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment". Cleaner Production focuses on a strategy of continuously reducing pollution at source, rather than relying on the treatment of waste streams in the conventional end-of-pipe method. The key to cleaner production is thus to minimize potential environmental impacts by minimizing the volume and concentration of polluting streams (HAYWARD and TRERISE, 2001; UNEP and DTIE, 2002). The National Cleaner Production Centers (NCPCs) Programme, established in 1994, concludes the benefits of cleaner production as seven aspects: 1) reducing overall operating costs; 2) improving the environmental situation; 3) gaining competitive advantage; 4) increasing productivity and product and process improvement; 5) advanced workplace quality; 6) better media and public profile; 7) better compliance with environmental regulations.

3.4 Other Approaches Associated with CP

3.4.1 Pollution prevention

Pollution prevention, so-called P2, is a term often used interchangeably with PC. As the national environmental policy of the United States (Under Section 6602 of the Pollution Prevention Act of 1990), United States Environmental Protection Agency (EPA) defined pollution prevention as the "source reduction—preventing or reducing waste where it originates, at the source—including practices that conserve natural resources by reducing or eliminating pollutants through increased efficiency in the use of raw materials, energy, water and land." (EPA, 1995). Specific benefits of P2 activities include: 1) cleaning air and water; 2) less solid waste in landfills; 3) conservation of natural resources; 4) reduced soil erosion; 5) savings on electric and water bills; 6) increased property value.

3.4.2 Eco-efficiency

Comparatively, eco-efficiency (EE) declared by the World Business Council for Sustainable Development (WBCSD) at the 1992 Earth Summit in Rio de Janeiro, is a broad term, encompassing the principles of sustainable development, cleaner production, environmental management and more—but using all these principles to be more efficient and productive, providing a means for businesses to pursue development that is sustainable both economically and environmentally. Eco-efficiency focuses more closely on improving business outcomes, through the use of improved environmental management and resources efficiency (Environment Australia, 1999; ROBINS and KUMAR, 1999). Eco-efficiency directly links environmental performance to financial performance—if a process is made more efficient, then both financial and environmental benefits will follow.

3.4.3 Industrial ecology

Industrial ecology (IE), synonymous with industrial metabolism, is a concept for new patterns of industrial production and is closely related to the Cleaner Production concept. Industrial ecology and industrial metabolism are studies of industrial systems and economic activities, and their links to fundamental natural systems. It involves designing industrial infrastructures as if they were a series of interlocking man-made ecosystems interfacing with the natural global ecosystem. IE takes the pattern of the natural environment as a model for solving environmental problems, creating a new paradigm for the industrial system in the process. IE aims to achieve a pattern of industrialization that is not only more efficient, but also intrinsically adjusted to the tolerances and characteristics of the natural system. The emphasis is on forms of technology that work with natural systems, not against them. An industrial system of this type will have built—in insurance against environmental surprises, because their underlying causes will have been eliminated at the design stage. Particularly, cycling patterns of ecosystems is introduced into the industrial production processes and environmental management in terms of ensuring that wastes from one process become inputs for another (TIBBS, 1992; ROBINS and KUMAR, 1999).

3.4.4 Other approaches towards environmental protection

The concepts of waste minimization (WM) and green productivity (GP) were introduced respectively by EPA in 1988 and 1994. Just like cleaner production, green productivity is a strategy for enhancing productivity and environmental performance for overall socio-economic development, while waste minimization is taken as waste prevention approach and its techniques are defined as on-site reduction source of waste by changes of input raw materials, technology, good operating practices (EPA, 1995; APO, 1996) (Table 2).

