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Waste Management in China: Issues and Recommendations

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Foreword

No country has ever experienced as large or as fast an increase in solid waste quantities that China is now facing. In 2004 China surpassed the United States as the world's largest waste generator, and by 2030 China's annual solid waste quantities will increase by another 150% - growing from about 190,000,000 tons in 2004 to over 480,000,000 tons in 2030. The social, financial, and environmental impacts of this growing waste stream are significant. All aspects of China's waste management system are undergoing wholesale changes as government tries to respond to the challenge.

China needs to move up the "waste management hierarchy" promoting waste minimization, reuse and recycling, before other waste disposal methods are pursued. However, even with aggressive waste diversion activities China's future waste disposal needs are enormous. For example China's cities will need to develop an additional 1400 landfills over the next 20 years.

This paper contributes to China's municipal solid waste discussions by presenting updated and relatively accurate projections of municipal waste quantities and composition. Key trends are documented and possible responses are proposed.

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Acronyms

ADB	Asian Development Bank
CEMPRE	Brazilian Business Commitment for Recycling
COD	Chemical Oxygen Demand
EPB	Environnemental Protection Bureau
ESB	Environmental Sanitation Bureau
ER	Emissions Reduction
EU	European Union
FOB	Freight on Board
ICI	Industrial Commercial Institutional
LFG	Landfill Gas
MOC	Ministry of Construction
MSW	Municipal Solid Waste
NGO	Non Governmental Organization
OCC	Old Corrugate Cardboard
PPP	Public Private Partnerships
PVC	Polyvinyl Chloride
RDF	Refuse Derived Fuel
RMB	Renminbi
SEPA	State Environmental Protection Agency

SECTION 1 – EXECUTIVE SUMMARY

This report intends to contribute to the municipal solid waste dialogue in China. The report provides a general sector background and presents the World Bank's current understanding. Detailed recommendations are made.[1]

The report was prepared using assessments by four consultants hired by the World Bank in 2004[2] and a review of the Asian Development Bank's comprehensive report, completed in 2001, entitled "Strengthening Urban Solid Waste Management: National SWM Strategy (TA3447-PRC)" and compendium report "Public Private Partnerships in Waste Management." Field visits and project reviews were also carried out by Bank staff.

China recently surpassed the U.S. as the world's largest municipal solid waste (MSW) generator. In 2004 the urban areas of China generated about 190,000,000 tonnes of MSW and by 2030 this amount is projected to be at least 480,000,000 tonnes. No country has ever experienced as large, or as rapid, an increase in waste generation. Management of this waste has enormous domestic and international implications. This report presents waste quantity estimates, that are considered to be sufficiently credible for national planning and resource allocation purposes.

Based on current solid waste plans, China could face an 8-fold increase in its country-wide waste management budget between now and 2020 (rising from today's estimate of 30 Billion RMB to about 230 billion RMB). The need for increased budgets will be most severe in smaller cities (those under 1,000,000 people).

Significant improvements have been made in the waste management sector over the last ten years. For example, most larger cities are aggressively moving towards sanitary landfilling as their main disposal option. Improved landfill operations and increased availability is likely China's most pressing waste management need.

Even though the pace of China's solid waste improvement is significant, China has been unable to keep up with the growing demand for waste service coverage, environmental requirements for safe disposal systems, and rationalization of cost-effectiveness in service delivery.

China's waste management practices now have global impacts. For example, secondary materials prices in the U.S. are now influenced by China's demand for these materials. The MOC's goal of increasing the rate of waste incineration to 30% (up from the current 1%) would likely at least double the global ambient levels of dioxin.[3]

This report identifies critical solid waste management issues for China:

1. Waste Quantities: unsurpassed rate of growth in waste generation, dramatically changing composition, and minimal waste reduction efforts;
2. Information Availability: lack of reliable and consistent waste quantity and cost data makes planning for waste management strategies extremely difficult;
3. Decision-Making Process: lack of consistent policy and strategic planning toward technology selection, private sector involvement, cost recovery, inadequate public access and participation in the planning process;

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1. This report does not address the key areas of hazardous waste, medical waste, sewage sludge, or waste pickers. Recommendations for follow on work in these areas are made.

2. InterChina Consulting—A Review of Waste Management Activities in Chinese Cities; AMEC Earth and Environmental—Review of Waste Quantities and Composition in China; Gabriella Prunier—A Review of Private Sector Participation in China Waste Management Sector, and; Environmental Resources Management—CDM Umbrella Guidelines for MSW in China. All prepared in 2004 and all available from the World Bank.

3. Dioxin is a highly toxic persistent organic pollutant; total global loading is a concern locally and globally.

4. Operations: facilities do not always meet design standards, particularly in pollution control, and facility operations are deficient, waste collection operations are often not rationalized;
5. Financing: inadequate cost recovery through user charges and tipping fees;
6. Institutional Arrangements: inadequate decentralization of collection and transfer services, inadequate municipal capacity for technology planning and private sector involvement, and inadequate clarity on mandates between government agencies, e.g. MOC and SEPA, and inadequate delineation between central and local government responsibilities.
7. Private sector involvement: The government's goal of increased private sector participation in solid waste services is hindered by unclear and inconsistent 'rules of engagement', non-transparent purchase practices, non-sustainable subsidies, inadequate municipal cash flows, unclear and inconsistent cost accounting practices, and an unclear regulatory framework.
8. Carbon financing: Increasing in importance in the Chinese MSW sector. China's cities could generate as much as $ 1 Billion per year from sale of carbon emissions reductions, resulting from landfill gas recovery, composting, recycling, and anaerobic digestion.[4] The opportunity may however be time limited so quick interventions are needed.

The report makes many recommendations (Section 8). The key recommendations discussed in detail in Section 8 are:

- Encouraging 3 cities to act as 'pilot' or 'model' cities to introduce replicable sustainable models. The pilot should aggressively pursue waste minimization strategies, generate credible and comprehensive waste management data (especially costs and quantities), and serve as 'centers of excellence' for waste management technologies, policies, and training in China. The pilots should provide a venue to develop long-term management plans, i.e. over 20 years.
- China needs to move up the hierarchy of waste management, achieving more waste reduction, reuse, recycling, and recovery (composting and digestion), and thus minimize the amount of waste that needs to be disposed.
- Waste minimization should be a key priority to MSW planning in China. Particular emphasis is needed for the organic fraction of the waste stream (which will continue to be more than 50% of the total waste stream for the foreseeable future), and paper (which is likely the fastest growing component in the waste stream). Packaging waste should also be targeted as it represents a large fraction of the increase in waste volume.
- Consistent national policies on MSW legislation are needed. The policies should encourage cross-jurisdictions and inter-agency coordination, and facilitate implementation of economic instruments for improving waste management.
- An integrated sustainable waste management approach with a long-term objective of waste segregation is needed. This approach involves key stakeholders in the planning and decision-making process and takes a holistic view of the entire waste management system, including waste minimization, collection, transfer, treatment, recycling, resource recovery, and disposal. Important planning and decision criteria include; social, cultural, environmental, institutional, financial and technical.
- The recycling industry needs to be improved (more professionalization, improved product standards, market development, and better operating standards).

4. Based on a sale price of $4.50 per tonne and a maximum diversion rate of 50% LFG recovery and 10% composting levels. Excludes the potential ERs from recycling or energy savings/production.

- Composting may increase in importance (possibly encouraged by the sale of carbon emission reductions), however product marketing requires that compost quality be reviewed and marketing programs established.
- Incinerators in China are growing in popularity but their growth is often driven by artificial and non-sustainable subsidies and non-transparent financing structures, as well as a lack of understanding and experience about incineration facilities. All new incinerators should meet Japanese-EU emission standards for dioxin and mercury and all should have a sufficient level of operator training. In all cases complete and accurate cost-benefit analyses should be performed.
- Landfills need urgent attention to improve overall operating conditions. They need to be sloped to minimize leachate, developed in stages, and operated according to international standards for "sanitary landfills." More attention is needed on post closure uses of landfills, i.e. seen as an integrated and needed land use – maybe turned into golf courses or green spaces upon closure, (as part of urban planning and development). Chinese cities will likely need an additional 1400 landfills over the next 25 years.
- Increased planning and service provision is needed for "special wastes" such as hazardous waste, demolition waste, medical waste and disproportionately problematic wastes such as batteries, disposable diapers, single serving beverage containers, newspapers.
- "Brownfields" – lands contaminated from inadequate disposal practices or chemical spills – will grow in importance in Chinese cities as they continue to impact public health, environmental quality, and land values. There are likely at least 5,000 of these sites now in Chinese cities. The cost to clean up these sites will always be significantly higher than the cost to have to disposed of the waste properly in the first place. This is an area poorly understood in China and in need of deeper review.

Section 2 – Current and Projected Waste Quantities and Composition

China recently surpassed the United States as the world's largest municipal solid waste (MSW) generator. In 2004 the urban areas of China generated about 190,000,000 tonnes of MSW. By 2030 this amount of waste is projected to grow to at least 480,000,000 tonnes (see figure 2.1)—more than twice the amount that will be generated in the US at the same time.

Managing this waste will be an enormous task.

Between now and 2030 China will need to develop systems to deal with two-and-a-half times more waste than current levels. On a local and global basis, the environment will need to provide and assimilate the equivalent materials of two additional US economies of today. Annex 3 presents comparative global tables and charts showing China's consumption patterns, with significant growth in demand for energy and materials.

Three key aspects, urbanization, urban population growth, and increasing affluence, are driving the magnitude of China's increase in total waste generation. Urban residents produce two to three times more waste than their rural counterparts regardless of income levels[5]. In part, higher waste generation rates for urban residents are related to their urban economic activity, including commercial, industrial, and institutional activity. Also, urban dwellers tend to have higher average incomes than rural residents, and thus higher consumption patterns. Figure 2.2 highlights the direct link between increasing affluence (measured in GDP) and waste generation.

Annex 1 presents expected waste trends for urbanized areas in large Chinese cities (those with a population of at least 750,000 people in 2000—of which 51 are in the eastern region, 38 in the central region, and 22 in the western region). This review does not provide individual data for medium-sized cities (those with a population under 750,000) of which there are over 500 in China. However, the total urban waste quantities presented in this report at the national level includes these smaller cities; per capita generation rates are assumed to be the same as those for larger cities. The database shows that the highest generation rates occur in the largest coastal cities; and, otherwise, generation rates are relatively consistent among medium and large cities.

Solid waste service levels vary across Chinese cities as with other municipal services. Service levels tend to decrease from the eastern coastal cities to the west.

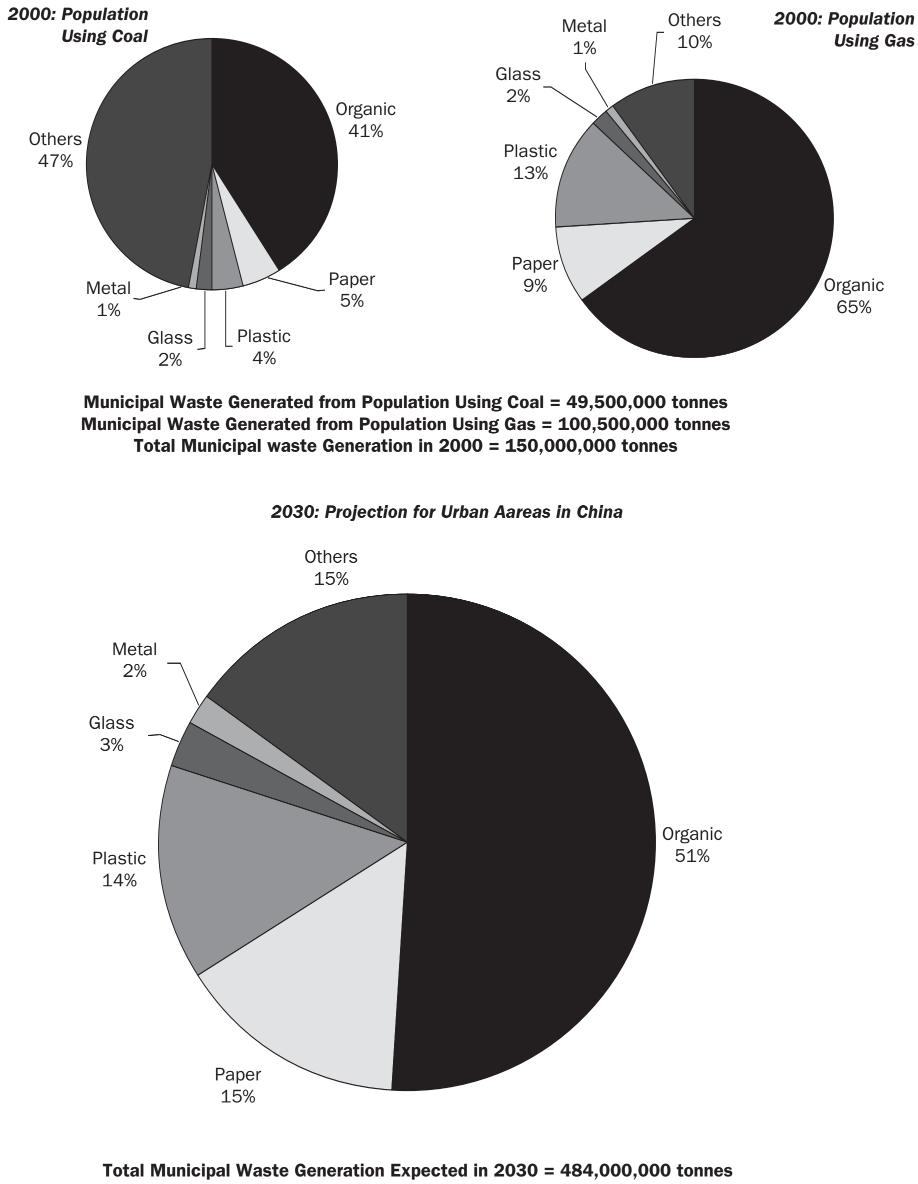
Estimating Waste Quantities

Annex 1 presents one of the most comprehensive estimates for waste generation per city (populations over 750,000) from 2000 to 2030. This data, prepared by AMEC Earth & Environmental as part of this study, is based on existing government data and field visits to three representative cities (Kunming, Shanghai, Chongqing)

Reliable and comprehensive solid waste data is critical for service planning and enhancing accountability. China's waste data suffers from several shortcomings. These include: inconsistencies in definitions and methodologies; lack of referencing on data collection; frequently changing parameters which makes comparisons of trends difficult; and a lack of awareness of national resources and guidelines (protocols), e.g. China has a national standard for sampling and physical analysis of waste (CJ/T 3039-95) however many municipalities appear to be unaware of its existence.

5. Hoornweg, Dan and Laura Thomas. *What a Waste: Solid Waste Management in Asia*. May 1999, pg. 8.

Figure 2.1: Projected Municipal Waste Composition in Urban Areas of China–As Generated



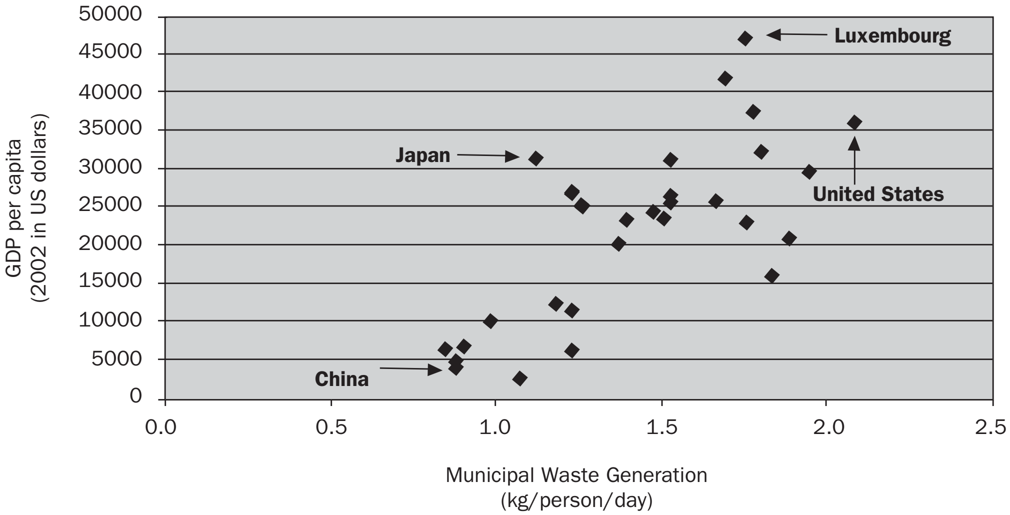
Note: Scale of charts has been set to reflect the difference in waste quantities in 2000 and 2030. Assumed 67% of the urban population has access to gas.

