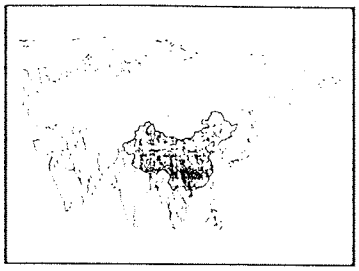

Sustainable urban development strategies for China

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I. INTRODUCTION

THIS PAPER CONSIDERS the transition that needs to be made in China to achieve sustainable urban development. After outlining the links between economic growth and energy use, a conceptual framework is developed to contrast the major economic, technology, energy and environmental assumptions between conventional and sustainable development strategies. Then, using five of China's cities (Beijing, Guangzhou, Shanghai, Shenyang and Xian) as examples, it demonstrates that urban environmental degradation in China, as in many Asian countries, is attributable to the pursuit of economic growth under the conventional development model. Finally, using the sustainable development model, it lays out a policy agenda that promises to move China toward environmentally sound urban development.

Most Asian countries have experienced rapid economic growth since the 1970s. While the world economy grew at an inflation adjusted rate of 2.1 per cent annually for the period 1977-1987, 37 Asian countries registered an average annual growth rate of 4.8 per cent.[1] China's performance was even more impressive, with the country's economy growing at an average annual rate of 9.6 per cent during the last decade.[2] Compared with the world economy, China's economy grew nearly five times faster.

Historically, rapid economic growth in Third World countries has often been accompanied by even more rapid growth in commercial energy use. This trend is evident in the recent economic growth of most Asian countries. Whilst the rate of energy consumption in the rest of the world increased by an average of 3.1 per cent annually during the period 1977-87, Asian Third World countries expanded their energy use by more than 7 per cent.[3] China's energy consumption grew at an annual rate of 5.2 per cent during that same period.[4]

Successful economic growth among Asian Third World coun-

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tries has been accompanied by a second, related tendency. As these countries enjoyed economic growth, they found themselves experiencing high levels of energy-induced environmental degradation. The negative environmental effects of Asian economic growth are dramatically visible in large cities where industry and populations are heavily concentrated and where large amounts of fossil fuels are consumed.

This is particularly true in China, where most industrial and commercial energy use facilities are located in or near large cities. As a result, China's large urban populations are exposed to a multitude of air pollutants, including sulphur dioxide, nitrogen oxides, carbon monoxide, volatile organic compounds, fly ash and other suspended particulate matter. Suspended particulate matter and sulphur dioxide are both by-products of coal combustion, and coal has been the major energy source fuelling development in China. Currently, coal provides more than three-quarters of the country's commercial energy use.[5] When this fact is coupled with China's requirement for further economic expansion to meet the growing needs and desires of its population, it is clear that China faces difficult, even self-contradictory, choices of economic growth versus social health and sustainable relations between society and the natural environment. The self-contradictory character of these choices can be traced directly to the growth oriented development path that the country currently has adhered to. It is our argument that a national transition to a sustainable mode of development is needed.[6] This will significantly affect China's large cities which are the nexus for realizing the nation's development, energy and environmental choices. Through a national transition to sustainability, China's cities can improve human health and environmental quality while maintaining their role as the key contributors to the national economy.

II. CONVENTIONAL VS. SUSTAINABLE URBAN DEVELOPMENT: A CONCEPTUAL FRAMEWORK

DIFFERENCES BETWEEN THE conventional and sustainable urban development models are identified in Box 1 in terms of urban, energy, environmental and technological dimensions. In the conventional development model, there is typically a direct spatial tie between cities and industrialization. Cities have played a decisive role in economic development. The key to this role was the complementarity between industrial technology and urban form. The phenomena of industrialization and urbanization became virtually inseparable.[7] Cities provide industry with convenient modes of transport and communication, easy access to skilled labour, and plenty of consumers. Besides these spatial ties, the conventional development model links cities and industrialization in terms of economic ideology, energy and technological system design, and environmental orientation. Western cities became centres of growth-promoting activities that accelerated the use of resources (including new energy sources) for growth.[8]

1. Byrne, J., et al. (1992), "Energy and environmental sustainability in East and South-East Asia", *IIEE Technology and Society Magazine*, Vol.10, No.4, page 22.