Table 2 Interchangeable phrases to describe efforts to cut environmental impacts and improve resources efficiencies

Item	Cleaner production (CP)	Industrial ecology (IE)	Eco-efficiency (EE)	Pollution prevention (P2)	Waste minimization (WM)
Definition	The continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment	Incorporation of the cyclical patterns of ecosystems into designs for industrial production processes and environmental management particularly in terms of ensuring that wastes from one process become inputs for another	A broad term, encompassing the principles of sustainable development. A business strategy to provide goods and services while continuously reducing ecological impacts	Defined under the Pollution Prevention Act, and other practices that reduce or eliminate the creation of pollutants	In this concept, waste prevention approach and its techniques are as on-site source reduction of waste by changes of input raw materials, technology changes, good operating practices and product changes
Brief description	"waste treatment does not fall under the definition of CP"	"in unison with natural systems"	"doing more with less"	"source reduction"	"on-site reduction and cycling"
Approaches and benefits	1) Conserving raw materials, water and energy. 2) Eliminating toxic and dangerous raw materials. 3) Reducing the quantity and toxicity of all emissions and wastes at source during the production process. 4) Reducing the environmental, health and safety impacts of products over their life cycles. 5) Incorporating environmental concerns into designing and delivering services	1) Industrial ecosystems. 2) Balancing industrial input and output to the constraints of natural systems. 3) Dematerialization of industrial output. 4) Improving the efficiency of industrial processes. 5) Development of renewable energy supplies for industrial production. 6) Adoption of new national and international economic development policies	1) Reducing material intensity. 2) Reducing the energy intensity of its goods and services. 3) Reducing the dispersion of any toxic materials. 4) Enhancing the recyclability of its materials. 5) Maximizing the sustainable use of renewable resources. 6) Extending the durability of its products. 7) Increasing the service intensity of its goods and services	1) Increasing efficiency in the use of raw materials, energy, water, or other resources. 2) Protecting natural resources by conservation. 3) Reducing the amount of any hazardous substance, pollutant, or contaminant into the environment. 4) Reducing the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants	1) On-site source reduction of waste by new production processes. 2) Off-site recycling by direct reuse after reclamation. 3) Enhancing the recyclability of its materials. 4) Maximizing the sustainable use of renewable resourcesReducing the quantity of all emissions and wastes at source during the production process
Comparability	The terms, cleaner production and pollution prevention, are often used interchangeably. The term pollution prevention tends to be used in North America, while Cleaner Production is used in other parts of the world	Beyond eco-efficiency: moving to industrial ecology, which goes beyond the conventional focus on the individual firm to place industrial production within a wider ecosystem view	Cleaner production and eco-efficiency are closely linked, however, eco-efficiency focuses more closely on improving business outcomes, through the use of improved environmental management and resources efficiency	Often used interchangeably with waste minimization and cleaner production. Pollution prevention means not generating waste in the first place by reducing it at the source	Closely linked with pollution prevention, waste minimization, however, is a broader term that also includes recycling and other means to reduce the amount of waste which must be treated/disposed

4 CLEANER PRODUCTION WITHIN CITIES

4.1 CP Efforts Towards Sustainable City

Policies and practices of cleaner production and other similar initiatives, including waste minimization, pollution prevention, recycling, and community-based environmental protection approaches offer a set of strategies designed to balance environmental and economic needs. Doubtless, CP′s efforts to isolate industrial facilities contribute to the enhancement of urban environment, however, are not necessary to archive a goal of sustainable urban development. According to ROBINS and KUMAR (1999), to date there is few explicit linkage between this new and more positive agenda for industry, sustainable development and the pressing issues of urban growth and renewal. Most focus on generic issues for national policy-making and the management of individual firms, ignoring the specific spatial issues facing particular towns and cities. Therefore, as pointed out by ROBINS and KUMAR, the much-needed shift from a linear to a closed loop manufacturing system will require far greater attention to local flows of materials within city regions (ROBINS and KUMAR, 1999).