Most available information is based on 'waste collected' data rather than 'waste generated' data. However, waste generated data is more useful since it includes recyclable secondary materials, and encourages more full-cost accounting of the overall MSW system and program financing. Data presented in this report are waste generated estimates. Improving the reliability of waste management data will be critical in China over the next five years (mainly lead by the cities).

Primary data collection should rest with the solid waste departments of municipal ESBs and EPBs. Clear and consistent methods of data collection will need to be provided and disseminated to the responsible departments. Current practices limit long-term MSW planning.

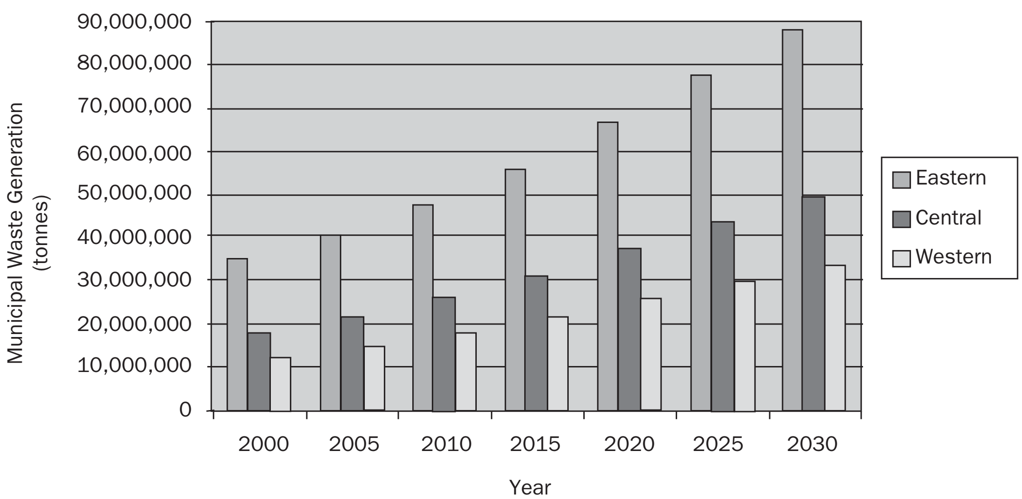
Figure 2.3 segregates projected waste quantities into the urban areas of Eastern, Central and Western China. Although it was initially anticipated that Eastern, Central and Western cities would have different per capita waste generation rates, this analysis does

Figure 2.2: OECD Countries Municipal Waste Generation Compared to GDP



Source: OECD, 2002 and 2003

Figure 2.3: Projected Municipal Waste Generation in Urban Areas of China by Region



Based on population data from United Nations, 2002
Source: AMEC

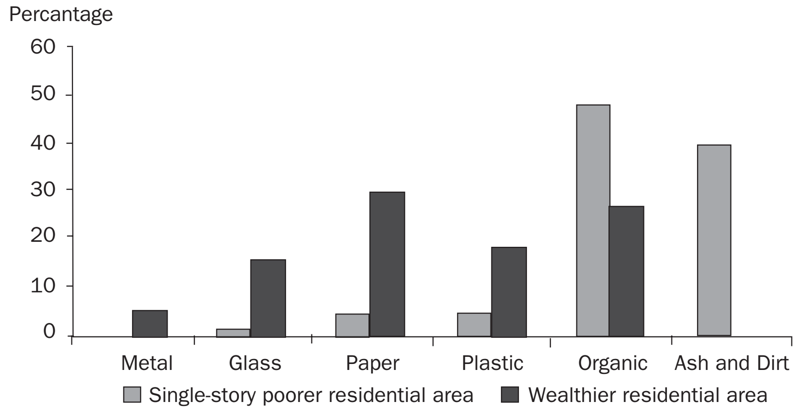
not substantiate this assumption. Thus for the purposes of this report a consistent per capita generation rate was applied for all urban residents throughout China.

Even though citywide waste generation rates are comparable, it is recognized that high-income urban residents have a higher generation rate than low-income residents. Figure 2.4 highlights the variations in waste generation by affluence in Beijing. The individual city data presented in Annex 1 should however be suitable for use in the broad municipal planning context. Further refinements could be made based on a specific city's income levels vis a vis the national average.

Defining Municipal Solid Waste

Solid waste is defined as any solid material intentionally discarded for disposal, however much of this waste, such as recyclables, is valuable to someone else and can be extracted from the waste stream. MSW definitions should include all waste generated since the

Figure 2.4: Variations in Waste Generation and Composition by Affluence: Beijing, China



Source: Hoornweg and Thomas, What a Waste, Solid Waste Management in Asia

municipality may be required to assume responsibility if there is no longer sufficient impetus to remove the material from the waste stream. Defining where the waste is generated is also important since this often defines the type of waste that can be expected and is important for allocating user fees, which may vary by generator.

What is included as municipal solid waste (MSW) can vary considerably. This report defines MSW as all waste originating in urban areas from residential, industrial (non-hazardous), commercial and institutional sectors (see table 2.1). This definition is consistent with international practices and enables better comparisons across Chinese cities and globally. MSW does not usually include hazardous waste generated from industrial processes, or medical waste, however these waste streams are commonly addressed in reviews of MSW and are therefore included in this report.

Most Chinese municipal solid waste generation data is presented in three categories; municipal, industrial, and hazardous waste. “Municipal waste” usually includes residential, institutional, commercial, street cleaning, and non-process waste from industries. In some cases, construction and demolition waste is also included and can dramatically skew the generation rate, especially in times of high economic growth and related construction activity. “Industrial waste” is usually limited to “process waste” such as process by-products like scrap metal, slag, and mine tailings. “Hazardous waste” usually refers to industrial hazardous waste generated as a by-product of the manufacturing process, medical waste, small-scale generation of hazardous waste from households, institutions and commercial establishments, and occasionally small amounts of radioactive waste, e.g. smoke detectors and medical process waste.

The categorization of wastes in China is not always consistent or comprehensive from city to city and adversely affects the utility of the database. MSW should be carefully categorized within 7 categories (see table 2.1), consistent with international practices.

Figure 2.5 presents industrial solid waste generation estimates for 1995, 2000, and 2002. These waste quantities are significant. In 2002 over 1,000,000,000 tonnes of industrial waste was generated in China (over 5 times the amount of MSW - and this is likely an under estimate). This industrial waste is typically high volume (and mass) process by-products such as mine tailings, slag, and coal ash. This waste does not typically enter the municipal waste stream as industries are required to deal with the waste on their own (under SEPA supervision). For purposes of this study industrial process waste is NOT included in the review of MSW activities unless industry cannot deal with the waste and it enters the municipal waste stream.

Figure 2.1 presents a summary of waste composition in 2000 and that projected for 2030. The figure shows that significant changes in waste composition will continue, and

Table 2.1: Sources and Types of Municipal Solid Waste

Source	Typical Waste Generators	Types of Solid Waste
Residential	Single and multifamily dwellings	Food waste, paper, cardboard, plastic, textiles, leather, yard waste, wood, glass, metal, ash, special waste (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires) and household hazardous waste
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants	Housekeeping waste, packaging, food waste, construction and demolition materials, hazardous waste, ash, special waste
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastic, wood, food waste, glass, metal, special waste, hazardous waste
Institutional	Schools, hospitals, prisons, government centers	Same as commercial
Construction and Demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal Services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings; landscape and tree trimmings; general waste from parks, beaches and other recreational areas; sludge from water and wastewater treatment plants
Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process waste, scrap materials, off-specification products, slag, tailings

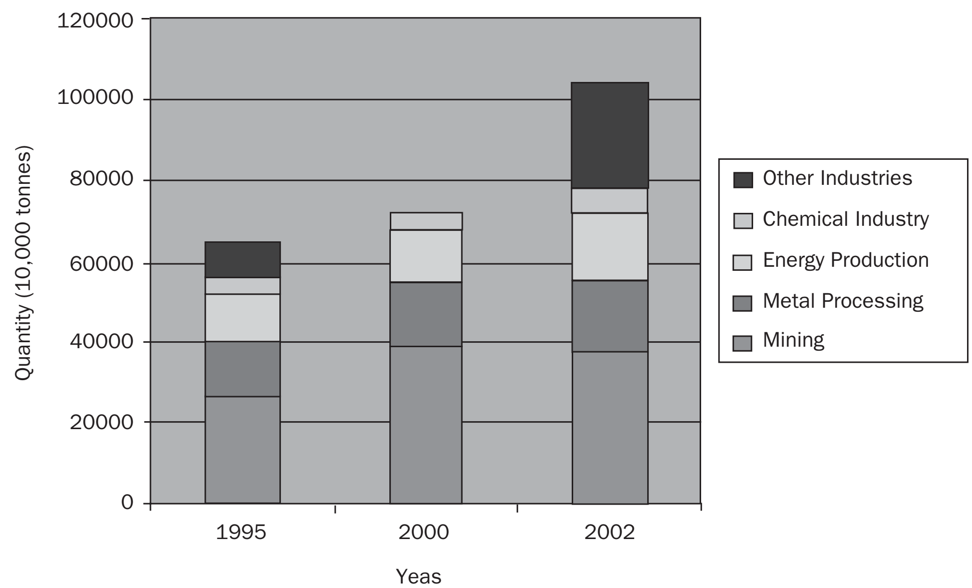
Adapted from World Bank, 1999

these will affect the choice of solid waste treatment and disposal technologies. For example, by 2030 it is estimated that all urban households will be using gas for home heating and coal ash will only be a minor component in the waste stream. Coal ash now has a disproportionately large negative impact on China's MSW programs. About 25,000,000 tonnes of coal ash are now disposed in the urban waste stream. Coal ash mixed with organics degrades finished compost quality by introducing heavy metals. Coal ash in the combusted waste stream also reduces an incinerator's efficiency, and coal ash is very abrasive and reduces the operational life of collection vehicles and waste processing facilities.

Figure 2.1 reinforces the priority and importance of the organic fraction of the waste stream. In 2030, even with a marked increase in packaging waste, paper products and plastics and a complete reduction of coal ash, organics will still make up more than 50% of the waste stream. These organics are poorly suited to incineration due to their high water content, and have the propensity to generate leachate when landfilled. See section 5.

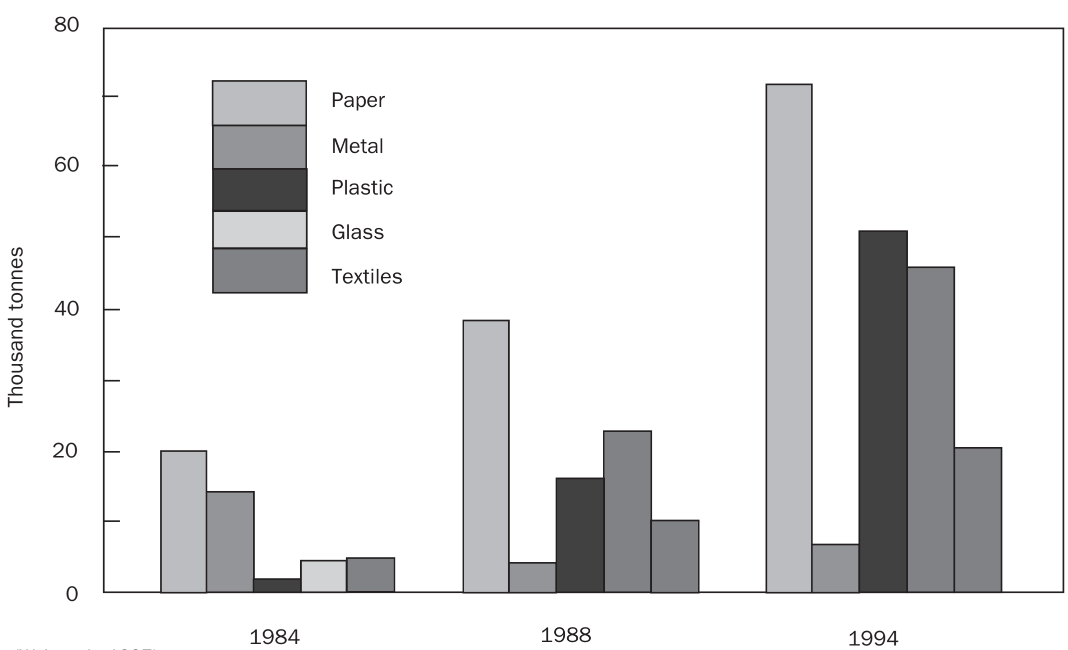
China's waste stream is growing fastest in paper, plastics and multi-laminates, such as plastic coated paper. Annex 3 illustrates how countries like the US and the EU have much higher per capita use of paper, about 10 times more than China in 2000, however, in China's urban areas this disparity is diminishing (with no noticeable reduction in use by

Figure 2.5: Industrial Solid Waste Generation in China



Source: China Statistics Press 1997 and 2003, SEPA 2000

Figure 2.6: Wuhan City Waste Composition–RECROP



(Wei et al., 1997)

Source: Hoornweg and Thomas, What a Waste, Solid Waste Management in Asia

OECD countries). Figure 2.6 provides anecdotal confirmation of the rapid growth in paper, plastics, and glass in the municipal waste stream; over the period from 1984 to 1994 quantities more than doubled in Wuhan.

Paper provides an important example for China's 2030 waste stream. It is expected that about 10% of the 480,000,000 tonnes will be readily identifiable and retrievable paper products. Secondary paper fibers for recycling are now worth about 500 RMB/tonne in China. Therefore, conceivably, by 2030, China's "urban ore" could have 24 billion RMB of paper in it (values based on 2004 secondary materials prices in China, which will likely increase significantly over the next 25 years). Similar revenues could be anticipated from materials such as aluminum, specific plastics, glass, and steel. Even though these prices are intended to be illustrative only, and significant costs would be associated with recovery of the materials, by 2030 China's urban waste stream will represent one of the world's largest sources of commodities such as paper and metals. Similar to the US, and as already observed in China, a broad based secondary materials market will exist, see Section 5.

China's urban waste stream is undergoing similar trends observed in other countries as they developed. Waste is increasingly containerized for collection (this is important to reduce the addition of rain water, reduce pests, and to increase collection efficiencies); waste volumes are quickly increasing (much faster than mass) - packaging waste is making up a larger fraction of the waste stream; problematic waste items are having an increasingly disproportionately large impact on waste management activities, e.g. batteries, electronic products, fluorescent light bulbs, household hazardous waste; waste is becoming increasingly flammable and fires in collection vehicles, transfer stations and landfills are more common; and, residential, or household waste is a diminishing share of the total waste stream (but still receives a disproportionate share of attention).