2. China State Statistics Bureau (1990), *Chinese Energy Statistics Yearbook 1989*, China Statistics Press, Beijing, page 3.

3. See reference 1, page 2.

4. See reference 2, page 149.

5. See reference 2, page 149.

6. For the conceptual discussion of sustainable development, see the World Commission on Environment and Development (1987), *Our Common Future*, Oxford University Press, New York, pages 9 and 43; also Mitlin, Diana (1992), "Sustainable development: a guide to the literature", *Environment and*

Box 1: Conventional vs. Sustainable Urban Development Models

Conventional Model	Sustainable Model
The Urban System	
* Urban concentrated industrial complexes	* Regionally dispersed industrial complexes
* Manufacturing oriented	* Community oriented
* Short-term economic growth emphasized	* Long-term development emphasized
* Commodity oriented	* Conservation oriented
* Consumption driven	* Balance sought between consumption and conservation
* Resources seen as inputs to production system	* Resources seen as limited, vulnerable requiring stewardship
* Resource-intensive, governed by economic priorities	* Resource conserving, governed by multiple priorities
* Economic costs are primary	* Economic costs balanced by social/environmental costs
The Energy System	
* Fossil fuel based	* Alternative energy based
* Energy abundance and cheap supplies emphasized	* Conservation and renewability emphasized
* Diversify sources of supply	* Reduce energy intensity
* Market based prices not reflecting social/ environmental costs	* Social/environmental cost based prices
* Technology focused	* Conservation focused
* Efficiency in economic production emphasized	* Efficiency in end-uses emphasized
* Scale economies and technological centralization emphasized	* Modularity and technological decentralization sought
The Environmental System	
* Humans dominate the environment	* Humans and environment are seen as mutually dependent
* Environment as an abundant source of commodities	* Exhaustibility of natural resources recognized
* Environmental impacts external to economic choice	* Environmental impacts internal to economic choice
* Rehabilitation oriented	* Prevention oriented
The Technology System	
* Large-scale economies sought	* Moderate-scale economies preferred
* Centralized system emphasized	* Decentralized system emphasized
* Infrastructure driven technology choices	* User-driven technology choices
* Technical decisions governed by economic costs	* Technical decisions governed by social/environmental costs
* Environmental impacts ignored	* Environment sensitive designs promoted

SOURCE: Adapted from Byrne, J., et al (1992), "Energy and environmental sustainability in East and South-East Asia", in IEEE Technology and Society, Vol. 10, No. 4, page 26.

Urbanization, Vol.4, No.1, pages 111-124.

7. Byrne, J., et al. (1985), "The post-industrial imperative: energy, cities and the featureless plain" in Byrne, J. and Daniel Rich (editors), *Energy and Cities, Energy Policy Studies*, Vol.2, Transaction, New Brunswick.

8. Odum, Howard T. and Elizabeth C. Odum (1976), *Energy Basis for Man and Nature*, McGraw-Hill, New York, pages 153-154.

Generally, the ideology of the conventional model reflects its over-arching goal of wealth creation. The urban economy is commodity based and consumption driven. Urban systems operate to produce more goods to meet rapid growth in population and consumer demand. To expand production, resources are intensively used and valued in terms of economic priorities. That is, economic costs, not broader social costs, are the primary concern under the conventional development model.

Viewing ever-increasing energy consumption as a pre-requisite to economic growth, the conventional development model emphasizes stability, reliability, and optimization of energy supply in the design of energy and allied technology systems. It considers adverse social and environmental impacts as external to energy decisions. Energy system goals are couched almost exclusively in terms of supply. The conventional model argues that countries must not only secure abundant and cheap energy resources, but they must also ensure continuing supplies by diversifying the sources used. The primary means for achieving these goals is through large-scale, centralized and capital intensive technological systems. Technological choices are governed by economic concerns, determined by energy demands, and driven by industrial infrastructure needs.