4.2 Links Between Industrial PC Practice and Urban Environmental Performance

There are two different ways to link the practice of

cleaner production in industrial sector and performance of urban environment. The first is so-called Good Urban Governance (GUG). To drive sustainable development in cities, action need to be taken at different levels. It means that at city level the local authorities and other public agencies with responsibility for urban management need to put strategies that drive industrial production in urban areas according to clear targets for sustaining local carrying-capacity and ensuring community benefit. To do that, changes in traditional spatial planning, assessment and zoning procedures, targeting investments at collective infrastructure services are necessary (ROBINS and KUMAR, 1999; O′MEARA, 1999). The second is the Cleaner Practices for Cities (CPC), in which a large corporation offers an analogy to a city and CP strategies are integrated into urban activities. In this context, urban systems can include industrial sectors, industrial facilities, which may contain one or more distinct industrial processes, urban areas, or even regions with multiple urban areas. In this way CPC is believed to have potentially far greater impacts than simply limiting CP efforts on isolated industrial facilities (USAEP Implementing Contractor *et al.*, 2000) (Fig. 2).

4.3 Initiatives Towards Integrated Environmental Management and Sustainable Urban Development

There is an increasing emphasis worldwide on improving governance in cities as a means of achieving sustainable development. According to World Bank (1999), the definition of good governance should be understood in the context of its vision for the sustainable city.

Established by UN-Habitat in 1990, Sustainable Cities Programme (SCP) promoted a broad-based, participatory process for the development of a sustainable urban environment, emphasizing cross-sectoral coordination and decentralization of decision-making. At the local level, the SCP acts as a technical cooperation program, using carefully planned and structured city demonstration projects to strengthen the capacities and abilities of the participating in local governments and their partners in the public, private and community sectors.

The focus of this technical support is environmental planning and management (EPM), for which the SCP has developed a distinct EPM planning approach. The EPM approach is being continuously developed and refined to reflect local experiences and needs (UNCHS-UNEP, 1997).

There are many different level initiatives toward urban

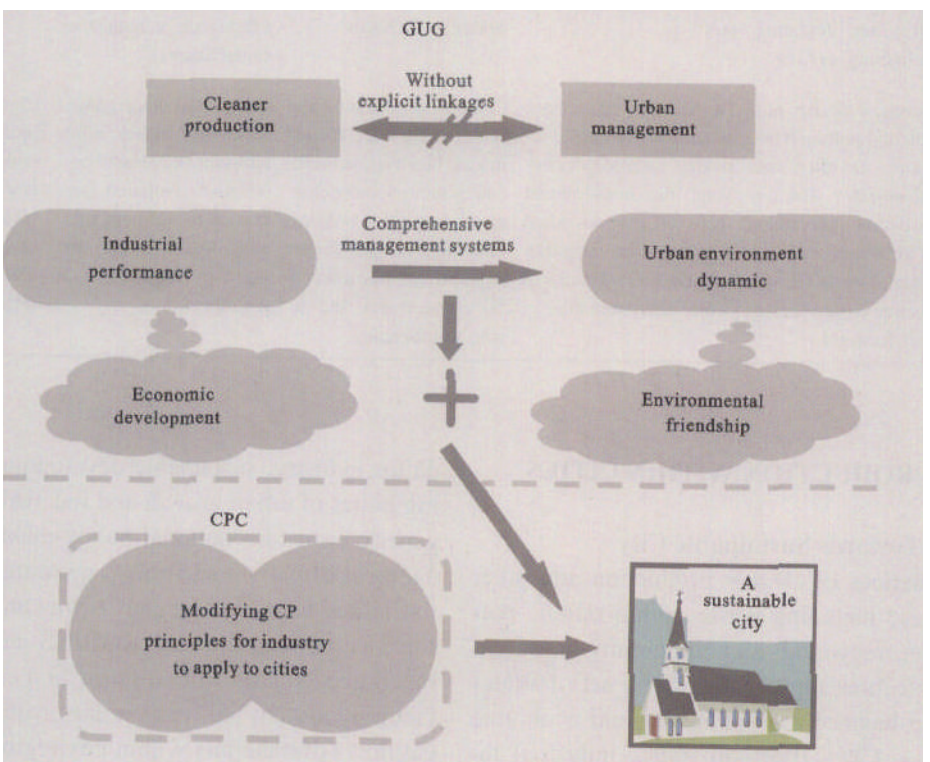

Fig. 2 Relations between cleaner production practice and urban environment performance