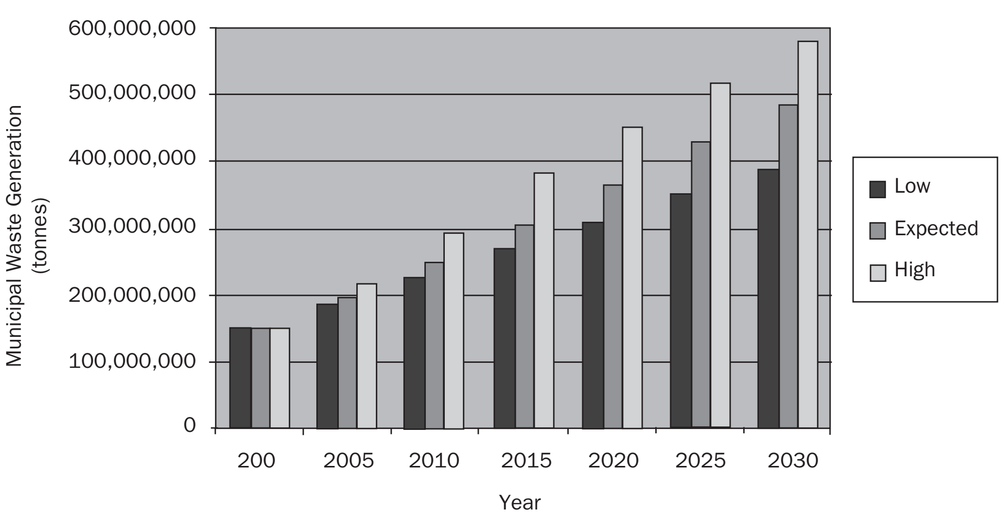
The Rate of Growth

Arguably the most important aspect facing solid waste planners in China is the *rate* of growth in waste generation. Figure 2.7 illustrates three proposed scenarios for waste generation in urban areas, low, expected, and high. In 2030 the per capita waste generation for the three scenarios is 1.20 kg/p/day, 1.50 kg/p/day, and 1.80 kg/p/day respectively. Based on OECD and other Asian country experience this dramatic (50% variation) range of waste generation is possible.

Figure 2.2 shows that although there is an inextricable link between growth in GDP and growth in per capita waste generation, significant variations are possible. Japan and United States illustrate this; both countries have a similar per capita GDP but Japan's per capita waste generation rate is only 1.1 kg/p/day, while each urban resident in the US produces almost twice as much waste, 2.1 kg/p/day.

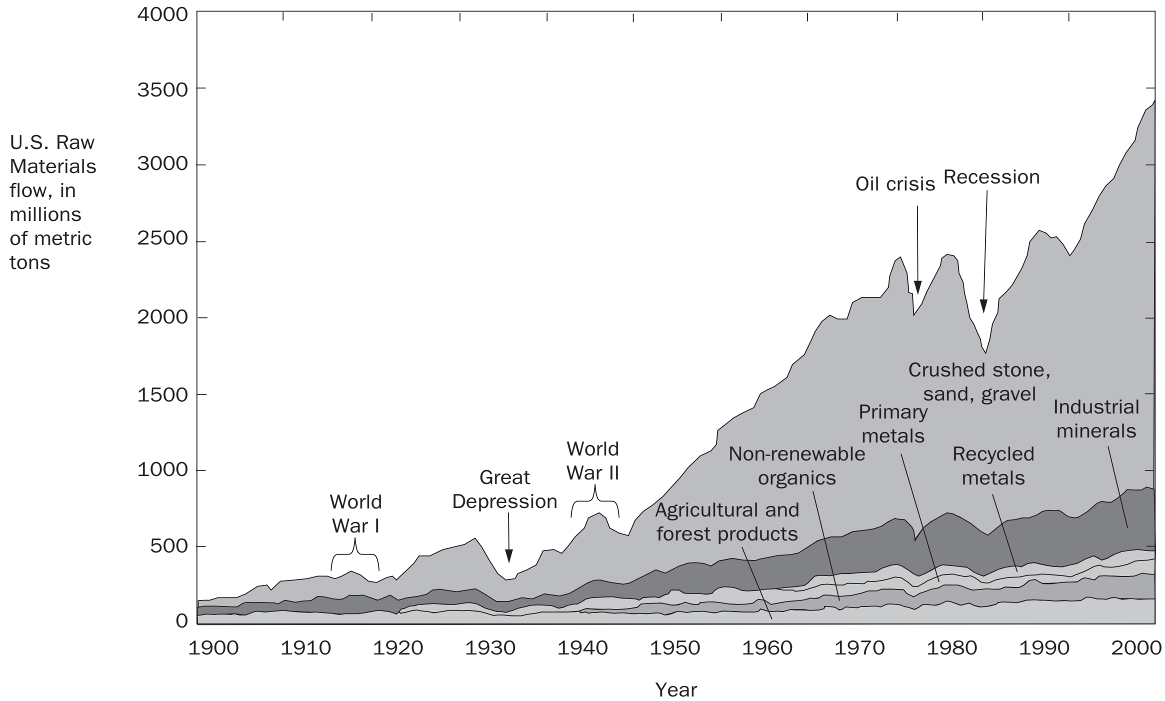
The difference between China following a 'low' waste generation growth rate versus a 'high' rate, would be about 200,000,000 tonnes per year. Following the low-case scenario would save several billion RMB in waste management fees (in addition to significant environmental benefits).

Figure 2.7: Projected Municipal Waste Generation for the Urban Population in China



Source: AMEC

Figure 2.8: U.S. Flow of Raw Materials by Weight, 1900–2000



Source: Wagner, Lorie A., Materials in the Economy- Material Flows, Scarcity, and the Environment U.S. Geological Survey, Feb 2002

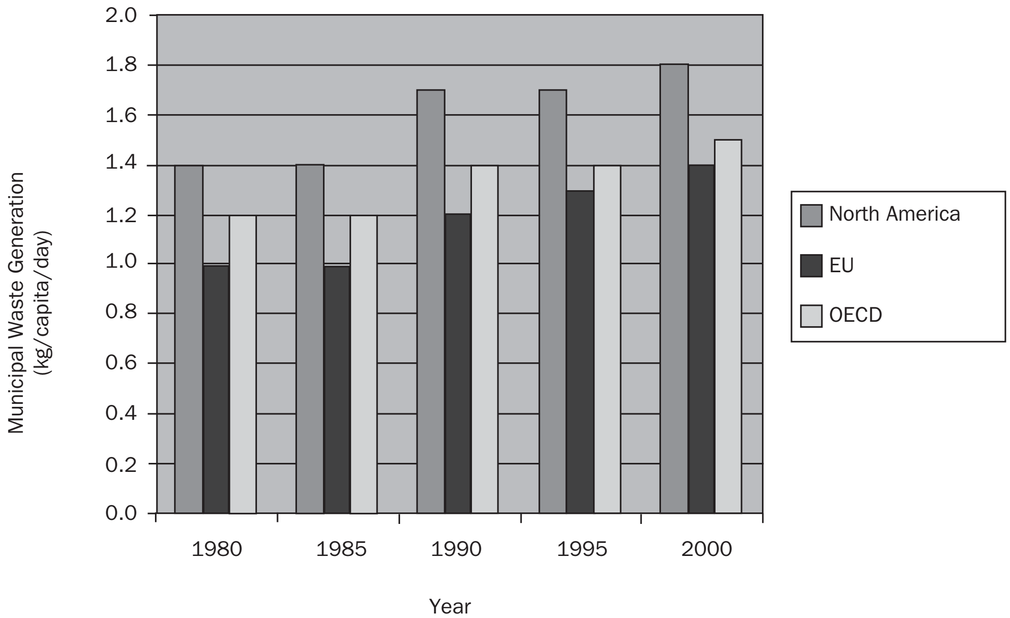
Early indications are that China's waste generation trend is following a "high" growth rate scenario. There are many reasons for this but the main one may be social attitudes and buying habits, see Annex 3. Efforts towards waste minimization do not yet appear to be aggressively pursued, see Section 4.

The Commodities Connection

China's waste stream is a result of materials flowing through, and no longer wanted within the urban economy. The amount of waste generated is directly linked to the country's economy. China's high demand for raw materials such as aggregates, hydrocarbons, metal and paper are now having a global impact. Scrap metal prices in the US, secondary fiber prices in Europe, and the spot price for crude oil are all affected by China's requirements.

Figure 2.8 illustrates the link between materials and the economy in the US over the last 100 years. This connection is repeated in all countries undergoing economic development; none more so than China which is now at a materials throughput level of where the US was in about 1950 (US GDP of $1,000 per capita in 2004's dollar). Based on the US experience, and other countries, the Chinese economy will triple to quadruple its materials consumption over the next 30 to 50 years. About 10% of materials used in an economy end up as MSW. Today in the US for example, each resident uses about 10 tonnes of materials (mostly stone and gravel, and minerals) and produces about 1 tonne of MSW. Figure 2.8 also shows another important observation in waste management; namely, reduced waste generation closely follows an economic recession (e.g. the US recession of 1981 and depression of 1923). This is obviously not a preferred waste reduction strategy, but it does illustrate the need to start de-linking economic growth with materials consumption and waste generation.

Figure 2.9: OECD Countries Municipal Waste Generation



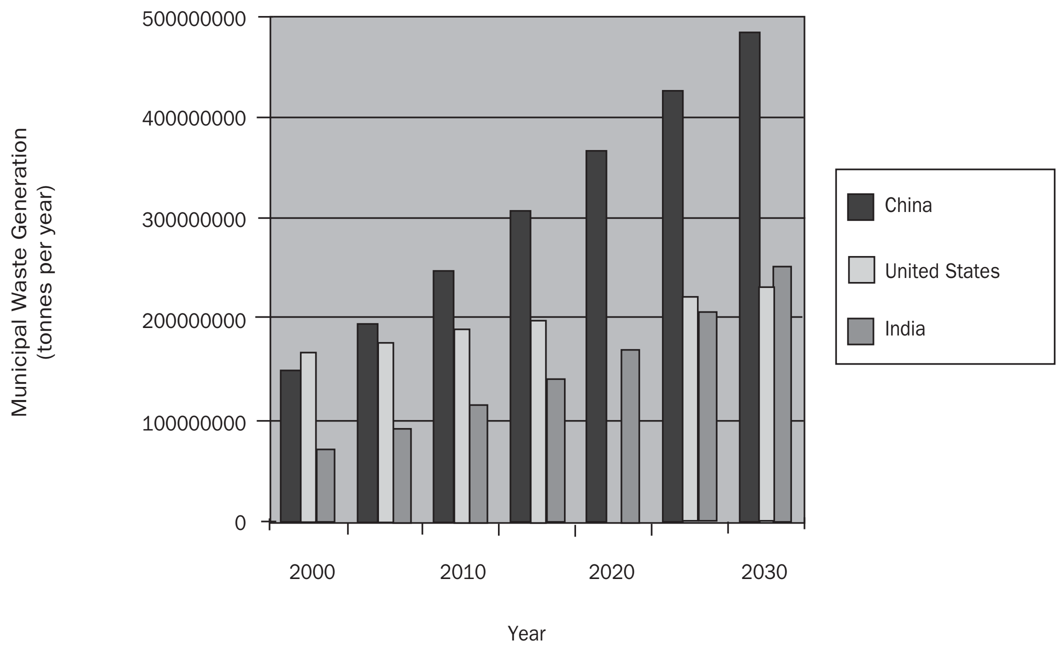
Source: AMEC

Table 2.2: Projected Municipal Waste Generation for the Urban Population in China

Year	Projected Urban Population (thousands)[1]	Low Waste Generation Rate (kg/p/day)	Low Waste Generation MSW Generation (tonnes)	Expected Waste Generation Rate (kg/p/day)	Expected Waste Generation MSW Generation (tonnes)	High Waste Generation Rate (kg/p/day)	High Waste Generation MSW Generation (tonnes)
2000	456,340	0.90	149,907,690	0.90	149,907,690	0.90	149,907,690
2005	535,958	0.95	185,843,437	1.00	195,624,670	1.10	215,187,137
2010	617,348	1.00	225,332,020	1.10	247,865,222	1.30	292,931,626
2015	698,077	1.05	267,538,101	1.20	305,757,726	1.50	382,197,158
2020	771,861	1.10	309,902,192	1.30	366,248,045	1.60	450,766,824
2025	834,295	1.15	350,195,326	1.40	426,324,745	1.70	517,680,048
2030	883,421	1.20	386,938,398	1.50	483,672,998	1.80	580,407,597

[1] *United Nations, 2002*

Figure 2.10: Projected Municipal Waste Generation for China, India and the United States



Based on population data from United Nations, 2002

Section 3 – Roles and Responsibilities

In most countries, solid waste management is a municipal responsibility. For some components of solid waste management, where there are minimal economies-of-scale such as door-to-door waste collection, operations are delegated to sub-municipal levels, such as districts or neighborhoods. Where special siting conditions or large economies-of-scale require regional facilities, multiple municipalities need to work together (e.g., inter-municipal agreements or regional disposal authorities). Solid waste management is often one of the largest budgetary allocations of local governments and is usually the largest category of municipal employees, including street sweepers, waste collectors, disposal laborers, and related sanitation inspectors.

Each country's national legislative and regulatory framework for solid waste management dictates roles and responsibilities at each level of government, including requirements of private sector service agents and waste generators. Typically, central government laws delegate solid waste service responsibilities to local governments and set basic standards, including occupational and environmental health and safety standards. Municipal government laws outline service norms to be provided and the participatory requirements of each waste generator. Municipal laws often define practices that are illegal (such as littering and clandestine dumping) and impose related sanctions.

Table 3.1 provides an overview of the solid waste legislative arrangements in China. Arrangements are complicated and often overlap, or have areas where no agency is responsible. Increasing volumes of waste, growing budget allocations, increasing sophistication needed for proper service delivery, equipment procurement, and private sector contracting, require improved regulation.

Much has been written on the solid waste management functions and responsibilities of Chinese agencies. For example Annex 2 is a summary of the Asian Development Bank's Report, "Strengthening Urban Solid Waste Management," proposes functions and responsibilities for national ministries (mainly SEPA and MOC), provincial government agencies, and municipal government solid waste units (including district level responsibilities).

The regulatory framework in China would be enhanced by greater separation of management and planning functions from operations functions, as well as separation of policy development and regulations from implementation activities. Environmental standards for waste management facilities (such as incinerators and landfills) need to be established by national ministries (SEPA) and those agencies need to monitor adherence to these standards. Municipalities cannot be expected to objectively regulate themselves. Also needed is a non-regulatory agency, or separated department of a regulatory agency, that focuses on the technical aspects of waste management service provision, e.g. landfill design standards, and waste management master planning. MOC has so far taken this role, but MOC's operational standards and practices (by virtue of ownership and management of the facilities) should be consistent with SEPA's overall regulatory framework.

National government will be increasingly called upon to develop and review waste minimization programs (e.g. deposits or packaging legislation), emissions reduction programs (e.g., clean fuels for solid waste fleets or carbon financing for landfill gas recovery), and resource recovery programs (e.g., compost quality standards and compost marketing). Such programs will transcend any single ministry's purview and will need significant inter-ministerial cooperation, as well as ongoing input from other stakeholders such as academics, trade associations, and NGOs.

Other Stakeholders

Currently there is only marginal influence on overall waste management services by stakeholders outside of the Chinese government. This reflects historical aspects of China's planned economy; but this is changing quickly. Similar to other countries, trade associations

Table 3.1: Summary of National Chinese Laws and Regulations on MSW

Laws and Regulations (Chinese)	Laws and Regulations (English)	Brief Description	Issuer	Effective Time
中华人民共和国固体废弃物污染环境防治法	Law on Prevention and Control of Environmental Pollution Caused by Solid Waste of PRC	First law to regulate the management of MSW.	The Standing Committee of the National People's Congress	April 1, 1996
中华人民共和国清洁生产促进法	Law for Promotion of Cleaner Production of PRC	From each step of the production, the manufacturers should take measurements to reduce pollution.	The Standing Committee of the National People's Congress	January 1, 2003
中华人民共和国环境影响评价法	Law for Environment Impact Assessment of PRC	Emphasize the importance of preventing environmental pollution from source; any new construction must obtain EIA approval before breaking ground.	The Standing Committee of the National People's Congress	September 1, 2003
城市市容和环境卫生管理条例	City Appearance and Environmental Sanitary Management Ordinance	Principle guidelines on city appearance (outdoor advertisement & horticulture) and environmental sanitary (MSW & public latrines) management; Local government would work out practical measurements.	The State Council	August 1, 1992
城市生活垃圾管理办法	Regulations Regarding Municipal Residential Solid Waste	Regulations regarding the management of collecting, transferring and treating residential solid waste.	The Ministry of Construction of PRC	September 1, 1993
城市生活垃圾处理及污染防治技术政策	Technical Policies on the Disposal of Domestic Waste and the Prevention of Pollution	Guidance and standards of the technologies applied in the MSW treatment.	The Ministry of Construction of PRC	June, 2000
关于推进城市污水处理 垃圾处理产业发展的意见	Comments on Promoting the Industrialization of Municipal Waste Water Treatment and Municipal Solid Waste Treatment	An important signal for attracting private and foreign investment into municipal wastewater and solid waste industry.	State Development & Planning Committee, The Ministry of Construction, and State Environmental Protection Administration	September, 2002

Source: InterChina

(e.g., those wanting or not wanting packaging restrictions or promoting specific waste management aspects such as incineration), community groups and neighborhood associations (e.g., promoting community recycling initiatives or opposed to proposed disposal facilities), international NGOs and other stakeholders (e.g., China's demand for scrap metal has already resulted in US municipalities taking actions to restrict export of scrap metal), labor associations (advocating changes to worker conditions or pay levels), are rapidly increasing in influence. This influence will increase even more in China due to the enormous economic importance of China's waste sector.