In the conventional development model, environmental values are framed entirely within an industrial context. The natural environment is viewed as an inexhaustible source of commodities and reservoir for the absorption of industrial wastes. The economic value of natural resources is purposefully kept low to spur rapid growth, and pollution is treated as an unavoidable side-effect of economic progress. This model produces urban economic systems that are resource intensive and highly polluting in order to keep production costs down. Ironically, this model produces urban environmental degradation as a **condition** of social advance. Air pollution became evident during the industrial revolution, when many cities were covered with black shrouds of coal-driven smoke.[9] But this air pollution was not generally viewed as something negative; rather, it signalled within the industrial interpretation of social development that a city was prospering.[10]

9. French, Hilary F. (1990), "Clearing the air", *State of the World 1990*, W.W. Norton & Co., New York, pages 98-118.

10. Mumford, Lewis (1934), *Technics and Civilization*, Harcourt Brace, New York, pages 168-169.

Recent interdisciplinary efforts among social scientists, technologists and environmentalists to conceptualize an alternative to this prevailing growth oriented, resource intensive, environmentally destructive path to industrial urban development have coalesced with the articulation of a **sustainable development model**. The sustainable model focuses societal emphasis away from short-term economic gain and environmental exploitation towards long-term social and economic viability and environmental integrity. It moves societies away from exclusively economic considerations towards broader social and environmental concerns. Within this framework, future as well as present needs are integrated into developmental considerations.

Spatially, the sustainable development model calls for a well-designed dispersal of industrial complexes rather than their unplanned concentration. This spatial arrangement reduces urban energy demands and environmental pollution.[11] In addition, as manufacturing decentralizes, urban centres can focus on

11. Lowe, Marcia D. (1992), "Shaping Cities", *State of the World 1992*, W.W. Norton & Co., New York, pages 119-137; also Center for Renewable Resources (1984), *Renewable Energy in Cities*, Van Nostrand Reinhold, New York.

community needs and can relate urban development to social goals and values. Urban land use, landscape architecture, and building construction under the sustainable model should be designed to emphasize energy efficiency, resource conservation, and environmental protection. Mass transport would prevail in urban transport systems, and greater energy efficiency in residential, commercial and industrial sectors would be promoted. The urban economy would be geared toward community based and conservation driven development. Institutions that underpin sustainable systems would be responsible for developing energy conserving and environmentally sensitive means to achieving desired social outcomes.

Although fossil energy supplies are still needed at this time to boost economic development, efficient energy use and renewable energy resources should form the long-term basis for system development. In the sustainable model, technological flexibility is emphasized and, for this reason, conservation and renewables are given development priority. Social and environmental impacts are treated as internal to energy decisions. Energy system goals would include social equity and environmental stewardship, as well as support of industrial production activities. The sustainable model calls for an energy system, specifically, and a technology system, generally, that is moderate in scale, decentralized in organization, and user-driven. Technological innovation is guided by the criteria of resource conservation, minimum environmental impact and social equity. Ecologically, the sustainable view of development recognizes the interdependence between humanity and the natural environment. Resources are recognized as exhaustible and vulnerable. Environmental impacts thus become a major concern in the pursuit of economic development.

The distinctions between the conventional and sustainable development models are fundamental. Reconciling economic growth with a healthy environment depends upon which development orientation is chosen. In the following section we analyze the interrelationships of energy, environment and development in five Chinese cities to demonstrate that deteriorating urban environments are the product of growth oriented urban development.

III. UNBALANCED URBAN DEVELOPMENT: A CASE STUDY OF FIVE CHINESE CITIES

a. Deteriorating Environmental Quality

INTERNATIONAL AND DOMESTIC studies have revealed striking evidence of declining environmental quality in five Chinese cities - Beijing, Guangzhou, Shanghai, Shenyang and Xian. One five-year analysis based on data from the Global Environmental Monitoring System (GEMS) established that, of 170 monitored sites around the world, these five cities ranked among the 25 sites with the highest sulphur dioxide levels.[12] Their respective ranks were: Shenyang (2nd), Xian (7th), Beijing (9th), Guangzhou (12th), and Shanghai (21st) in order of severity.

12. WHO and UNEP (1987), *Global Pollution and Health: Results of Health-related Environmental Monitoring*, page 5.

13. See reference 12, page 6.

For suspended particulate matter, these same five Chinese cities ranked among the ten most polluted in the world, far exceeding the World Health Organization's minimum standard.[13] Additionally, in terms of the number of days during a given year which exceeded the WHO's standards for suspended particulate matter and sulphur dioxide, three of the five - Xian, Beijing and Shenyang - were among the worst violators (see Table 1).

Table 1: Average Days Per Year That Concentrations of Sulphur Dioxide and Suspended Particulate Matter Exceeded the World Health Organization's Guidelines (in 1988).