sustainable development, with similar integrated/intersectional approaches to that of the SCP, including the Sustainable Cities Initiative run by the United States Agency for International Development, the Healthy City projects by the World Health Organization, the Metropolitan Environmental Improvement Programme jointly by

the World Bank and United Nations Development Program, the CITY NET by Economic and Social Commission for the Asian and Pacific Area, and Private-Public Partnership for the Urban Environment Programme by the United Nations Development Programme. Much details about initiatives mentioned above are given in Table 3 (WHO, 1996; UNCHS-UNEP, 1997; WERNA *et al.*, 1999; ROBINS and KUMAR, 1999; PLUMMER and NHEMACHENA, 2001).

The existence of multiple initiatives is not necessary, and it needs good coordination, particularly when two or more programmes are concomitantly implemented in the same city. This means the initiatives associated with the concept sustainable city need to be flexible enough to be adapted to other integrated international programmes.

4.4 Concept of Cleaner Practices for Cities and Necessities of CPC Strategies

In contrast, initiated by the US-Asian Environmental Partnership (USAEP) and United States Agency for International Development (USAID), cleaner production

Table 3 International initiatives toward sustainable urban development

Initiatives	Run by institution, time	General description	Objectives	Global/Regional/Country Level
Sustainable Cities Programme (SCP)	UN-Habitat and UNEP (United Nations Human Settlements Programme and United Nations Environment Programme), 1990	A joint UNCHS/UNEP facility for building capacities in urban environmental planning and management. The programme is founded on cross-sectoral and stakeholder participatory approaches and contributes to promoting urban governance	1) Sharing environment development information and expertise. 2) Understanding and accepting environment-development interaction. 3) Building environmental planning and management capacities. 4) Promoting systemwide decision-making. 5) Stakeholder based development prioritization, strategy and action planning. 6) Managing environmental resources and risks for achieving sustainable development. 7) Leveraging resources for lasting change. 8) Building inter-agency partnerships, facilitating global exchange of experiences and know-how	The regional and international levels
Sustainable Cities Initiative (SCI)	USAID (U S Agency for International Development), unknown	A project from the Alliance to Save Energy, is developed by the Alliance teamed with Hagler Bailly Consulting to develop innovative solutions to urban energy and environmental problem	1) Training municipal officials in energy planning. 2) Identifying key opportunities for energy-efficiency and environmental technology companies. 3) Developing industrial audit program	India, Mexico, and Russia
Metropolitan Environment Improvement Program (MEIP)	World Bank and UNDP (United Nations Development Program), 1990	Addressing a range of environmental issues within these areas based on specific metropolitan regions	1) Assisting metropolitan areas to develop environmental management strategies (EMS) and action plans in the context of urban and industrial development. 2) Strengthening the institutional and legislative framework for environmental planning, monitoring, and enforcement. 3) Helping identify and prepare high-priority investment projects and mobilize the resources necessary to implement them. 4) Promoting community-led and private sector efforts to improve their residential and industrial environments. 5) Networking among local and national government agencies, civic, community, schools and academic groups and the communications media. 6) Initiating a process of cross-country dialogue to share information and lessons, prepare case studies and topic papers, and offer training on specific topics	Initially, five cities: Beijing, Bombay, Colombo, Jakarta and Metro-Manila. In 1993 Katmandu was added. Secondary cities in such as Cebu and Davao (Philippines), Semarang and Surabaya (Indonesia), and Kandy and Galle (Sri Lanka) were added to the program in 1996. In 1999 Vietnam and Thailand joined MEIP, while Sri Lanka and Philippines "graduated" in 1999
Healthy City	WHO (the World Health Organization), 1986	The European office of WHO at first time proposed a health promotion programme to be known as " Healthy City" project. The intention of the programme was to apply the principles and strategies of "Health for All" through local action in cities and to put it on the agenda of local government	1) Practicing the principles of "Health for All" in the urban areas. 2) Supporting city for information and analysis—health impacts assessment, environmental audits, analysis of health requirements and opportunities. 3) Supporting city for Policy and advocacy—formulating and advocating specific health policies	Popular around the world, with more than 1000 cities or towns adopting them. There are networks of Healthy City projects in all regions of the world