Trade associations can particularly influence waste management policies, see Annex 5. Transnational manufacturers whose products often contribute a disproportionately large amount to the waste stream, such as Coca Cola, Pepsi, and other beverage providers such as breweries and water bottlers, Procter and Gamble, Unilever, Tetra Pak, and Nestlé, have a large stake in how the waste stream is managed. Locally, newspaper and magazine publishers have a similar keen interest in how the waste stream is managed. Such consumer products, which contribute markedly to the waste stream through discarded product packaging or short-life items such as newspapers and shopping bags, could be specifically subjected to deposits or waste management taxes.

Over the last 15 years, recycling trade associations, initially developed to influence policies on deposits and waste fees, have grown to be an integral part of the overall waste management planning process in their respective jurisdictions. CEMPRE of Brazil (see box 3.1) and Corporations in Support of Recycling of Ontario, Canada (see Annex 5) are two illustrative examples. China's large waste volume and 400,000,000 urban customers will likely foster similar developments.

Professional Associations now have an extremely important role in MSW operations in North America and Europe. Most OECD jurisdictions have professional technical agencies such as professional city managers, professional engineers, and some have solid waste associations (such as the United Kingdom's Institute of Waste Management). Their individual and corporate members are bound by professional codes of practice. Also, their regular meetings and annual conventions provide opportunities for members to exchange ideas and information. These stakeholder associations significantly improve the overall professionalization of the sector. Many are members of the International Solid Waste Association (ISWA) which conducts global conferences and develops policy and technical guidance that broadly meets the needs of its wide range of international members.

Community groups often have a significant influence on waste management policies and operations. In most countries community groups participate in facility planning and can highly influence the decision-making process on siting and permitting of transfer, treatment, and disposal facilities. Without well-conceived public participation in facility planning, community groups in the immediate vicinity of proposed facilities can delay

Box 3.1 Brazilian Business Commitment for Recycling (CEMPRE)

The Brazilian Business Commitment for Recycling (Cempre) is a non-profit association dedicated to the promotion of recycling within the scope of integrated waste management. Established in 1992, Cempre is maintained by private companies from various sectors that have come together to ensure that their perspective on solid waste (particularly packaging issues) are considered by waste planners, and to help governments manage their waste efforts. Cempre's aim is to increase the societal conscientiousness about recycling, and waste as a whole, through publications, technical research, seminars and data banks. The conscientiousness raising programs are directed principally at those who influence public opinion, like mayors, directors of companies, academics, and non-governmental organizations (NGO's). In addition the organization provides, via a World Wide Web, tips on how to sell recyclable material; economic indicators on, technical aspects of, waste collection and recycling; and a database on packaging and the environment.

Cempre's involvement has extended beyond Brazil. The Latin American Federation of Business Associations for the Promotion of Integrated Solid Waste Management was created to exchange information amongst its members. The Association for the Defense of the Environment and Nature (ADAN) in Venezuela, CEMPRE/Brazil, CEMPRE/Uruguay, the Industry and Commerce Pro-Recycling Organization (ICPRO) in Puerto Rico, and Sustena in Mexico, have formed a partnership.

and even block facility implementation. Local community groups can also play a large role in litter prevention, waste collection schedules, truck routing, and establishing waste minimization programs such as recycling and container deposit-refund systems.

There are many things that waste managers can do to maximize the benefit of community involvement. A well operated waste management system is usually the easiest way to garner public support, however this is not always possible; and no matter how well a system is operated, some opposition to land-use changes for landfills or incinerators can be expected. China's public opposition to landfilling is generally minor, and some landfills have even been desired due to potential job creation. In the future, where new facilities may become contested, China may need to consider incentives that support proposed facilities, such as payment of host fees.

Probably the most influential community group that affects waste management in China is waste pickers, see Section 5. Policies and programs to upgrade their livelihood and working conditions need to be considered, as well as how best to integrate them within overall waste management operations.

Non Government Organizations have a tremendous influence on waste management in OECD countries. NGO groups are often concerned about environmental issues – and solid waste issues attract much of this attention. Solid waste can have significant environmental impacts if not managed properly. There is also an opportunity to use concerns about municipal solid waste, as leverage to encourage up-stream changes in resource extraction and materials use. Interestingly, the environmental impact that an item may cause as solid waste is only about 5% of its total environmental impact.[6] Most of the environmental impact has occurred in the extraction, processing, and use of the item. Therefore input from international environmental groups on solid waste management often encourages waste minimization, expansion of recycling, composting, deposit-refund, materials taxes, and non-incineration (as the pollution can have global impacts).

6. What a Waste: Solid Waste Management in Asia. World Bank, 1999.

SECTION 4 – WASTE MINIMIZATION

Figure 2.7 shows the difference in waste quantities in 2030 depending on whether China follows a "low", "medium" or "high" growth in waste generation rate. The difference between the high and low rates is about 200,000,000 tonnes/year of waste by 2030. The high rate of 1.8 kg/person/day would still be 20% lower than the current US rate (total MSW waste stream). The low rate is already being achieved in some cities in China so higher values are likely. The actual rate will be most influenced by economic development and patterns of "consumerism". Based on current trends and urban lifestyles the actual waste generation rate would likely be higher than what is presented in this report as "expected". To achieve the expected growth rate China will need to enact serious waste minimization programs.

Affluent Chinese are already among the world's highest consumers of some well-known luxury products.[7] Packaging is dramatically increasing throughout China. In large grocery stores and shopping malls in China, many products, e.g. oranges and napkins in restaurants, are now individually plastic wrapped. Newspapers and magazines are growing in thickness as advertising increases, and electronic goods, such as hand phones, computers, and video and audio equipment are already a substantial component of the waste stream as consumers upgrade to newer versions.

Waste collection centers in many cities have undergone renovations to enable more compaction, as the urban waste stream increases in packaging materials, shipping cartons and plastic bags. This phenomenon is likely happening in all Chinese cities (e.g., Kunming has modified most of its collection centers), although it may be more pronounced in larger coastal cities.[8]

For large waste generators, such as large commercial or industrial facilities, one way to reduce waste quantities is to introduce quantity-based user fees, as well as disposal fees (i.e., tipping fees) for facilities that bring their own wastes to transfer or disposal facilities.[9] Managers are often concerned that the introduction of disposal fees will lead to illegal dumping of waste. This is a legitimate concern and requires careful attention to enforcement of illegal dumping laws. Tipping fees provide a direct incentive for waste generators to reduce waste volumes. Another way to encourage waste reduction is simply by increasing awareness, which often leads to process modifications, alternative disposal practices, and product changes. Tipping fees, based on disposed volumes, should first be applied to industrial-commercial-institutional (ICI) generators, rather than residential generators. ICI generators make up over 50% of the waste stream and are better able to respond to financial incentives through changes to operations. Residential waste generators respond to awareness efforts to encourage source segregation, e.g. using different containers for organic and non-organic waste, and changes to collection schedules. China's "Circular on Promoting the Industrialization of Waste Disposal through the

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7. China is Louis Vuitton's third largest market, (8% of all sales), and China represents the fastest growing market for many luxury products, BusinessWeek, March 22, 2004.

"What is striking about the new consumer group [of young women] is the similarity to those in developed countries. The difference really comes from their consumption patterns compared with the generation before them in China rather than other societies. They are like any teenagers that you would find in a rich suburb of Chicago or St Louis. They want the latest model, they want their computer, they want their camcorder, they want cool Swatches." Hung Huang, publisher of the Chinese version of Seventeen Magazine. From The Economist, February 17, 2004.

8. A review of China waste management – fact finding visit, D. Hoornweg, February 2003.

9. What a Waste: Solid Waste Management in Asia. The World Bank, 1999.

Introduction and Implementation of Paid Service of Municipal Solid Waste", June 7, 2002[10], provides the framework for municipalities to introduce waste collection user charges and disposal fees. No specifics are provided in the Circular, however it enables municipalities to have different fee structures for residentially generated waste versus industrial/commercial/institutional (e.g., charges per unit area of property for households and charges per tonne or cubic volume for industrial, institutional and commercial establishments).

The introduction of user charges based on amounts of waste generated is one of many possible "market based" instruments used to influence waste minimization and improve management. Box 4.1 provides examples of common market based instruments used by various governments. Some of these instruments can generate substantial revenue for government. Some instruments, such as materials bans and eco-labeling, will require a cooperative working relationship with industrial and commercial establishments for implementation and monitoring. Waste Exchanges (or Materials Exchanges) have grown in popularity and efficacy throughout OECD countries. Waste exchanges typically facilitate the exchange of one generator's waste to another entity that can use the waste (see Box 4.2).

Waste minimization is mainly driven by individual habits that value environmental protection and resource conservation. These social values take time to develop and change, however they are essential to environmentally sustainable and cost-effective services. Americans for example are more 'wasteful' than Japanese (based on materials used per unit of GDP) and this is mainly a cultural and lifestyle issue that affects manufacturers and their product packaging choices as well as each individual's consumer patterns. Chinese governments will need to take an active role in increasing overall public awareness about waste minimization. This could include introduction of activities such as school curriculum additions, environmental education and awareness programs for adults, and preferential purchasing programs. Due to the enormity and complexity of this education, a broad-based effort is required, e.g. inclusion in school curriculum, political leadership, and recognition of outstanding efforts.

Chinese authorities will not be able to stop the waste stream from growing; all they can do is reduce the rate of growth. Waste minimization efforts, such as the use of market based instruments, are urgently needed. Most OECD countries have set long term waste minimization, or per capita generation, targets. China's current waste management data is not yet sufficiently reliable to monitor such targets (see Section 2), however that does not negate the value of setting specific targets and implementing aggressive waste minimization programs. These should include:

- Establish tipping fees for waste receiving facilities, i.e. transfer stations, landfills, incinerators, compost plants. Fees should be based on mass or volume.
- Establish provincial and national and possibly international materials exchanges, including internet websites for waste exchange, including health and safety requirements for potentially hazardous waste materials.
- Set a waste reduction goal (generation growth rate) that recognizes the link to economic growth, e.g. 3% less than GNI growth (SEPA and MOC)
- Set a national maximum 2030 per capita waste generation target relative to; i) the current rate (about 0.9 kg/person/day), ii) experience in OECD countries (now averaging about 1.6 kg/person/day), and iii) that reflects projected economic growth estimates and expected technological improvements; say 1.45 kg/person/day. (SEPA and MOC)
- Establishing and monitoring these targets requires a joint committee, with at least SEPA and MOC participation, in central government.

10. Official Document of State Planning Commission, Ministry of Finance, Ministry of Construction, and State Environmental Protection Administration.

Box 4.1: Examples of Market Based Instruments in Municipal Solid Waste Management

- **Tax credits and tax relief,** allowances on property taxes, customs duties, or sales taxes to motivate investment in waste management improvements
- **Charge reduction,** based on proof of recycling or reuse in reducing wastes or requiring collection or disposal
- **Tax rebates,** for pollution savings or energy efficiencies
- **Environmental improvement funds,** established to support pollution reduction, resource protection, energy efficiency
- **Research grants,** to stimulate technology development
- **Host community compensation,** incentives given by host communities to allow waste transfer or disposal facilities to be built there
- **Development rights,** long-term leases of land and development rights provided to private companies building waste treatment and disposal facilities, or to those remediating and reclaiming old disposal sites
- **Tipping fees,** changes to generators based on volumes of waste disposed
- **Waste exchanges,** facilitated exchanges or waste materials
- **Trade Associations,** encourage industries to join together to provide common inputs to waste management issues
- **Product life cycle assessment** predicts overall environmental burden of products and con be used in certification programs
- **Deposit-refund,** deposit paid and refund given upon product return for reuse, e.g. beverage containers
- **Take-back systems,** manufacturers take back used products or packaging
- **Tradable permits** allow trading of emissions among various polluters
- **Bans** on materials or wastes causing disposal problems, e.g. mercury batteries
- **Procurement preferences,** evaluation criteria adding points for products with recycled content or reduced resource demand
- **Eco-labeling** notes product's recyclable content and whether product is recyclable
- **Recycled content requirements,** laws and procurement specification noting the precise recycled content required
- **Product stewardship** encourages product deigns that reduce pollution, include the full cost of solid waste recycling and disposal, reduce wastes and encourage recycling
- **Disclosure requirement:** waste generators are required to disclose their pollution
- **Manifest systems,** precise cradle-to-grave tracking of hazardous wastes
- **Environmental Rating of Industries:** published list enable consumers to consider whether to buy from polluting companies, e.g. Indonesia's PROPER program
- **Liability insurance,** liability assurances by contractors and private operators
- **Bonds and sureties,** guarantees for performance by contractors and private operators
- **Liability legislation,** laws defining environmental restoration settlements
- **Insurance pools,** restructuring of insured parties to enable pollution risks to be covered
- **Liens** placed on land where government remediation is required
- **Procurement transparency and competition** to encourage bidding on a level playing field
- **Performance-based management contracting:** oversight contractors commit to overall service improvements
- **Clean city competitions** reward neighborhoods and cities that have improved cleanliness

From: Cointreau, Sandra, *Economic Instruments for Solid Waste Management*, August 2003

Box 4.2: Industrial Waste Materials Exchange Agencies

In North America, companies often list their industrial waste materials (liquids & solids) in “waste exchanges”. While printed publications may be widely distributed to other industries, recyclers, brokers of chemicals, etc., in an attempt to find another party who might be interested in procuring the listed material, Internet websites, e.g., Tennessee Materials Exchange: www.cis.utk.edu; are gradually replacing “hard copy” lists. The Internet reaches many more potential users at a fraction of printing and mailing costs. In addition to listing “available” materials, i.e., manufacturing “waste products”, there are also lists of “wanted” materials. The objective is to reduce disposal costs, on the part of the waste generator, and reduce raw material procurement costs, on the part of the party needing material inputs for manufacturing operations. Historically, 75% of successful waste generator-end-user agreements occur when the transportation distance between parties is no greater than 80 kilometers.

There are approximately 40 waste exchange agencies in North America. Most are wholly or partially supported by state or provincial funds and function as not-for-profit organizations. They may or may not charge to list materials. The agencies do not handle materials themselves. Rather, they have been humorously defined as a combination of a “dating service and classified advertisement”, an operation that attempts to bring waste generators and potential users together. Once the parties are put in contact with each other, the agency steps away and the parties reach their own agreement on liability and cost.

Source: Richard Buggeln, Ph.D., Manager, Tennessee Materials Exchange

SECTION 5 – INTEGRATED SUSTAINABLE WASTE MANAGEMENT

Integrated sustainable waste management (ISWM) is a successful concept that has evolved after years of solid waste management experience. The ISWM concept rests on all key stakeholders being involved in the integrated planning of all waste system elements (i.e., from the point of generation to ultimate disposal, and including all steps of waste reduction, recycling, reuse and resource recovery in between these points) and addressing all system aspects (e.g., institutional, financial, regulatory, social and environmental aspects).[11]

There is no one single solution for waste management collection, transfer, treatment or disposal. For example, most cities benefit from having various types and sizes of collection equipment for various neighborhood access and collection conditions. A mix of treatment systems are typically preferred for purposes of resource recovery optimization relative to market demand, fluctuations in waste quantities, and built-in redundancy to help in emergency situations. A mix of public and private services in collection, transfer, and disposal enhances competition and cost-effectiveness. During planning, comparative evaluation of various options is essential to develop the optimum mix of options that are most sustainable (i.e., optimizes environmental, social, and health effects while providing economic delivery of waste management services). Integrated solid waste management planning includes an evaluation of the overall system to determine the economic breakpoint for direct haul versus transfer, and assessing the number and strategic locations of key treatment and disposal facilities.