City	Sulphur dioxide	Suspended particulate matter
New Delhi (India)	6	294
Xian (China)	71	273
Beijing (China)	68	272
Calcutta (India)	25	268
Shenyang (China)	146	219
Tehran (Iran)	104	174
Jakarta (Indonesia)	-	173
Shanghai (China)	16	133
Guangzhou (China)	30	123
Bombay (India)	3	100
Manila (Philippines)	24	14
Rio de Janeiro (Brazil)	-	11
Toronto (Canada)	1	1
New York City (USA)	8	0

SOURCE: UNEP and WHO (1989), "Monitoring the global environment: an assessment of urban air quality", *Environment* Vol.31, No.8, October, pages 12 and 29.

Chinese research on urban air quality has confirmed that the five case study cities suffer from severe air pollution. In fact, this research indicates that environmental quality has been steadily declining: in the years between 1981 and 1985, these five cities increased their emissions of sulphur dioxide by 18 per cent.[14] These cases illustrate China's urban environmental dilemma. China's cities have played a key role in the country's rapid growth but development has been accompanied by significant environmental degradation. By concentrating industries within urban areas and by relying on a coal intensive, technologically inefficient energy system, Chinese development policy has resulted in conflicts between urban life and environmental quality on the one hand and economic growth on the other.

14. China State Survey Office for Sources of Industrial Pollution (editors) (1990), *Evaluation of Industrial Pollution Survey*, Environmental Science Press, Beijing, China.

b. Industrial Based Urban Development

Development of China's cities as industrial centres can be historically traced. Chronic civil wars and the incompetence of the nationalist government had essentially brought China's economy to a collapse. When the Chinese Communist Party took over the leadership of China in 1949, China's existing industrial infra-

structure and skilled industrial workers were located almost entirely in its cities. Consequently, China's cities naturally bore the responsibility of national economic reconstruction. In the decades following the establishment of the People's Republic of China, continued industrial development in urban areas ensured that China's cities would play an important role in the country's economic renewal. By 1985, 67 per cent of China's industrial enterprises were located in cities, and the gross industrial output produced by these urban enterprises accounted for nearly 70 per cent of the total output produced by the nation as a whole.[15]

15. See reference 2, page 197.

The expanding metropolises of Beijing, Guangzhou, Shanghai, Shenyang and Xian came to dominate China's economy. As China's people and industries settled in these five cities, their influence on China's economy grew. By 1990, these five urban centres housed 6 per cent of China's urban population. Yet, these same five cities accounted for 9 per cent of all Chinese urban industrial enterprises and produced 16 per cent of China's gross industrial output in 1990 (see Table 2). During that year, Shanghai and Beijing ranked first and second in terms of gross industrial output, while Guangzhou, Shenyang and Xian ranked 4th, 6th and 18th, respectively.

Table 2: Selected Indicators for the Five Cities (1990)

Indicator	Total *(467 cities)*	Beijing	Guangzhou	Shanghai	Shenyang	Xian
Population *(million)*	717.2	10.4	5.9	12.8	5.7	6.0
Number of industrial enterprises *(thousand)*	389.1	6.4	4.7	13.5	5.6	3.5
Value of industrial output *(US$ billion)*	379.0	12.9	7.8	28.6	6.2	3.1

SOURCE: China State Statistics Bureau (1991), *Chinese Urban Statistics 1990*, Longman Group (Far East), Hong Kong.

The enterprises located in these Chinese cities are mainly from such heavy industries as iron and steel, metallurgy, machinery, petroleum, and petrochemicals. By 1990, over half of the industrial output from three of the five case study cities - Beijing, Shenyang and Xian - was derived from heavy industry. In fact, several of the ten largest Chinese enterprises - among them the Capital Iron and Steel Company, Yanshan Petrochemical Company, and Baoshan Iron and Steel Complex - are located in the case study cities. The significant economic contributions by heavy industries in the five cities have been fuelled by a coal based energy system. As noted below, this system is highly inefficient and heavily polluting.