Table 3 (continued)

Initiatives	Run by institution, time	General description	Objectives	Global/Regional/ Country Level
CITY NET	ESCAP (Economic and Social Commission for Asia and the Pacific)/ the Shanghai Municipal Construction Commission, 1989	CITY NET is a network promoting local urban improvement initiatives in Asian-Pacific region. It is the only network of promoting co-operation among a whole range of urban stakeholders at local level	1) Promoting the exchange of expertise and experiences among various stakeholders, particularly local authorities and NGOs. 2) Expanding bilateral relationships into a multilateral network. 3) Endeavoring to make cities in the Asian-Pacific region′ people friendly: environmentally friendly, socially just, economically productive, participatorily managed, and culturally vibrant	Asian-Pacific region
Private-Public Partnership for the Urban Environment Programme (PPPUE)	UNDP (the United Nations Development Programme)/ SPMP (the Sustainable Project Management Programme)/ MIT (the Massachusetts Institute of Technology), 1994	UNDP initiated the PPPUE facility in 1994. Since its launching, PPPUE has expanded into a network of governments, businesses, non-governmental organizations, members of the scientific and academic community, and other developed and developing country institutions	1) Helping to address some of the most urgent urban environmental needs and to create healthy living conditions for all citizens in cities of the developing countries. 2) Improving in those basic services that are most relevant to improving the living conditions of the urban poor: water and sanitation, solid waste management, energy services and decentralized renewable energy production, central municipal services. 3) Supporting innovative forms of partnerships in the triangle of governments, businesses and civil society	Governments, businesses, non-governmental organizations, members of the scientific and academic community, and other developed and developing country institutions
Clean Cities	USDE (U S Department of Energy), unknown	The program supports public-private partnerships that deploy alternative fuel vehicles (AFVs) and build supporting infrastructure. By encouraging AFV use, the Clean Cities Program helps enhance energy security and environmental quality	1) Creating new jobs and commercial opportunities. 2) Facilitating alternative fuel vehicle production and conversion. 3) Expanding local refueling infrastructure. 4) Increasing the use of alternative fuels. 5) Developing "clean corridors". 6) Increasing public awareness. 7) Advancing clean air objectives. 8) Supporting regulated fleets	At both the national and local levels within the United State

is tentatively integrated into urban activities towards sustainability issues surrounding urban areas in Asia. As known, in many ways cities and industries mirror each other so that CP for cities could be built on these similarities by selectively applying industrial CP strategies to urban practices. Modifying the CP definition for industrial production to apply to cities, the so-called the Cleaner Practices for Cities (CPC) could be defined as: the continuous use of preventive and integrated environmental management strategies related to a city′s municipal services to improve the efficiency of its financial expenditures and simultaneously reduce risks to the environment and human health.

According to USAEP Implementing Contractor *et al*. (2000), seven critical elements need to be presented to accelerate successful implementation of CPC strategies in urban areas: 1) support at the highest levels; 2) involvement of all relevant stakeholders; 3) development of a policy framework; 4) linking economic performance to environmental one; 5) establishment of measurable goals; 6) sufficient financial support; 7) implementation of a focused action plan.