A landfill is not an option; rather it is a part of every solid waste management system, providing disposal space for the residuals of treatment facilities (e.g., ash from incineration, non-compostables from compost plants), as well as space for all non-treatable wastes. Landfills are always needed to provide back-up disposal capacity in the event of up-stream facility closures or unduly large amounts of waste, e.g. from emergencies such as earthquakes. Landfill life is extended by implementing recycling and resource recovery options, and thus initial capacity is never compromised by consideration of other disposal facilities.

Developing a solid waste system that maximizes the benefits of each component by minimizing costs and maximizing environmental protection and public acceptance, while being sufficiently flexible to adapt to changing circumstances, is the main objective of a good waste management master plan (see Annex 8). The World Bank's guidance note on strategic planning for solid waste management provides a good starting point.

Waste management strategies need to propose ways to encourage a local "waste management ethic", e.g. sensitizing people to put waste out at prescribed times, source segregate recyclables, stop littering, and support waste reduction efforts. Strategies also need to have sufficient redundancy in case one component is temporarily out of operation, e.g. an incinerator is closed for maintenance or specific recycling markets are temporarily unavailable. They also need to accommodate sudden waste fluctuations that may arise after events such as storms or healthcare issues (e.g. SARS and avian flu). Waste is often affected by seasonal variations as well, e.g. more moisture during wetter months, coal ash in winter, greater residential waste volumes during holidays.

11. Integrated Sustainable Waste Management – the Concept, published by the Netherlands NGO "Waste", authors Arnold van der Klundert and Justine Anshutz, 2001

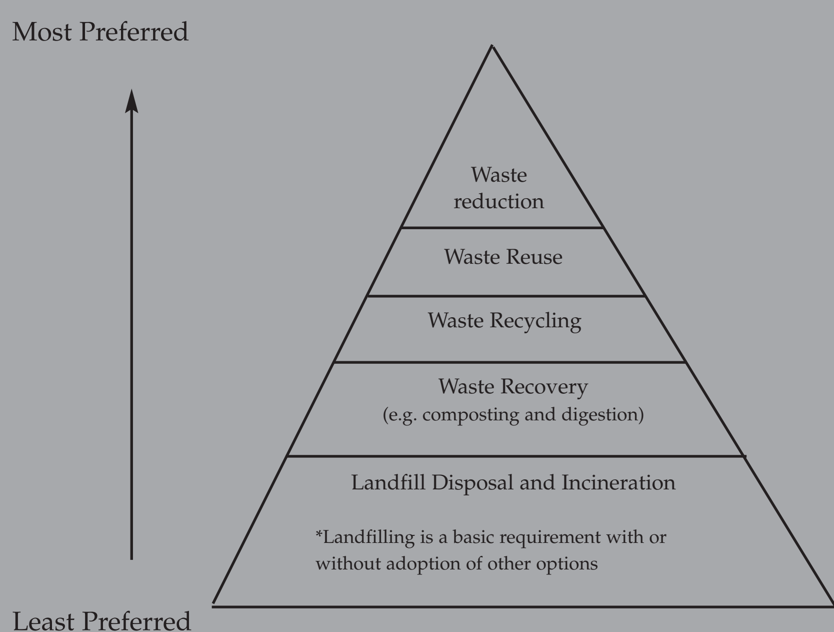
Hierarchy of Waste Management

Integrated sustainable solid waste management strategies are usually based on the "hierarchy of waste management" (i.e. Reduce-Reuse-Recycle-Compost-Dispose, see Box 5.1). The hierarchy of waste management simply advocates that the best approach to waste management is to first and foremost try to reduce waste generation and separate potential recyclables at source to improve the quality of materials for reuse, including organics for composting or anaerobic digestion. What cannot be reduced should be reused if possible. What cannot be reduced or reused should be recycled, particularly secondary materials such as metal and paper. Wastes that cannot be recycled should be recovered, usually through bacteriological decomposition (e.g., biodegradable organics are recovered through composting or anaerobic digestion). The waste hierarchy leads to reduced quantities requiring transfer and disposal; extends landfill lifetimes; reduces extraction of non-renewable raw materials; provides local generation of material feedstock for industry; reduces deforestation; reduces Greenhouse Gas generation; provides valuable recovered resources (e.g., methane gas and compost); provides employment and income; and directly involves all waste generators in improving the environment through waste minimization and source segregation.[12] (see Annex 7 and Annex 9).

The hierarchy of waste management advocates maximum flexibility and critical reliance on relatively simple and inexpensive landfilling. Landfilling is always cheaper than composting, incineration or anaerobic digestion and these up-stream technologies

Box 5.1 The Waste Management Hierarchy

Advanced technological solutions in the long term will provide a greater use and wider range of waste management solutions. Those options further up the hierarchy demonstrate an increasing focus on waste minimization and re-use of materials for increasing proportions of total solid waste.



12. Integrated Sustainable Waste Management – the Concept, published by the Netherlands NGO "Waste", authors Arnold van der Klundert and Justine Anshutz, 2001

need to be carefully matched to the quality and quantity of the waste stream. These components are recommended only when market demand covers their incrementally higher costs over landfill. Carbon finance (see Section 6), compost marketing, methane gas sales, and electricity sales are potential revenue opportunities that need to be reviewed when designing an integrated waste management system. Supportive government policies are needed (but not subsidies). For example, incineration can disrupt the hierarchy of waste management and be a serious disincentive to waste recycling of materials such as paper, textiles, and cardboard; especially where long-term concession agreements have a "take-or-pay" agreements for minimum quantities of waste delivery to incinerator plants.

The Role of Waste Pickers and Waste Collectors

China's overall waste management system includes high levels of formal and informal waste sorting and recycling. Much of the waste is 'high-graded' before it is placed out for collection, both at residences and in commercial and industrial establishments. Estimates vary, but there are likely around 1,300,000[13] people who work in the formal urban waste collection system (paid by local governments or businesses—their main job is the collection and transport of waste, selling recycled materials is only a secondary revenue stream) and another 2,500,000[14] in the informal sector (paid mainly by the sale of collected materials).

Informal waste pickers are usually highly disadvantaged: they are often from the neighboring country-side and have little legal standing in the city; their children often pick waste as well; they are very susceptible to fluctuating market prices for secondary materials; they work in hazardous conditions[15]; and they are often loosely organized, which reduces the effectiveness of introduced assistance programs. Waste picking from collection points is not recommended because it interferes with waste containment and collection systems. Waste picking at landfills is also not recommended because it is dangerous to the individuals and makes proper site management difficult. Landfills should have a small working 'face', and be compacted and covered regularly; all of which is incompatible with waste picking.

In many countries, informal waste picking is seen to be beneficial to an overall waste management program. Waste picking provides employment and up to 20% of the waste stream might be removed (therefore no longer requiring further management). For informal waste pickers to work supportively within a well-managed solid waste system, source segregation is essential and the pickers need to be legitimized and cooperatively involved in the waste collection system. With source segregation practiced by waste generators, the opportunities for adequate income to the waste pickers is enhanced, and worker safety issues are minimized. Government efforts to network the waste picking communities directly with materials end-users (such as industries) and finance equipment that enhances their ability to match end-users buying specifications (such as special sorting, washing, and baling equipment) improves waste picker incomes and upgrades their overall working conditions.

Waste collectors, and street sweepers, are usually the largest single group of employees in cities. Any changes to waste management programs that could impact these employees need to be considered carefully. Occupational health and safety studies from

13. Based on 33 large cities @ 5,000, 188 medium cities @ 3000, 132 small cities @ 2000, and an estimated 30% additional private sector employees. From personal communications with staff in Beijing, Shanghai, Chongqing, and Kunming.

14. Industry estimate. Overview of Solid Waste Services in China. InterChina 2004

15. Waste pickers life expectancy in Mexico is 11 years lower than the national average (53 versus 64). World Bank 1994.

various low-income and high-income countries show that waste collection is a particularly hazardous occupation. Workers are vulnerable to traffic accidents, puncture wounds, chemical burns, back injuries, and respiratory illness from high concentrations of bioaerosols and other particulates. Regular medical examinations and preventative vaccinations are recommended, as well as protective working uniforms that include boots, gloves, covering clothing, visibility vests, and dust masks.

The Role of Recycling

Recycling is an important component of any integrated waste management system. Much of the waste stream can be recycled. For example papers, plastics, glass and metals. Each commodity has a market-based monetary value (see Annex 7). Commodities such as aluminum have a high raw material cost and are readily recyclable (saving considerable energy), and thus have a higher value. Some paper products such as old corrugated cardboard (OCC) are easily recycled and therefore have a higher value than say, mixed paper.

The cost of sorting and transporting recycled materials versus the value of the material as a feedstock in local industrial production determines what is recycled. Also, the feasibility of recycling is affected by avoided disposal charges; e.g., every tonne of waste diverted from landfill may save $10 to $25, or from incineration may save $50 to $150. As waste disposal tipping fees become more established in China, more domestic materials are likely to be recycled.

China's current recycling rates are lower than most other countries, and likely much lower than intuitively believed[16]. The secondary materials market in China is affected by several factors, including: value to the recycler (for example a domestic pulp mill), avoided disposal costs and price paid in the exporting country (this is the main driver for the high levels of imported waste in China), avoided disposal costs and price paid to domestic producers (this impacts domestic waste pickers—this factor is minimized by the relatively low tipping fees in most Chinese cities), cost of domestic and international transportation (it may now be cheaper to transport secondary materials by ship to Chinese port cities than it is to transport domestic materials by truck or rail to the same facilities), and cost of enacting environmental safeguards associated with recycling the material (this is the largest driver for the importation of e-waste in China—environmental costs in the U.S. are prohibitive, while in China minimal environmental safeguards are enacted).

Much of China's current recycling system is being adversely affected by the import of low-cost secondary materials from high-income countries that are exporting these materials to avoid using their limited landfill capacity and paying their higher costs of disposal (largely due to more stringent environmental regulatory requirements). In 2002 the US exported an estimated $1.2 billion in scrap and secondary materials to China – up from $194 million five years earlier.[17] The Hangzhou Jinnjiang Paper Company in Linan, for example, imported up to 90% of its feedstock paper from the U.S. (at a cost of $95 per tonne FOB Newark, N.J. in 2003).[18] Electronic waste provides another example of how China is being affected by global markets for recycled materials (see Annex 12). In the U.S. alone more than 40 million computers became obsolete in 2001; and as much as 80 percent

16. China's waste paper recovery rate is 30% — much lower than other Asian countries, e.g. Korea — 66% and Taiwan 55%. This is linked to the lower level of economic development and because much of the domestic paper is non-wood based which produces an inferior product to imported waste paper. Prospects for the Pulp and Paper Industry in China. Proceedings of a Workshop. Beijing, China, April 1999.

17. Wall Street Journal, 9 April, 2003

18. Ibid

of these were exported, mostly to China, at about a tenth of the price of recycling or disposal in the U.S.[19]

Using recycled feedstock, rather than virgin resources, provides large environmental benefits. In recycling aluminum for example 95% of the energy needs can be reduced. Paper produced from recycled secondary fibers saves energy and reduces overall pollution, especially organic loadings. China's pulp and paper production from raw materials accounts for about 47% of the country's total chemical oxygen demand (COD) discharges.[20]

Paper, due to its large and growing portion of China's waste stream and its relative high recyclability, is the priority commodity for planners of recycling programs to address. If China were to set a modest target of 50% recycling of waste paper by 2030, over 38 million tonnes of waste paper could be diverted from disposal (see Figure 2.1). Another priority is scrap metal recycling. China's scrap metal generation will continue to grow rapidly; especially as larger waste items such as scrap cars are disposed.

Professionalization and institutionalization of the secondary materials industry should be encouraged in China. Waste exchanges would benefit from supportive government policies. Also, codes of practice should be enacted for the recycling industry since the industry can have a significant impact on worker health and the environment.

Composting

Composting should be an important waste management tool in China. Even in 2030 when the waste stream more reflects fully matured economies, China's urban waste stream will contain over 50% biodegradable organic matter (today it is likely closer to 60%). Managing the biodegradable organic fraction of the waste stream is challenging; it is wet (usually in excess of 50% moisture, which makes combustion impractical); it is dense which makes transportation more expensive, it is one of the largest sources of anthropocentric Greenhouse Gas, and it is the fraction of the waste stream that causes nuisances such as odor, landfill leachate, and attracts vectors likes rats and flies.

Experience with large-scale composting is however often poor. Most facilities developed have not performed as well as expected and the compost produced is often of poor quality. This is because most compost facilities in China, and elsewhere, attempt to compost mixed waste that has components that adversely affect compost quality. If mixed waste is shredded before composting, the finished compost quality is degraded by the presence of heavy metals, ash, pieces of plastic and glass shards. See "The Role of Composting in Developing Countries", The World Bank, 2002.

In theory there is an unlimited market for quality compost—the process simply returns organic matter to the soil from where it originally came. However, market demand depends on the price of the finished compost and the cost of transport, as well the price willing to be paid by the end-user. Farmers raising low-revenue crops such as grains, generally cannot afford compost. The market potential exists primarily with farmers that raise higher-revenue crops, such as vegetables, tea, coffee, fruits and flowers. When avoided disposal costs and environmental benefits are factored (such as carbon emission reductions, and reduced erosion and water-course nitrification), the economics of composting become far more attractive.

There is also often a misconception that compost is a fertilizer. Compost has little effect as a fertilizer (when unfortified) and is most valuable as a soil conditioner that improves the overall soil structure resulting in less erosion, better moisture retention, better seed germination, better plant growth (stronger roots and better disease suppression), and the

19. The Washington Post, 24 February, 2003

20. Prospects for the Pulp and Paper Industry in China. Proceedings of a Workshop. Beijing, China, April 1999.

Table 5.1: Proposed Compost Standards

Mg/kg dried matter	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Heavy Metal standard	10	3	50	80	150	1	50	300

World Bank, 1997

need for less synthetic fertilizer. Compost increases the efficiency of fertilizers by reducing runoff and making the fertilizer more available to the plants over a longer period (the compost molecularly binds to the fertilizer and holds it ready for plant use). In addition to horticultural and agricultural uses, compost would be an excellent product for application to eroded lands in China (for example areas near Beijing which have been degraded and cause much of the annual dust storms) as well as to arid lands.

A significant driver for composting could be carbon emission reductions (see Section 6). Composting avoids the formation of methane since the organic fraction aerobically biodegrades and hence no methane is generated. At today's prices for internationally traded emission reductions of $4.50 per tonne of ER (under the Clean Development Mechanism emerging from the Kyoto Protocol) composting would receive an international subsidy of about $12 per tonne. This is about 2.5 times the equivalent amount that would likely accrue from landfill gas recovery.

Large scale composting is assisted through the establishment and enforcement of quality standards. Table 5.1 proposes compost standards for China that would encourage broader market development and are attainable with the use of source segregated organics. The main aspect required through the standards is the level of heavy metals. Other compost characteristics, such as pathogens, maturity, larger contaminants like plastic and glass, salinity and the C:N ratio are generally dictated by the market and the compost process used. The standards proposed in Table 5.1 are for finished compost that would have no restrictions on use (leaving it to the market to find the optimum use). There may be occasions where specific compost of inferior quality might be used for limited applications such as mine tailings rehabilitation and pits and quarries restoration.

Some cities have pursued anaerobic digestion (biodegradation in the absence of oxygen) of the organic fraction of the waste stream. Anaerobic digestion generates methane that can be burned to produce power. More research is needed in this area as the costs are usually higher than composting and generally more sophisticated process controls are required.