c. The Problem-ridden Energy System

Caught in a growth focused development path, the five Chinese cities in our study have consumed large amounts of energy during rapid economic growth and urban expansion. In 1985, these five cities alone accounted for over 14 per cent of the total electricity consumed by China's 324 cities.[17] Electricity consumption per capita in four of these five cities far exceeded the national urban average of 113 kilowatt-hours. Beijing was highest with 383 kilowatt-hours per capita, followed by Guangzhou (284), Shanghai (232) and Xian (228). Only Shenyang, at 144 kilowatt-hours per capita, was near the national city average.[18]

Coal is the primary fuel for electrical generation in most Chinese cities, including the five case study cities. For instance in 1988, 98.3 per cent of Beijing's and 99.8 per cent of Shanghai's electricity was generated by coal-burning power plants.[19] In addition, owing to shortages in electricity supply, many Chinese cities power their factories, heat their apartment buildings and satisfy cooking needs by directly burning coal. In Shanghai, for example, in 1985, there were more than 10,500 industrial boilers and 800,000 household stoves powered by coal.[20] Because of its relatively low price and the considerable size of national deposits, coal dominates the Chinese commercial energy sector and accounted for 76 per cent of total energy consumption in 1988.[21]

Coal is not only intensively consumed but it continues to be inefficiently used. International comparisons of energy consumption per million US dollars of GDP among selected countries give strong evidence of the low level of energy efficiency in China. In 1986, while industrialized countries consumed between 212 and 679 tons of coal equivalent (tce) to produce US $1 million in national output, China used nearly 3,200 tce to produce the same value of GDP.[22] According to Vaclav Smil, China's average fuel conversion efficiency is as low as 30 per cent, compared with Japan's standard of 60 per cent.[23] And compared to other Asian Third World countries who use an average of 724 tce per $1 million of output[24], it is clear that China's economic sector is highly energy inefficient.

The use of coal as a fuel source is inherently problematic from an environmental point of view. In the best of circumstances, this fuel's use can lead to major air pollution and solid waste disposal problems. Inefficient use of coal only exacerbates an already significant tendency toward environmental degradation. In China, the problem is becoming acute because more than 83 per cent of the coal burned in China is not sorted or washed.[25]

The deteriorating state of China's urban environmental quality is largely traceable to the intensive and inefficient use of coal. Recently, Chinese authorities reported that 90 per cent of sulphur dioxide emissions and 73 per cent of industrial dust in its cities comes from coal-burning.[26] Unless basic changes are made in energy, environment and development relations underpinning China's urban structure, urban environmental degradation is likely to continue and even worsen. The cumulative result of the country's embrace of a growth focused urban development model in the form of concentrated, heavy industry based urban struc-

16. China State Statistics Bureau (1991), *Chinese Urban Statistics 1990*, Longman Group (Far East), Hong Kong.

17. China State Environmental Protection Bureau (1986), *Compilation of Environmental Statistics 1981-85*, China Environmental Science Press, Beijing, pages 119-124.

18. See reference 17, page 369.

19. See reference 2, pages 102-106.

20. Huang, Shuying (1986), "Air pollution and prevention" in *Shanghai Economy 1983-85*, Shanghai People's Press, Shanghai, page 756.

21. See reference 2, page 149.

22. See reference 2, pages 386 and 394.

23. Smil, Vaclav (1984), *The Bad Earth*, M.E. Sharpe, Armonk, page 117.

24. Based on conversion of figures in Byrne, et al. (1992), see reference 1, page 22.

25. See reference 1, page 115.

26. Qu, Geping (1991), "Comprehensive renovation of the urban environment: an important task of modernization", *China Environmental Science*, Vol.2, Beijing, page 83.

tures and a supply oriented energy system is the present condition of unsustainable development. China can no longer afford to follow its current development path. A policy agenda that can put China on a sustainable development path is imperative.

IV. POLICY AGENDA: TOWARD A SUSTAINABLE URBAN FUTURE

OUR ANALYSIS OF the five Chinese cities points to the need for a policy agenda that will enable China to move from its current development orientation toward a sustainable development path. In this section, we offer an agenda intended to begin the transition to a sustainable urban future. Three propositions guide our construction of the proposed policy agenda:

* Because China's urban environmental problems are mainly a result of national development strategy, our policy agenda focuses on **national** energy, environment and development policy actions;
* China's urban environmental degradation is significantly related to the country's inefficient use of energy and, therefore, reform of China's energy system is essential;
* Finally, China's energy, environment and development choices have substantial global implications and, for this reason, cooperative international actions are needed to facilitate China's transition to sustainable development.

a. Moving Towards a Sustainable Path

China has recently been preoccupied with expanding its economic wealth, accelerating national development, and increasing production capacity. To date, this development strategy has resulted in an economic system characterized by instability, an energy system that threatens long-term sustainability, and urban areas with substantial environmental problems. It is time for China to recognize the structural contradictions associated with the existing development path and embrace a policy agenda in line with the principles of sustainability.