From a few case studies conducted in the cities of Asian region, it is preliminarily demonstrated that these modified, or smart, strategies should increase the efficiency of urban inputs, such as energy, and simultaneously lower outputs such as wastes. The following steps offer one approach to introducing CPC strategies to Asia: 1) a comm on understanding of CPC goals and strategies; 2) building credibility and support for instituting CP strategies on a wider scale; 3) building consensus on specific issues or policies and implementing innovative projects; and 4) developing a CPC marketing approach designed to bring investors and industry to the table (USAEP Implementing Contractor *et al*., 2000).

5 CLEANER PRODUCTION AND CPC PROSPECT IN CHINA

5.1 Huge Impact of Rapid Urbanization and Industrialization on Environment

China has the largest urban population in the world but a relatively low urbanization level. The current rate in China is only 31%, 15% lower than world average, 27% less than that of medium-income countries and 47% lower than that of high-income countries (WANG and WU, 2001). However, urbanization has been progressing most rapidly in China since the 1980s. It was reported that in 1997 the urban population was 393×10^6, and estimated that 60% or more of the total population of China would have lived in urban areas by 2030. In the other words, urban population of China would be about 1×10^9.

Urbanization and city sprawl have a huge impact on the natural environment. The consequence of past and present urban and industrial activities in the urban areas and associated waste disposal is the prospect of soil contamination problems. There is a rapidly increased production of solid waste and hazardous waste along with urban development and industrial activities. In 1995, only industrial solid waste (excluding that of the town-running enterprises) produced in the Chinese cities accounted to 645×10^6t, 22.6% higher than that in 1985. The accumulative storage amount of solid waste in China reached to 6.6×10^9t. Untreated solid waste in more than 30 Chinese cities exceeded 10×10^6t, and the dumps and landfills totally occupied a land area of some 55×10^3ha. According to statistical data of 688 cities in 1998, the Chinese urban wastewater reached 1.4×10^9t per year, only 30% of industrial wastewater was treated and urban wastewater treatment capacity was no more than 2×10^6t per day in China (ZHAO, 2000).

Air pollution is a major problem associated with most urban areas. Sources of air pollution include industrial and vehicle emissions, energy production. In 1995 the total emission of soot in China reached to about 1.5×10^9t, while that of sulfur dioxide was 1.9×10^9t, 14.1% and 42.7% respectively higher than that in 1985. It is believed that these emissions mainly produced by the industrial activities and MSW (municipal solid waste) burning from the urban areas. As known, suspended particulate matter and acid deposition associated with urban air pollution are the potential factors degrading environments, commonly resulting in soil acidification. The total estimated area suffering from acid rain was 250×10^6km^2 in China, 2.5 times larger than that of 1985. Soil acidification has become one of major forms of soil degradation in the southern, southeastern China and the Changjiang Delta region where industrial and urban activities are comparatively intensive in the country.

5.2 Cleaner Production in China: Responses, Practices and Legislations

Along with rapid industrialization and urbanization processes, China is being facing with much more problems between the development of economy and the protection of environment and resources(HIGGINS and FITZGERALD, 2001). Therefore, Chinese government, institutions and enterprises responded positively to the concept of cleaner production advocated by international society and progressed greatly in some respects such as demo in enterprises, propaganda and training, agenda construction, international cooperation and policy legislation.

China has always attached importance to implementation of cleaner production since 1993 when the concept of cleaner production was introduced into China. In 1994, the Nation Cleaner Center was established, and as followed some local and special cleaner production centers. Up to now, more than 140 training centers for cleaner production throughout the country have been put into effect. By the end of 1997, cleaner production had been practiced in 219 industrial enterprises scattered throughout China. It was estimated a profit about 500×10^6 yuan (RMB) per year benefited from implementation of cleaner production. As for the environment profit, the industrial discharge of COD was reduced by 78×10^3t, of wasted water by 1.26×10^6t, and of wasted gas by 800×10^6m^3 per year (WANG *et al*., 2001).