Incineration

Incineration is a possible component of an integrated waste management program for large cities where space for landfills may be limited and siting of landfills outside of city jurisdictions may be politically difficult. Much of the waste stream can be significantly reduced in volume by being burned, and often there is sufficient heating value in the waste to produce power from the process. Incineration is often pursued by municipal officials as a key waste disposal option since they are perceived to have less public opposition to landfilling and they involve one-time large capital allocations that may be easier to budget and acquire. However incineration is usually constrained by three key aspects; very high cost, potentially toxic emissions, and an incinerator's ability to act as a disincentive to other more economically and environmentally sound waste disposal options.

Shanghai provides an illustrative example for Chinese cities. At least 3% of Shanghai's GDP is now spent on solid waste management, and this share is growing quickly. Shanghai's total waste management costs will likely be most influenced by the amount of incineration used (collection costs are the largest fraction of waste management costs but they are not largely impacted by waste disposal type). As a "ball park" estimate, if

Shanghai pursues an incinerator intensive waste management program, overall waste management costs would at least double (international averages are about US$ 30 per tonne for landfilling and US$ 150 per tonne for incineration). Shanghai, which has the most 'internationally standard' waste stream (i.e. higher fraction of plastics and papers and less moisture) in China still has a waste composition that is barely autogenic (a high enough heating value to burn on its own). Most Chinese cities would have to use supplemental fuel in order to burn their solid waste, and thus there would be no net energy generation to offset the high costs of incineration.

Incinerators generate three types of emissions; stack emissions, bottom-ash, and fly-ash. Fly-ash, which is about 5% of the total, is hazardous and requires special (and usually expensive) treatment. Bottom-ash, which is about 50% to 70% of the in-feed mass (but only about 15% of the in-feed volume), requires safe transportation and disposal (usually to a sanitary landfill or less-optimally for uses such as road bases or building materials). The emission category of most concern is usually the associated stack emissions.

By the nature of burning garbage, stack emissions are generated. The first and most important method of emission control is to operate only internationally standard high temperature incinerators that have a secondary high temperature afterburner (e.g. newer facilities in the EU and Japan). Remaining emissions are then reduced through pollution control equipment at the back-end of the incinerator, e.g., particulate baghouse filtration, flue gas cleaning, and activated carbon filtration. Incinerator pollution control equipment is extremely expensive and relatively difficult to operate. Many high-income countries are curtailing the expansion of incineration due to public health problems associated with their emissions (see Box 5.2). Of most concern are dioxins, furans and mercury.

In addition to dioxins, mercury will likely be a significant concern for China's waste planners. China's heavy reliance on coal for electrical power generation is already having global implications; as much as 50% of the mercury falling on North American lakes is from Chinese power plants[21]. China will likely be encouraged to adopt a mercury-reduction program. Waste incinerators are one of the largest sources of air-borne mercury.

Another argument against incineration is that they are a disincentive to waste minimization. This is however difficult to quantify for a single city, even one the size of Shanghai. Incinerators are capital intensive and are designed for 20 to 30 year lifespans. If operated by a private contractor, they typically have a "take-or-pay" agreement of

Box 5.2 Dioxins in Japan

Since 1983 the Government of Japan has undertaken an aggressive dioxin reduction program. Considerable public concern arose over ambient dioxin levels, especially since 1997. Dioxins were associated with various health issues, such as cancer and birth defects.

The Government of Japan introduced an eight point dioxin reduction plan which particularly focuses on waste incineration since incineration contributes about 88% of Japan's total dioxin loading. The government imposed new emission standards in 2002 consistent with those of the European Union, i.e. all new incinerators over 4 tonne/hour capacity must not exceed 0.1 ng-TEQ/m^{3}N. This is significantly more stringent than China's current guidelines.

Source: Office of dioxins Control, Ministry of the Environment, Japan

21. Wall Street Journal, Page 1. 17 December, 2004.

guaranteed minimum waste delivery from the city. Therefore once built they discourage waste reduction or recycling. In fact they compete with recycling markets for combustibles such as paper, cardboard, textile and wood.

Despite their inherent limitations incinerators may have an important role in large Chinese cities. Annex 9 provides a checklist to follow in the development of incinerators. Key aspects include: i) meeting internationally recognized standards for air pollution, especially dioxin, ii) 'high-grading' the in-feed waste stream (e.g. providing more a 'refuse derived fuel, RDF' rather than mixed waste—RDF would include multi-laminate packaging, which is difficult to recycle, plastics with low recycling potential, low grade papers, non-recyclable wood, possibly rubber), iii) providing effective waste diversion programs (keeping out items that disproportionately contribute to emissions such as PVC plastic, batteries and fluorescent light bulbs), iv) operating the incinerator within a pricing regime that reflects all costs and encourages optimum waste disposal practices.

The government of China has issued a series of favorable policies to encourage investment in incinerators. These incentives include VAT refunding, prioritized commercial bank loans, state subsidy (2%) for loan interest, and guaranteed subsidized price for purchase of electricity. These policies are expensive and may encourage municipalities to develop more incineration capacity than is warranted. It is recommended that all incineration subsidies and incentive policies be reconsidered.

Landfilling

China's 660 cities now have about 1,000 major landfills. All integrated waste management programs need a well-sited and well-operated landfill(s). Landfilling is: i) cost effective, ii) robust in that it can accommodate large fluctuations in amount and type of waste, iii) when well operated and sited has minimal environmental impact and nuisance potential, iv) is relatively modest in land requirements (China's total land required for landfilling over the next 30 years, without incineration, is about 100,000 Ha).

Landfills in China are often not well operated.[22] The main shortcomings are: i) the presence of waste pickers, ii) inadequate slopes, iii) over design and premature construction of subsequent phases (synthetic liners are exposed to the elements and huge additional volumes of leachate are generated), iv) inadequate collection and treatment of leachate, v) insufficient compaction and waste covering, and vi) little, if any, landfill gas collection. These shortcomings are however being quickly remedied and significant improvements are already apparent. Guangzhou and Ningbo, for example operate good sanitary landfills, and Shanghai is working to quickly improve conditions at Laogong Landfill.

Over the next ten years all cities in China over, say 1,000,000 people, are expected to be operating sanitary landfills. Annex 16 provides a definition for sanitary landfilling and proposes minimum operating standards for newly commissioned landfills in China. This is critical for at least two important reasons. First, if current landfills are not well operated, getting public support for new landfills will become increasingly difficult. Second, the environmental impact of poorly operated landfills is significant and the costs to ameliorate these sites later is always much higher than what it would have cost to operate them properly in the first place. Cities like Chongqing are already facing the high costs associated with cleaning up old dumpsites.

Over the next five years (at least) proper landfill operations in China are likely to be enhanced through the provision of funds for the sale of carbon emissions reductions. Methane from poorly operated landfills and uncollected MSW is the world's largest source of anthropogenic Greenhouse Gases.

Many municipal decision makers have a disproportionately negative view of landfilling, often seeing it as a waste of scarce land. Much of this is brought about by the poor

22. A review of landfill practices in China—Back to office report, February 2004.

history of facility siting and operation, and the lack of productive post closure use of landfill sites. When developing new landfill sites, planners should already be anticipating its post closure use. Closed landfills can make excellent green spaces and golf courses when adequately integrated with neighboring land uses.

Waste Dumps

Few of China's waste disposal sites are "sanitary landfills" (see Annex 16 for a definition). Efforts are underway to improve the conditions of landfills in some cities, e.g. Shanghai, Guangzhou, Ningbo, but mainly Chinese cities are now operating dumps (dumping areas with little or no control on the waste's impact on human health and the environment). In addition to the immediate problems of public health and nuisances, dumps present a long term liability for cities. The legacy of waste dumps is a serious issue in most urban areas. Cities in the U.S. and Europe have had hundreds of old dump sites that needed to be ameliorated and costs were enormous. Most of these "brownfield sites" were addressed due to their impact on groundwater.

China's groundwater, which in future will be relatively more valuable than that of European and American cities due to population densities and relative scarcity of water, needs greater protection. Over the next 50 years China is likely facing an enormous brownfield site clean-up cost. A city like Chongqing has about 50 dumpsites, at least 5 of which need to be urgently cleaned up. Shanghai has a similar environmental legacy. Of the 660 cities in China over 1,000,000 population, there are probably at least 5,000 brownfield sites needing cleanup. Budgeting adequate funds to do this will be extremely challenging.[23]

Global experience argues strongly that China's current and new dumpsites need to be operated in a manner that protects groundwater resources. In almost all cases of brownfield site redevelopment, the costs of amelioration are higher than the amortized costs of not creating the pollution in the first place – especially for landfills which are relatively inexpensive to operate properly once they have been constructed.

"Special" Waste

Many items in the waste stream require development of specialized handling and treatment programs. Medical waste and hazardous waste are examples of areas that require specific local and national planning, and provision of dedicated facilities and collection programs. These programs often require considerable management capacity and incur high costs to waste generators and municipalities. Municipalities need training on systems for special waste management and a scheduled requirement for addressing this issue as part of their municipal solid waste system.

Hazardous waste and medical waste programs require unique planning (see Annex 11 for a summary) and full integration with local MSW programs. Some synergies can be gained by sharing facilities and staff expertise. In most cases these services are best provided when facilities are shared across jurisdictions and performance contracts with the private sector (or government owned utilities) are developed for service provision. In all cases there is considerable need in waste generator training and assistance. For example medical waste management requires significant work within the medical facilities in areas such as waste segregation and containerization, and hazardous waste generators need to identify, label, and properly manifest (for safer transportation) their wastes.

23. The City of Toronto provides a useful example. The city's waterfront is contaminated with waste residues (mainly from previous industrial processes) and despite the considerable potential land value, the costs to clean up the site are higher than the increases in land values, and hence much of the waterfront remains derelict.

Other wastes that may require special programs include household appliances[24] and demolition waste. Demolition waste, which is the largest fraction of the waste stream in Hong Kong, is usually used as fill material in low-lying areas, but as these options are limited due to concerns with ground water pollution arising from demolition waste, municipalities will increasingly need to accommodate these wastes at landfills.

Sludge Disposal

Disposal of organic sludge from wastewater treatment facilities, industrial operations and dredging is an issue of rapidly growing urgency in China, particularly in larger cities along the coast. China's high population density and intensive livestock farming make use of sludge drying beds and land disposal problematic (the land's absorptive capacity is used up by manure). Deep sea disposal is also problematic. Composting or anaerobic digestion of partially dewatered sludge is possible but is expensive and is limited to only highly putrescible organic sludge. Sludge incineration (after dewatering) is also very expensive. Landfilling of dewatered sludge is problematic as sludge increases leachate quantities and presents materials handling difficulties at the tipping face. Landfills therefore typically limit receipt of dewatered sludge to under 10% of total incoming solid waste.

Annex 10 illustrates the wide range of sludge disposal options in OECD countries, and the use of landfilling. China's options at sludge disposal are limited, and sludge volumes are growing rapidly. This report does not present a review of sludge management options but suggests that a national and regionally-specific sludge management plan be prepared for all coastal provinces (as a start, all communities will likely require sludge management programs over the next twenty years).

The Need for Waste Segregation

In order to develop cost-effective and environmentally sound waste management options waste segregation is needed. The type and amount of segregation will vary, but composting and incineration cannot be optimized without source segregation of incompatible hazardous wastes, and recycling revenues are optimized only if recyclable secondary materials remain clean through source segregation. The amount of waste requiring landfill would likely double without up-front waste diversion programs.

Waste segregation usually involves asking waste generators to place their waste out for collection in either two or three streams (see Table 5.2). Most OECD cities now have some form of waste segregation. Much of this segregation is already happening in China through the efforts of waste pickers, however as waste volumes continue to increase and disposal costs continue to consume a larger fraction of municipal budgets, increased and more formal waste segregation will be required.

Changes to Waste Collection Practices

Residential waste collection in Chinese cities is undergoing rapid change. Already, many cities have had to retrofit neighborhood transfer stations[25] to enable both horizontal and

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24. Households in China are still mainly acquiring their first set of household appliances, however over the next several years households will be upgrading appliances—which is already taking place with computers and other electronics goods. These items will add considerably to the municipal waste stream.

25. "Neighborhood transfer stations" are defined as those facilities that are typical in Chinese cities and serve some 500 households and small scale ICI establishments (about a 1 kilometer radius). Most of the waste is delivered by handcarts—about 25 waste collectors delivering waste to each facility.

Table 5.2: Two Stream vs. Three Stream Waste Segregation

Two Stream		Three Stream		
Organics (or "wet")	**Non-organics** (or "dry")	**Organics**(compostables)	Recyclables	Waste
Organics, e.g. food waste, horticultural contaminated dry waste e.g. soiled packaging, disposable diapers	Recyclables, e.g. paper and metal non-recyclable dry waste e.g. packaging, consumer products such as electronics	–organic waste for composting –possibly bags as waste container	Paper metals some plastics	–Soiled packaging –ash dry waste e.g. electronics
Pros- -Cheaper to collect -usually maximizes waste diversion		Pros -easier composting and recycling programs (less up-front screening required) -may be able to take 'Waste' fraction directly to disposal facility		
Cons- No distinction made in waste generators mind of what is recyclable or compostable versus what is waste Recyclables and compost may be more contaminated		Cons- -requires more training and participation of the public -higher collection costs -compostable organics and recyclables may be placed in the 'waste' stream		

vertical waste compaction (illustrating the increase in packaging materials, plastics and paper). As waste volumes continue to increase, these facilities will likely become inadequate. Many of these facilities are located in prime commercial locations and space for expansion is not available. Strategic planning of new transfer sites is important to the future cost-optimization of city solid waste systems.

Larger "central transfer stations"[26] will become increasingly important in China. Most cities over 1,000,000 will need to build these facilities over the next 5 to 10 years as they respond to growing waste volumes. Land use plans will need to accommodate these requirements.

Chinese cities, with their high population densities and relatively large sizes, require customized and highly efficient residential and especially ICI waste collection programs. Residential waste collection is now sporadic in many cities. Some areas are getting waste collection up to three times per day, while other areas receive no regular waste collection. People will likely need to accept changes in their waste collection practices; some examples could include twice per week collection, placing organic-recyclable-waste out for collection in separate containers. ICI waste generators will likely need to develop better storage of waste on-site (again in separate containers) and pay collection and tipping fees based on waste volumes.

The most important change to waste collection in China will be increased waste segregation. Although waste segregation entails slightly higher collection costs and requires compliance from waste generators, it is a critical component of an integrated waste management strategy since it is a prerequisite for new and innovative waste management

26. "Central transfer stations" are defined as facilities that receive the majority of waste via collection vehicles and then compact and consolidate the waste for delivery to disposal sites—usually by road, but also by rail, and by ship (e.g. Shanghai). Large cities may have as many as 10 transfer stations (on average each facility can accommodates some 1,000 tonnes per day).

programs. Waste segregation significantly increases waste diversion potential (non-contaminated dry waste is more easily recycled), increases quality of produced compost and recyclables, and optimizes incineration.

Waste segregation also increases awareness of waste management issues and is usually accompanied with reductions in waste generation (or reductions in the rate of growth). Waste segregation is also important to enable better financing of waste management activities. By segregating the waste stream and optimizing collection and disposal options costs can be better allocated and financing more easily obtained, e.g. more likely to have guaranteed revenue streams.

Box 5.3 Critical Aspects of an Integrated Waste Management Program

- Follows the hierarchy of waste management
- Has considerable at source waste segregation
- Is based on an up-to-date, publicly available waste management master plan
- Includes a sanitary landfill
- Optimizes the role of recycling, composting and incineration based on local conditions

Operates within a framework of i) cost recovery (fees based on waste amounts), ii) laws and regulations (e.g. illegal waste disposal is discouraged), iii) application of market based instruments, and iv) wide-scale public acceptance (e.g. residents prepare their waste for collection as prescribed).

Section 6 - Carbon Financing for Municipal Solid Waste in China

As a Greenhouse Gas, methane has 21 times more global warming potential than the equivalent amount of CO2. The biodegradation of organic matter, in the absence of oxygen, generates methane as a by-product. Municipal solid waste, which is rich in organic matter, when deposited in landfills, degrades to produce significant amounts of landfill gas (LFG). LFG is usually about fifty percent methane[27]. Methane from MSW is one of the world's largest contributors of Greenhouse Gases. To reduce Greenhouse Gases LFG can be flared or combusted as fuel. The methane fraction of LFG can be used to generate electricity, converted to vehicle fuel, or burned in industrial boilers, as already piloted in China.