But moving to a sustainable development model does not mean that China must surrender its recent economic success. Rather, sustainable development means redirecting the country's energy, environment and development relations so that economic growth occurs within a framework of energy conservation and environmental protection. In place of the existing model's quantitative idea of growth, a sustainable path emphasizes economic success that is consistent with qualitative values such as improved social health and urban environmental quality. In other words, social and ecological dimensions of urban life are to be integrated with economic ones to define China's development goals. Moreover, China would seek to balance the needs and demands of its current population with those of succeeding generations under a sustainable development strategy. To meet these new goals, national policies in the areas of urban development, environment,

energy and technology need to be reformulated. International support is also necessary if China is to meet the goal of sustainability.

b. Urban Development Policy

To move toward sustainable development in its urban economies, community based rather than production based industrial development planning needs to become the mainstay of national urban policy. It is widely recognized that manufacturing enterprises, especially heavy industries, are among the largest energy consumers and the heaviest environmental polluters in modern society. Therefore, they should not be clustered within densely populated urban areas. But it must be pointed out that the movement of heavy industry to outlying areas only represents a limited, short-term solution to China's social and environmental conflicts. Long-term solutions require the introduction of new, more environmentally benign technologies. Furthermore, movement toward a community orientation in industrial development planning requires greater attention to the development of tertiary industries (including professional services, information-processing and trade) in cities. These industries, if developed vigorously, would ensure that China's large cities would continue as prominent centres for the national economy as well as significant cultural and political institutions.

National urban policy should also reflect the interlocking nature of urban development with energy and environment. For example, China needs to better rationalize its geographic distribution of industries. Currently, too many industries are concentrated in China's eastern and north-eastern urban areas which are far from the country's renewable energy resources in the west. In addition to the reduction in fuel use within the industries, access by energy-intensive industries to the energy-rich regions is desirable. Such a shift will not only reduce the cost and burden of energy transportation but it would also contribute to efficient and effective energy use - both of which would have a positive effect on China's urban environment.

c. Environmental Policy

The Chinese government has tried to halt urban environmental deterioration during the past two decades. In 1978, China amended its constitution to include protection of the environment as one of the society's basic commitments. Since then, China has enacted several pieces of environmental legislation and enforced a number of new environmental regulations. In addition, administrative agencies have been established at the national, provincial and local levels, and China has created a nationwide monitoring network, research institutions, and university environmental programmes to address this issue. Also, a number of localities have recently announced fines for the discharge of pollutants and begun an annual "Environmental Awareness Month". In the recent Earth Summit (the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992), a Chinese

environmental official declared that the Chinese government had decided to incorporate environmental impact assessments into state long-term development plans.[27]

Although the above initiatives represent positive steps, they are not enough to solve China's urban environmental problems. Because economic growth has been considered the nation's "number one task", China's environmental sensibility has often had to give way to economic consideration. Economic measures, such as GNP, have become the dominant indicators of achievement. Environmental costs have been excluded from the cost of national economic activity, and environmental legislation and regulations have sometimes been suspended or ignored when they were seen as a threat to economic growth. The lack of enforcement has also arisen because responsible agencies are inadequately managed and funded.[28]

But the pursuit of economic growth at the expense of the natural environment cannot be sustained over the long run. To address this conflict, existing methods that measure economic performance in narrow, monetary terms should be replaced by methods that include environmental realities and long-term costs.[29] The imposition and enforcement of pollution fines, the creation of transferable emission rights, and the preparation of explicit plans to phase out certain environmentally inappropriate practices (such as burning unwashed coal) are needed. Also, annual technology and policy competitions should be held among universities, city governments and state enterprises to address urban environmental problems. In this way, society can be encouraged to develop alternatives to existing social and industrial practices that harm the urban environment.