To promote practice of cleaner production and to ensure the implementation of the strategy on sustainable development, different governmental organizations in China have developed policies and guidelines that are relevant to cleaner production. For instance, the State Economic and Trade Commission (SETC) and the State Environmental Protection Administration (SEPA) are the two key organizations involved although sectoral agencies also play a role in China (SEPA, 2000). On June 29, 2002, the National People′s Congress approved new and comprehensive cleaner production legislation, the *Cleaner Production Promotion Law*, which is the most significant of a number of initiatives. Chinese government has taken "establish cleaner production nationwide" as one of China′s key strategies for sustainable development. The *Cleaner Production Promotion Law* includes six chapters and forty-two articles. The six chapters are: 1) general rules; 2) promoting cleaner production; 3) implementing cleaner production in the process of production and service; 4) the requirements of

cleaner production for products; 5) encourage methods and legal responsibility; 6) supplementary articles. This law became effective on January 1, 2003.

5.3 Opportunities for Development of CPC Strategies in Demonstration Cities

In the *Cleaner Production Promotion Law*, emphasis is put particularly on practical application and implementation of the strategies in industrial sectors. And the detailed requirements for industrial CP implementation are worked out, contrastively, only some principles relevant to CP Strategies are given to shape environmental performances of agricultural and service sectors. In this context, lack of solid legal basis, implementation of CP in an area or a region encompassing different production sectors seems to face a far greater challenge. However, before the legislation of the *Cleaner Production Promotion Law*, SETC has issued a number of policy and guideline documents relating to the promotion of cleaner production, to encourage CP implementation at regional scales. Besides the identification of five industrial sectors for special priority, namely petrochemical industry, metallurgic industry, chemical industry (nigrogen fertilizer, phosphate fertilizer, chlor-alkali and sulphuric acid), light industry (pulp and paper, fermentation and beer-making), and ship building, in the guidelines issued by SETC, 10 cities including Beijing, Shanghai, Tianjin, Chongqing, Shenyang, Taiyuan, Jinan, Kunming, Lanzhou and Fuyang also are identified as demonstration sites for the promotion and introduction of cleaner production (Fig. 3).

The chosen demonstration cities of the listed above range in complexity from modest collections of mono-industrial centers to complex mega cities with multiple interconnected industry sectors. Doubtless, successful implementation of CP strategies in the industrial enterprises of these cities need better policy correspondence and service delivery provided by the local governments. Thus, there would be great opportunities for the municipal governments of the demonstration sites put to CPC strategies in practice by giving migration of the CP concept to whole cities, linking urban and industrial centers, and integrating the CP implementation into urban activities.

5.4 Strategic Steps to Sustainable Industrial Production in Cities Through CPC Practices

5.4.1 Enhancement of local governments' central roles

Traditionally, local enterprises simply regard urban governments as service providers with responsibility for common environmental services including solid waste collection and disposal, sewage treatment, and ensuring availability of a safe water supply. These services along with other local government functions are often organized in a manner minimizing communications, idea sharing, resources pooling and other interactions among functional areas. Within each functional area, environmental goals are pursued and environmental requirements achieved with little or no attention to environmental needs or requirements in other functional areas. This environmental management approach initiated by local