Rather than allowing methane to escape to the atmosphere, LFG can be collected and the methane converted to CO2 through combustion (providing a 20-fold reduction in overall Greenhouse Gas potential). Composting and digesting (biodegradation in the absence of oxygen or biomethanation) the organic fraction of the waste stream reduces the amount of possible methane generation at landfills, and therefore also reduces potential Greenhouse Gas emissions (even more efficiently than recovery of LFG). The potential Greenhouse Gas emission reductions produced through these types of MSW management changes are high. Projects that modify waste management programs to mitigate Greenhouse Gas emissions could qualify for additional funding through the Clean Development Mechanism.

The Clean Development Mechanism is an arrangement established under the Kyoto Protocol to assist countries to meet their obligations to reduce atmospheric emissions that contribute to global climate change. It enables industrialized countries to finance reductions in Greenhouse Gas emissions in developing countries. The mechanism enables carbon emissions reduction to be based on estimated emission reductions from new facilities, as well as actual emissions reductions for upgraded older facilities. Effectively, an entity (such as the Prototype Carbon Fund or independent private sector purchasers) buys non-emitted carbon dioxide (tCO2e)[28] from a project that avoids or reduces carbon emissions through its operation; such transactions are often referred to as "carbon financing".

Under the Clean Development Mechanism[29], a project that collects and combusts methane from a municipal solid waste landfill (landfill gas), composts, or anaerobically digests waste could receive payments from interested buyers for the value of the methane that is captured and combusted (instead of being emitted to the atmosphere)[30], or not

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27. A Greenhouse Gas absorbs and radiates heat in the lower atmosphere that otherwise would be lost in space. Greenhouse Gases and clouds prevent some infrared radiation from escaping, thus trapping more heat near the Earth's surface where it warms the lower atmosphere. Alteration of this natural barrier of atmospheric gases can raise or lower the mean global temperature of the Earth. The main Greenhouse Gases are carbon dioxide (CO2), methane (CH4), chlorofluorocarbons (CFCs) and nitrous oxides (N20).

28. tCO2e: Tons of CO2 equivalent (1000 kg); the unit of carbon emissions reductions trading refers to one less (not emitted) ton of CO2.

29. The Clean Development Mechanism refers to projects in which the emission reductions are generated in 'Part 2' countries and sold to entities in 'Part 1' countries. The "Joint Implementation" program, also under the UNCCF enables carbon emissions trading among Part 1 entities. See (website)

30. Several examples already exist in Brazil, South Africa, Bolivia and Argentina, see CDM website for project details.

produced. In addition, when this methane is used to generate power such as electricity, vehicle or boiler fuel, more emission reductions can accrue from the avoided emissions of the alternative energy (less use of coal plants, for instance). For new large landfills, say over 1,000 tonnes per day, it is usually economically viable (as well as environmentally preferred) to produce power from the LFG. Old landfills sometimes, but rarely, have sufficient lining and encapsulation as part of their design to enable recovery of the methane gas in concentrations that would enable self-sustaining combustion of the gas, however they should still install passive venting and LFG flaring facilities.

The capture and combustion of LFG is likely the largest potential source of emission reductions from China's MSW programs, however other large potential sources include composting (ERs accrue when composting the organic fraction of the waste since no methane is generated under composting's aerobic biodegradation process), anaerobic digestion (the organic fraction of the waste is digested in an enclosed tank and all methane is collected and combusted to produce energy), and to a lesser extent vermicomposting (composting with worms). Also, in the future waste management authorities will likely seek emission reduction credits from recycling MSW (for example producing aluminum beverage containers from recycled feed stock reduces energy requirements by 95% - significant reductions in Greenhouse Gases would therefore accrue. This would be similar with other metals and paper[31].)

The potential for MSW projects in China is significant. For example, the recent ERM report prepared as part of this study estimated that Shanghai alone, with 10% organic waste diversion through composting, and the remaining 90% landfilled, would yield about 7,000,000 t/yr CO2e. Also, based on conservative estimates from other landfill gas projects, about 370,000 MWh/year of power could be generated.[32]

Assuming that Shanghai represents about 3.5% of China's total urban output, China's overall carbon finance potential is about 200,000,000 t/yr CO2e. At current, conservative prices of $4.50 t/CO2e, as much as $900,000,000 per year of ERs could be sold from China's municipal solid waste programs. In addition to the potential $900,000,000 in ERs, China's municipalities could also anticipate the potential energy production of about 10,500,000 MWh/yr (at 320 RMB/MWh this would provide an additional RMB 3.4 Billion) from LFG combustion.

The $900,000,000 estimate represents an upper limit, as global responses to this much potential carbon finance would likely change the overall carbon finance structure. There currently are not markets for this many ERs.

Municipalities could apply a range of technologies to raise carbon financing for projects that use solid waste. Table 6.1 summarizes indicative values for various approaches of waste management and their potential savings in Greenhouse Gas emissions. It should be emphasized that source segregation of waste presents an opportunity for significantly higher carbon emissions benefits.

Carbon Finance Project Cycle

The project cycle for carbon financing requires independent audits and validation of actual carbon reductions over the project's lifetime. The following figure presents typical steps for a Clean Development Mechanism project. This figure illustrates that the process requires development of in-country capacity to administer functions such as validation and certification. Because of the monitoring and resulting emission-based revenues

31. Recycling 1 tonne of paper saves 1,440 liters of oil (energy equivalent), Canadian Geographic, 2003.

32. Based on potential CH4 production of 253,000,000 m3 with 50% available for power conversion at 30% efficiency and 5% used on-site.

Table 6.1: Estimated Savings in Greenhouse Gases emissions for various waste management technologies (compared with landfilling with no gas recovery)

Waste Management Option	Baseline Greenhouse Gas emissions (tCO2e/ t of waste)	Greenhouse Gas emissions (tCO2e/ t of waste)	Potential Saving in Greenhouse Gas emissions (tCO2e/ t of waste)
Landfill with Landfill Gas flaring	2.46	0.74	1.72
Landfill with Landfill Gas utilization	2.46	0.68	1.78
Anaerobic Digestion	3.54	-0.055	3.6
Composting and Vermicomposting	3.54	0	3.54

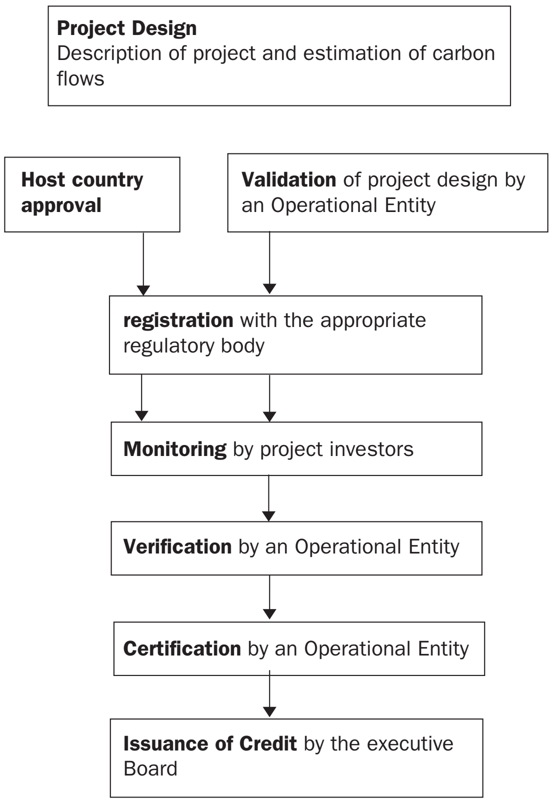
Notes: Anaerobic digestion and composting assume segregation of waste; avoided tCO2 quoted per tonne of the organic rich source-separated waste

involved, carbon financing provides an ongoing incentive for local governments to operate their waste treatment and landfill facilities well.

Given the opportunity to extract considerable fungible value from waste, Chinese municipalities are already developing carbon finance projects within the MSW sector. The first priority is to raise awareness about carbon financing and encourage waste management programs that promote at-source waste segregation as this maximizes the potential for ER production. In order to better facilitate project financing arrangements and access to carbon financing, cooperation at the regional and central government levels is needed. Relevant baselines, on which emissions reductions can be easily assessed, are also required (draft baselines now exist for Chongqing and Shanghai, plus there are many international examples). A streamlined approval process for project approvals under the Clean Development Mechanism at the central government level is evolving. This is also important for continued project development.

China would benefit through international technology transfer since LFG recovery and composting programs are management intensive and benefit from the involvement of experienced practitioners. China is now developing domestic experience with carbon finance projects. This is very important, especially since much of the carbon financing is 'time-bound' (some current buyers prefer early delivery of ERs). China's early response to carbon finance in MSW projects could result in significant benefits for the country.

Figure 6.1: The Global Development Mechanism Project Cycle



Project Design At the design phase a project developer defines the project boundaries and lifetime, establishes its CDM eligibility, estimates baseline emissions, total project emissions and emission reductions expected over the project lifetime.
Validation Confirmation that the project is in conformance with the Kyoto Protocol modalities and rules, with the rules under a specific scheme, and with the host country ruled.
registration Register the project with the CDM executive Board.
Monitoring Ongoing 9annual) estimates of actual emissions from the project.
Verification Independent verification that emission reductions or enhanced sequestration is additional to baseline.
Certification Written assurance of the emission reductions or enhanced sequestration.
Issuance of Credit The CDM Executive Board issues Certified emissions reductions (CERs).

Source: ERM

Section 7 - Waste Management Finance

Chinese urban governments now spend annually about 12.6 Billion RMB on waste management service provision (excluding capital costs—service provided for non-hazardous MSW in 2002—See Table 7.1). Additional capital costs are at least another 15 Billion RMB (see Table 7.1—the solid waste fraction of the total investment in environmental pollution control in China estimated to be 15%). These costs are expected to quadruple by 2010 and then to double again by 2020 (see Table 7.1). This increased cost is expected to be driven by population growth, cost increases in service provision, and an increase in the fraction of waste treated. Cities under 1,000,000 will be most impacted by growing waste management costs since waste volumes will increase considerably while potential revenue sources to pay for these additional services will likely not increase at the same rate. Their rate of budgetary growth could be as much as 20 times more than larger cities. Table 7.1 provides only a broad estimate of MSW management costs since accurate data is unavailable, however, the table illustrates the potential magnitude of budgetary increases that are possible.

Solid waste programs in Chinese cities will require at least 230 Billion RMB annually by 2020. Where these funds come from will be a large challenge for all levels of government. Increasing the professionalization and efficiency of this service provision is critical. Also, development of institutional arrangements that enable complete cost accounting would foster greater cost-consciousness and resulting efforts to economize. The public needs to be surveyed regularly to monitor their view of the services being provided and their willingness and ability to pay for such services and anticipated changes.

Like waste characterization data, detailed MSW budget information is not usually available for Chinese cities. National compiled and estimated data is often provided in various government publications, however as outlined in the InterChina Consulting report, 2004 and AMEC Earth and Environmental review, 2004, the data is difficult to verify. Specific detailed field visits to Shanghai, Chongqing, and Kunming, plus background project preparation data, suggest that current government data—financial and waste quantities—are seriously underestimated. More analysis and accurate compilation of MSW data is needed.

Reviewing the financing aspects of solid waste management in China is further complicated because operating costs (collection and disposal facilities) and capital costs (mainly for disposal facilities such as landfills and incinerators) are not always funded by the same government level. Increasingly national government funding for capital requirements is shifting to cities, especially the larger ones such as Beijing and Shanghai. These large cities have a large industrial and commercial base to support revenue generation for public services. Also, these larger cities are more able to attract private sector investment in new waste treatment facilities. Far more attention needs to be given to financing methods for solid waste, particularly for smaller cities, since this is now one of the fastest growing budget items for local governments. The growing MSW budgets are further complicated by rapidly growing costs to manage special wastes, such as hazardous waste, medical waste, and wastewater treatment sludge. Local governments will likely increasingly call upon provincial and national government to provide financial assistance to deal with these problematic wastes.

Solid Waste Costs in Shanghai, Chongqing and Kunming

As part of this study three cities were visited to review waste management expenditures and sources of funding. Table 7.2 provides the summary of costs, and sources of revenues for the three cities. Costs are roughly equally divided between; i) salaries and wages, ii) materials, fuel and electricity, and iii) equipmen—vehicles and others. Government estimates on expenditures are about 75% for collection of household waste and 25% for the

Table 7.1: Estimated total operating expenditures in residential solid waste disposal in Chinese cities, in 2002, 2010, and 2020

City Type	NO. of Cities	2002 Urban Population (Million)	Expenditure 2002 (million RMB)	Expenditure 2010 (millio RMB)	Expenditure 2020 (million RMB)
Tier 1	4	33	2,400	4,305	5,446
Tier 2	167	188 (estimate)	7,520	20,530	36, 831
Tier 3	489	132 (estimate)	2,640	25,344	64,576
Total	660	353	12,560	50,179	106,853

Source: InterChina, 2004
Note: Capital expenditures are not included and for the twenty years are estimated to be roughly the same as operating costs. These are broad projections only, and estimates, especially for Tier 3 cities, will likely vary considerably.

commercial/institutional sector (this suggests that much of the ICI waste stream is not being serviced by municipal crews). Revenues from cost recovery mechanisms cover about 50% of recurrent costs and 35% of total costs. Disposal fees (also called tipping fees), which account for about a third of revenues, are mainly (about 80%) paid by the ICI sector. The remaining revenues are derived from direct and indirect subsidies and general budget allocations.

Increasing the Role of the Private Sector

China's national and local governments have encouraged investment in solid waste management from the local private sector and foreign companies. Chinese authorities intend to promote commercial operations within the MSW sector in order to augment current government funding. The local conditions for commercial investment in the sector are, however, not yet mature (see Annex 14). Changes to local conditions to encourage more commercialization of the MSW sector need to include: fee collection systems, competitive and transparent procurement procedures for solid waste contractors, enforceable contracts with clear performance measures, licensing programs for various types of solid waste operators (including general waste collectors, medical waste collection and disposal companies, hazardous waste collection and disposal companies, and construction/demolition debris haulers).

Introduction of commercial operations must be done carefully. As the industry grows, it will become powerful and will fight to protect the high grade portions of an integrated waste system, while leaving the rest to the municipalities. If proposed innovations affect industry profitability they will oppose it.

As part of the Asian Development Bank's review of the sector (TA 3447–PRC) a supplementary report, 'Developing Public-Private Partnerships in Solid Waste Management', December 2003, was prepared. Also as part of this study a consultant was retained to prepare an overview of current private sector involvement in the Chinese waste management sector. Both of these reports are summarized in Annex 14.

The most important aspect for improved financing of the sector, including increased private sector involvement, is to develop clear and accurate government cost estimates for provision of solid waste service. Currently there is no certainty as to what the provision of solid waste services costs. Therefore local governments are not able to assess if the private sector could provide the service more efficiently. Similarly if local governments do not know how much the service costs or whether future capital funds will continue to be financed by China's national government, effective long term planning can not take place.