Ultimately, if China is to halt urban environmental deterioration, it must adopt vigorous measures that seek to prevent pollution at the source. Passive clean-up after the pollutant has already been produced (the so-called "end-of-pipe" remedy) is both ineffective and expensive.[30] Since China's urban pollution results significantly from its inefficient energy practices, a high priority for pollution prevention should be the reform of the existing energy system. Because of the unavailability of recent data, our examination of environmental quality in five Chinese cities reflects the situation of the 1980s. Since then, increased enforcement activity is likely to have slowed the rate of degradation in China's urban environmental quality.[31] However, such improvements will be modest until and unless China makes basic changes to its coal based energy structure. Therefore, a structural reform of China's energy system is essential to the achievement of environmental integrity.

d. Energy Policy

China's energy system has suffered from many problems common to Third World nations pursuing rapid growth. These problems include: continuous shortages in energy supply, extremely low energy efficiency, a fossil fuel based energy structure, obvious geographical disparities between energy producers and energy consumers, a concentration of energy demand within

27. People's Daily (overseas edition) (1992), "The coordination between social development and environmental protection", June 6.

28. Argentina had a similar experience. See IIED-AL with CEA and GASE (1992), "Sustainable Development in Argentina", *Environment and Urbanization*, Vol.4, No.1, pages 37-52.

29. Natural resource accounting is suggested to remedy the problems inherent in the present national income accounts by reflecting the depletion and degradation of natural resources in the calculation of national income. See World Resources Institute (1990), *Policies and Institutions: Natural Resources Accounting*, Oxford University Press, Oxford.

30. Commoner, Barry (1990), *Making Peace with the Planet*, Pantheon Books, New York.

31. *Beijing Review*, July 8-14, 1991.

urban areas, and artificially low energy prices. These problems have created what Amory Lovins has characterized as the *self-contradiction* of "hard path" energy regimes.[32] The defining objective of such regimes is cheap and abundant energy supplies. Yet, such systems invite waste, high levels of pollution, and a treadmill relation between energy and development. As a result, shortfalls, imbalances, and instability are logical attributes.

If China is to avoid the self-contradiction of hard path, energy intensive development of its energy system, it must begin by formulating solutions to these specific problems. As a first step, China should begin the process of switching from an energy system that relies on non-renewable energy sources to one in which the use of renewable sources steadily grows. If China continues its current pattern of energy exploitation and consumption, it will soon face the self-contradictions of energy imbalance, waste and continued pollution. It is important that China begins to move toward renewable resources so as to avoid the high capital costs of later "back-fitting" technologies to improve efficiency. A national transition to renewable resources is, however, impossible to realize overnight. Due to the country's ample and cheap coal endowment, China's energy structure will remain coal dominated for some decades. Gradually, renewable energy and conservation should diminish coal's dominance in China's energy system.

China's energy transition should be guided by the objective of developing energy resources that are renewable, clean and feasible. The highest priority should be given to solar, wind, geothermal, and biomass resources. Given the abundance of each of these resources in China, the development of an energy system fuelled by renewable energy is hardly far-fetched. China's geothermal resources are the world's largest and can be used for electricity supplies far beyond local needs.[33] Furthermore, China has the world's largest hydro-energy reserves with an exploitable potential estimated at 378,000 MW, more than twice that of current national electric generation capacity.[34] Development of these resources should be based on their modularity and flexibility. Unlike the "hard path", what Lovins called "soft path" resources are distinctive for their ability to be scaled to community needs. This affords greater opportunities for local governance and supervision and avoids the economic and technological "brittleness"[35] of large-scale, centralized energy systems, such as those currently in use in China. Adoption of this approach would also enable China to avoid entanglements with such risky and costly technologies as nuclear power.[36]

Besides the development of renewable resources, it is urgent that China give energy conservation and energy efficiency the highest consideration in its energy planning. Resource conservation and efficiency improvements have the potential to reduce overall energy demand and at the same time to reduce environmental risks. In this way, major reductions in carbon dioxide emissions are expected, given the scale of China's aggregate contribution to current greenhouse gas emissions (although still at a low level in terms of per capita emissions). To move towards a more energy-conserving system, the Chinese government should adopt economic, institutional, technological and planning meas-

32. Lovins, Amory B. (1977), *Soft Energy Paths: Toward a Durable Peace*, Friends of the Earth International. San Francisco.