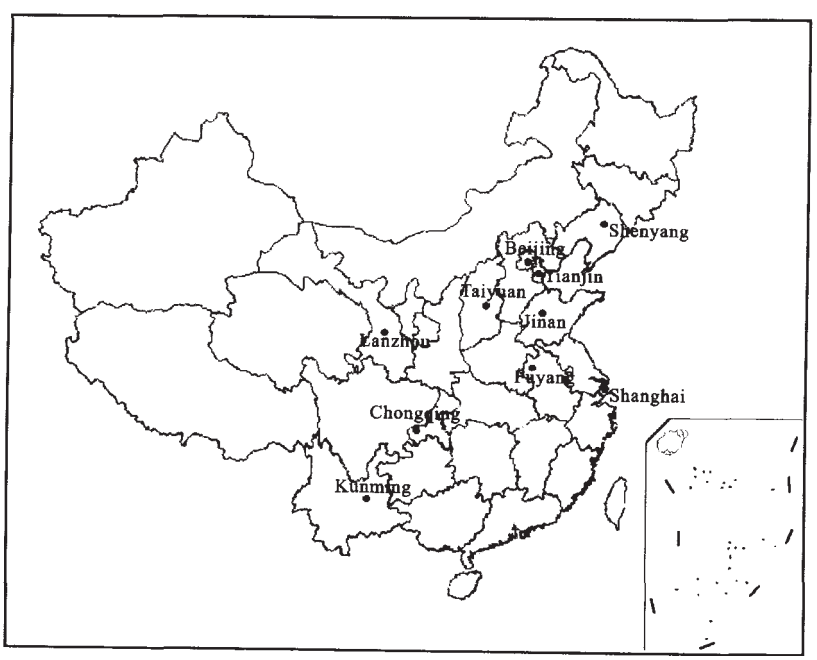

Fig. 3 Sketch of distribution of CP demonstration cities issued by SETC

governments maximizes inefficiencies and encourages internal competition for resources without regard to the overall environmental needs of the local system (XI and LI, 2001).

To pave the way for implementing new cleaner practices for cities strategies, the role of local governments must be enhanced. Besides ensuring availability of infrastructure and services with water, sanitation, drainage, garbage collection and management, transport, and protection and management of public space and cultural heritage, the local authorities must develop appropriate regulations that cover urban planning to promote environmental performance, resources management and ecosystem health. The mechanisms of incentives and penalties should be introduced into administrant systems, and much greater emphasis should be put on demand management that seeks administrative and technical solutions to reduce the need for investments. Governmental public policy can include incentives through CP strategies to encourage good practice in energy and water conservation and waste reduction; through taxes and charges to limit private automobile use; and through the removal of subsidies and government control to revise distort decisions towards environmentally damaging results.

5.4.2 Common understanding of CPC goals and tradeoffs of competing interests

In the demonstration cities, all communities should know the inside implication of cleaner production for city and a common understanding of CPC goals and strategies should be developed, so that the conflicts could be minimized through cooperatively efforts of all affected stakeholders including industrial enterprises, production dealers and local residents. Because achieving CPC strategies involves tradeoffs and the resolution of competing interests, a common understanding of concerns, needs and interests thus could accelerate implementation of CPC strategies (ZLÖBL *et al*., 2001).

Amongst the stakeholders, industry needs to continually earn its "license to operate" from the wide group of sectors that are affected by its operations: employees, consumers, and the community. It will require community empowerment through consultation, participation and reporting to ensure that these often under-represented groups have an impact on industrial development. The partnerships among multiple stakeholders should be developed for short- and long-term efforts designed to build consensus on specific issues and to implement innovative projects. Developing goodwill among stakeholders can propel challenging initiatives in a long way .

5.4.3 Market transformation for boosting resources productivity

Development of industries in a fair and sustainable way in a certain area needs to be firmly rooted within the constraints implied by local carrying capacity and social need. However, the challenge always goes far beyond the factory gate and extends to the materials that industry sources and the products it sells in urban areas. Therefore, sustainable industrial production and consumption in cities requires a market transformation on both the supply and demand sides.

The goal of CP strategies is characterized by preventing pollution at the source and of managing the raw material more efficiently. In this context, successful implementation of CPC needs the local authorities and other public agencies charged with urban management to drive industrial production in urban areas according to clear targets of sustaining local carrying capacity. For this purpose, industrial development markets within or outside cities should be ruled through enterprise conventions, economic means and resources management to deal with persistent "market failures". The efficient consumption and recycling after use should be encouraged to boost resources productivity, going beyond the relatively simple savings that can be made through "good housekeeping" measures, to process optimization and re-engineering patterns.

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