33. See reference 23, pages 9 and 15.

34. *Far East Economic Review* (1992), June 11.

35. Lovins, Amory B. (1982), *Brittle Power: Energy Strategy for National Security*, Brick House Publishing, Andover.

36. For an examination of the problems of nuclear power in development, see Byrne J. and Steven Hoffman (1988), "Nuclear power and technological authoritarianism", *Bulletin of Science, Technology and Society*, No.7, pages 658-671; and Poneman, Daniel (1982), *Nuclear Power in the Developing World*, George Allen and Unwin, Boston.

ures that promote this resource option. Energy taxes to discourage waste and investment incentives to promote conservation opportunities should be incorporated into the country's development planning. Institutionally, national organizations responsible for promoting conservation and efficiency need to be established.[37]

Technologically, there are many end-use efficiency options currently available that can help China meet its energy needs as it gradually moves toward a renewable energy system. Because China is in the process of assembling its industrial infrastructure for the 21st century, this is a critical time for developing efficiency in the end-use sectors - buildings, transport, industrial processes and agriculture. The country should initiate end-use efficiency planning, borrowing from the Integrated Resource Planning (IRP) model in wide use in the North.[38] Other supply based efficiency options of special relevance to China include increased coal-washing capacity, greater use of natural gas, and the employment of fluidized bed combustion and integrated gasification/combined cycle generation.

China's centralist approach to the management of its energy system also needs to be changed. Although recent reform policies have begun to use market mechanisms to encourage decentralization, in many areas such reforms have yet to reach the energy system. First, state control over energy prices must be phased out, and energy resources must be priced in terms of their economic and environmental values. Second, government subsidies for energy production and consumption should be gradually ended so that energy producers and consumers bear the actual costs of energy and can adjust their practices accordingly. Third, local initiatives and participation should be encouraged in managing the energy system and its development. The current command-and-control approach to implementation should be replaced over time with market oriented incentives and local regulation.

Finally, to provide the technological support for the energy system's transition, China must promote research and development in renewable energy and conservation. China needs to increase its budgetary and personnel commitments in these areas. Moreover, the national government should encourage cooperation between China's industries and universities in research on wider use of conservation and renewable based energy technologies.

e. Seeking International Support

Since China is the world's third largest energy producer and the world's largest coal consumer, its transition to a renewable based energy system is of great importance not only to the nation itself but to the international community as well. Also, because China contains one-fifth of the world's population, its stable development is of great importance to the world as a whole. The global energy and environmental goals recently endorsed at the 1992 UN Earth Summit cannot be met if China is not an equal participant in the transition to sustainability. Therefore, the international

37. For specific ideas in an Asian context, see Byrne, J., Y. Wang et al. (1991), *Toward Sustainable Energy, Environment and Development: Industrial Strategies for Indonesia, South Korea, Malaysia and Thailand*, ESMAP/World Bank, Washington DC.

38. A particularly important adaptation of this model by Amulya K.N. Reddy for India should be explored. See Reddy, Amulya K.N. (1985), "An end-use methodology for development oriented energy planning in developing countries, with India as a case study", PU/CEES 181, Princeton University Center for Energy and Environmental Studies, Princeton.

community has a vested interest in helping China move towards a sustainable development path. Such support can come in the form of financial and technical assistance, international monitoring and technology transfer.

* The Global Environment Facility endorsed by the North at the 1992 Earth Summit should be implemented with specific attention to helping China make the transition from its current problematic energy and environmental basis of development to a sustainable basis.
* International support for the monitoring of global environmental quality in China would produce the needed information for the society and the world community to adopt steps for meeting national and global environmental quality targets.
* Because we share a "common future", as the World Commission on Environment and Development observed in its 1987 report, countries in the North should be prepared to transfer their less energy intensive and environmentally sound "green" technologies and products to their partners in Africa, Asia and Latin America. Also, worldwide information exchanges on new "green" technologies would be of great assistance to these countries, including China.

V. CONCLUSION

THE ENERGY, ENVIRONMENT and urban development challenges faced by rapidly industrializing countries such as China are great. However, these challenges can be met if countries are guided by the principles of sustainable development as described here; and if international support is mobilized to meet the needs of countries in the South. Together, countries in the North and South can produce the innovative ideas and enact the policies which will make our common urban future a sustainable one. We owe such a future to humanity and to our natural environment.