Table 7.2: Estimated financing for urban residential solid waste disposal in Shanghai, Chongqing, and Kunming in 2002 (million RMD)

Shanghai	
Total cost: 850 • Salaries and wages: 221.00 • Material/fuel/electricity: 315.00 • Equipment/ vehicle: 212.00 • Others: 102.00	Total expenditure financed: 850 • Disposal service fee: 329.00 • In which: • From private households 0% • From institutions 100% • Municipal government budget: 196.00 • District government budget: 325.00 Government expenditure breakdown: • for private household sector 680.00 • for institution sector 170.00
Chongqing	
Total costs: 244 • Salaries and wages: 85.00 • Material/ fuel/ electricity: 73.00 • Equipment/ vehicle 61.00 • Others: 25.00	Total expenditure financed: 244 • Disposal service fee: 73.00 • In which: • From Private households 30% • From Institutions 70% • Municipal government budget: 50.00 • District government budget: 121.00
Kunming	
Total costs: 100 • Salaries and wages: 27.00 • Material/fuel/electricity: 37.00 • Equipment/ vehicle: 26.00 • Others: 10.00	Total expenditure financed: 100 • Disposal service fee: 36.00 • In which: • From private households 30% • Municipal government budget: 24.00 • From institutions 70% • District government budget: 40.00 Government expenditure breakdown: • for private household sector 80.00 • for institution sector 20.00

Source: InterChina 2004

Suggested additional institutional reforms to promote 'marketization' and greater private sector participation in the sector include:

- Strengthening the supervisory role of government. Government needs to better oversee and manage contractors, concessionaires, and licensees providing MSW services.
- Creating sustained revenue sources. User fees and tax revenues (and explicit subsidies) need to increase to a sustainable level that covers all waste management costs.
- Protecting Public Interest. The public should be informed and involved in the decision making and monitoring process – especially as user charges are expected to increase. They should be regularly surveyed regarding their views on service delivery and cost.
- Adapting to local conditions. All contracts need to reflect the unique characteristics of participating localities. Each PPP needs to be tailored to local conditions and local

governments need to have the capacity to assess how requirements differ from one city to another.

- Regulated and transparent implementation. More clarity is needed in the tendering process; justification for government action needs to be provided as a regular component to PPPs.
- Capacity building. Develop a better understanding of the role of the private sector—in municipal staff, the private sector, and the public—through courses, advertising, and development of model contracts (and pilot application). A PPP support unit could also be established nationally to provide independent expert advice to municipalities.

Table 7.3: Expected Sources of Solid Waste Management Funding

	2002	2010	2020	Remarks
Total	100%	100%	100%	
Disposal fee	30-40%	70-80%	90-95%	Will depend on successful involvement of the enterprises and the successful implementation of the fee collection system
Private Households	10-20%	60-70%	80-85%	Collection is difficult and costly and fee levels are set too low. Will change over time.
Institutions	20-25%	10-20%	10-15%	Room for improvement (collection, fee levels)
Municipal government	20-25%	5-10%	0%	
District Government	40-50%	10-20%	5-10%	The governments still need to subsidize the poverty households

Source: InterChina

Table 7.4: Financial Data for Municipal Solid Waste, 2002; Shanghai, Chongqing, Kunming

	Shanghai	Chongqing	Kunming
Type of City	Municipality directly under the Central Government	Municipality directly under the Central Government	Capital city of Yunnan Province
Population	16.25 million	31.14 million	4.95 million
Total municipal solid waste generation in 2002	21.46 million tons (of which residential wastes is about 50%)	16.38 million tons	8.65 million tons
Total industrial hazardous solid waste generation in 2002	0.48 million tons	0.42 million tons	5,034 tons
Total medical waste generation in 2002	20,000 tons	1,700 tons (urban districts)	1,400 tons (urban districts)
Government expenditure on residential solid waste disposal			
Total government expenditures	RMB 850 million	RMB 244 million (estimated)	RMB 100 million (estimated)
Financial sources: Municipal government District/county government Service fee collection	 RMB 196 million RMB 325 million RMB 329 million	 RMB 50 million RMB 121 million RMB 73 million	 RMB 24 million RMB 40 million RMB 36 million
Treatment	Government has started to exit operational activities, becoming a purchaser of services provided by several commercial waste treatment companies, several foreign-invested and Taiwanese companies in operation already	Treatment facilities are largely operated by municipal authorities or SOEs. Some collective-owned companies have started entering through BOT arrangements	Treatment facilities are largely operated by municipal authorities; One medical waste treatment center which conducts waste collection, transport, and incineration
Fee collection Residential waste disposal fees	For collection from residents has not begun yet; but 2 communities in Minhang District have begun pilot programs to start charging fees of RMB 2.5 per household per month and RMB 30/ton for institutions	RMB 3~5 / household/month RMB 48/ ton for institutions (at Changshengqiao Lanfill)	RMB 5/ household/ month RMB 70/ ton for commercial enterprises RMB 60 /ton for non-profit organizations RMB 2/ 10 m2 / month for street side shops RMB 35/ ton for wastes transport directly to landfill by institutional waste generators
Fee for Medical waste disposal	Service fee has not been collected yet; the fee will possibly be set at RMB3/ bed/ day	RMB 1.82 per kilogram	RMB 0.20 / bed / day (the authorities are going to raise the fee to RMB3/ bed/ day)
Fee for industrial hazardous waste disposal To be charged at around RMB 1,800 /ton (average?) when the treatment center becomes operational in 2004		RMB 1,000 / ton in average (will be raised to RMB 2,000)	N.A.
Industrial waste discharge fee	RMB 115,845,000	Around RMB 100,000,000	RMB 21,466,000
Fines on industrial pollution	RMB 720,000	N.A.	RMB 605,800

Source: InterChina

Section 8 – Recommendations

1. Integrated Waste Management

All Chinese cities should aggressively pursue an integrated waste management strategy that involves all key stakeholders in strategic planning and decision-making, and holistically examines the pros and cons of all practical waste management techniques. Integrated waste management requires adoption of the hierarchy of waste management, heavy reliance on landfilling, aggressive waste minimization and diversion, and built in flexibility and redundancy.

Waste pickers need to be better integrated into waste management programs. By 2010 all large landfills in China should be free of waste pickers (at the tipping face). Overall, waste pickers contribute to China's waste management system; secondary materials are diverted and some 2,500,000 jobs are created. Nevertheless, a more integrated approach is needed and operating standards need to be defined for waste pickers (both in terms of working procedures, occupational health and safety requirements, and types of materials diverted at various points without interfering with collection and disposal operations).

China's recycling sector has not yet developed to match market economy opportunities. Professionalization and institutionalization of the secondary materials industry is needed. The industry will likely grow ten-fold over the next 25 years. Attention is needed in the areas of pricing, competition among domestic and imported materials, environmental impacts from the recycling process (e.g. e-waste and paper recycling), competition from incineration, and public encouragement to buy products with a higher content of recycled material.

Composting will likely take on a larger role in China. This may be driven by the value of carbon emission reductions, the fact that for the foreseeable future over 50% of the waste stream is organic, and the potential markets for finished compost (compost is effective at reducing soil erosion and degradation and helps soils retain moisture – especially important in China, where soils are highly degraded and relatively close to major cities). Clear compost quality guidelines need to be set and monitored, and specific large-scale compost use programs developed e.g. mine tailings rehabilitation and treatment of degraded soils.

Incineration will continue to play a role in waste disposal in China. However, only upper-income cities that have waste that can self-sustain combustion and generate net energy should consider incineration, and only then in very limited applications. All future incinerators in China should follow a standard review process, e.g. as outlined in the checklist provided in this report. New incinerators should meet Japanese – EU emissions standards for dioxin and mercury, and all new incinerators should include an analysis of how they will, or will not, impact the development of local recycling programs (especially for paper). The financing and purchasing of incinerators needs to be more transparent and the high subsidy paid for the purchase of electricity needs to be reconsidered (this may not be sustainable and without it the viability of some incinerators may not be warranted). Incineration is at least 3 to 4 time more expensive than landfilling in China.

The waste management component most in need of attention in Chinese cities today is landfilling. Development and operation of landfills in China is sporadic – some very good and very bad examples exist in the country (and on average both types cost about the same). The most important improvements needed are: ensuring that all finished slopes are at least 3:1 (This encourages better storm water run-off and less leachate. The current practice of finishing landfills with a flat top generates at least 10 times more leachate); construction in cells (synthetic liners should not be exposed to the elements for more than 1 year); waste compaction and daily covering; and better collection of landfill gas is needed. To properly operate a landfill, waste picking at the working face needs to be stopped.

Abandoned waste dumps will grow in importance in Chinese cities. These "brownfield sites" will be costly to remediate, but they will need to eventually be dealt with since they will continue to pose a public health issue and many will impact ground and surface water resources. All cities should prepare an inventory of their sites, stop creating new ones, and start developing a prioritized, costed and timed programs to remediate these sites.

"Special waste" will grow in importance in China. Special attention is needed in the emerging areas of: bulky waste (used appliances, consumer electronics); waste with disproportionately high amounts of potential pollution or handling costs such as batteries, tires, single serving beverage containers, disposable diapers, and plastic shopping bags; household hazardous waste; sewage sludge; coal ash; industrial hazardous waste; medical waste; and construction and demolition waste. These waste streams will impose high collection and disposal costs. Ideally, most of them should be handled by licensed haulers required to meet criteria for each type of waste that they are allowed to handle, and waste generators should be required to hire only licensed haulers or risk sanction.

All Chinese cities should encourage the long-term objective of at-source waste segregation. Far more flexibility and innovation is possible in the design of waste management systems when this fundamental prerequisite is in place.

An area that requires significant attention in Chinese cities is waste collection. The waste stream is rapidly growing in volume, increased traffic is affecting the productivity of collection vehicles, and collection systems need to be regularly upgraded to be cost-effective. For large cities, this will involve a greater reliance on larger vehicles, waste compaction and transfer stations. To enable improved waste disposal, including adequate emissions reduction, source segregation of wastes will increase, and waste collection systems will need to optimize separate collection schedules for recyclables versus general wastes. Waste collection budgetary targets and norms for workers and vehicles need to be regularly updated.

2. Waste Minimization

The two waste categories warranting most attention are organics and waste paper. Even by 2030 organics will still account for more that 50% of the waste stream. The quality of China's secondary fibers is increasing and this material will continue to increase in value, encouraging greater recycling (rather than incineration or landfilling).

Reducing coal ash in the waste stream is important—by 2015 all cities should eliminate coal ash from the general waste stream (either by providing segregated collection or having all homes converted to alternative heating sources rather than using coal).

China should set clear targets for waste diversion and reduction. These targets have global implications. A critical target would be that in 2030 per capita urban waste generation should not exceed 1.5 kg/p/day. The rate of growth in waste generation should be targeted to be less than the rate of economic growth.

Tipping fees for the commercial, industrial and institutional sectors, based on waste amounts, should be introduced as soon as possible at all waste disposal facilities.

Provincial and national materials exchanges should be further encouraged.

Waste minimization needs more aggressive and comprehensive public education campaigns. Activities such as commercial waste audits, school programs, business "greening", and public advertising should be encouraged locally and nationally. A broad array of economic instruments to encourage waste minimization should be encouraged (see Box 4.1).

A corporate partnership, similar to CEMPRE in Brazil should be established for China (see Box 3.1).

3. Waste Quantities and Composition

Better definition of waste categories is needed as well as greater consistency of data collection and management. Waste management planners need to be able to monitor MSW trends and this is not now currently possible with any level of confidence in China. Currently, systems are in place in China to encourage data consistency, e.g. waste sampling ordinance CJ/T 3039-95, however they are not yet widely followed. Most data should be collected on a "wet-weight, as generated" basis.

Per capita waste generation rates (like those presented in Annex 1) should be suitable for immediate planning purposes, but adjusted upwards to reflect improved data. The estimates in this report are much higher than those currently being used in China.

Better and more comprehensive waste management data is especially needed from the Industrial-Commercial-Institutional sector. Globally, in all urban jurisdictions this fraction of the waste stream accounts for at least 50% of the total waste stream.

Data on waste calorific content is needed, so that cities do not erroneously presume that their waste will self-sustain combustion and produce net energy through incineration. Only the largest upper-income cities have sufficient wastes that are high enough in plastic, paper, textile, cardboard, and other dry combustibles to self-sustain combustion (most of these materials are readily recyclable).

4. Roles and Responsibilities

National government (mainly SEPA) should take a broader role in promoting waste minimization, e.g. reviewing import restrictions, deposits, packaging legislation (the current trend for ad hoc municipal establishment of these efforts is problematic to manufacturers).

National government (both MOC and SEPA) needs to set clear performance targets for waste management facilities. Provincial agencies should then monitor facilities performance as it relates to this legislation. Consistent practical landfill leachate standards are needed, as are incinerator emission standards.

All new incinerators should meet Japanese/European standards for dioxin and mercury emissions (not doing this now will likely be far more expensive in the future).

There is a need to separate the management and operations functions of solid waste from policy development and regulation. Cities should be formally empowered to manage MSW (including establishing fees). National government agencies (SEPA and MOC) should set the policy framework in which cities need to operate.

Other stakeholders are emerging in China's waste management sector. These will include local and international NGOs, local residents, other countries, and trade associations. This should be encouraged. Working with these groups should be overseen by central government (mainly SEPA) although cities will also be contacted directly.

Cities (and central government) will need to be increasingly transparent in the purchase of waste management facilities. Purchase of facilities, such as incinerators, is currently highly skewed by non-transparent subsidies, improperly priced capital (e.g. subsidized loans which results in higher operating costs for the city), and ad hoc sole-source 'deals'.

Better coordination between local Environmental Protection Bureaus and the local Environmental Sanitary Administration is urgently needed. Similarly better coordination between central agencies such as SEPA and MOC is needed.

All levels of government in China, and the public, should actively adopt the hierarchy of waste management: reduce, reuse, recycle, recover, landfill disposal and incineration. Significant attention needs to be directed to waste reduction (i.e. slowing the rate of waste generation).

The central government (SEPA and MOC) should support (at least three) cities in the development of a 'pilot' integrated waste management program. The pilot should be seen as a permanent intervention in these cities—not a temporary study but rather the three cities should be developed as the vanguard and 'test markets' for MSW management in China. The programs should include: collection of reliable and consistent data on waste quantities and service delivery costs; maximizing revenues from carbon emissions reductions trading; aggressively promoting waste segregation, minimization, and recycling;

developing programs to integrate waste pickers into the overall waste management system; operating sanitary landfills; introducing waste disposal tipping fees (based on amounts disposed, especially by the ICI sector); estimate the financing needs and sources (operations and capital) for the next 25 years for each city; build required facilities such as sanitary landfills, transfer stations (including waste sorting facilities), compost plants; place a ten year moratorium on incinerator construction (to enable the development of maximum waste diversion prior to incineration); introduce a public consultation and participation program to encourage source segregation of waste (at least into two streams, preferably three) and within ten years collect residential waste no more than two times per week; disseminate the pilot's findings widely (including internationally); work with local waste pickers to optimize their role in the waste management system. These cities should be developed as "centers of excellence" where municipal training programs are developed and given for all Chinese cities.

Every city in China should develop a comprehensive waste management master plan that focuses on integrated waste management and provides a planning horizon of about 25 years for waste management options while still ensuring sufficient flexibility to meet changing demands.

A central government working group on waste management should be created—or expanded from existing mandates. This group should be chaired jointly by MOC and SEPA and should contain membership from other ministries, academic institutions, representative cities, and possibly international experts. The group should provide a forum to explore national waste management issues such as import restrictions, secondary materials market development. Within one year the group should provide national urban waste diversion targets.

The working group should review all waste management legislation in China and ensure consistency (where needed) across cities. The group should prepare a standard set of municipal waste management ordinances that could be adopted by cities. This same working group, or another, should provide clear directions to cities on how to measure waste quantities and composition, and how to define and collect local waste management financial information.

5. Carbon Finance

Revenue potential for carbon emission reductions from improved MSW practices should be considered in all future waste management planning. Efforts should be made by cities to maximize this potential revenue source. This will include greater reliance on LFG recovery. Carbon finance also enhances the potential viability of materials recovery, composting, and to a lesser extent, anaerobic digestion. Revenues from the sale of ERs should go to local governments to provide an incentive for continued good facility operations.

6. Waste Management Finance

Accurate waste management financial data is difficult to obtain, and this report can only provide a rough estimate, however Chinese governments should anticipate an eight-fold increase in the current 30 Billion RMB budget for MSW by 2020 (about 230 Billion RMB).

How this significant increase will be financed is not yet know—this requires priority attention. The provision of user fees will need to increase significantly.

Current accurate MSW financial information is not available. Standard accounting systems and clear delineation between operating and capital costs should be introduced in all cities.

Greater private sector involvement in the sector should be encouraged but this is currently constrained by several factors (see Section 7).

Section 9 – Glossary

Aerobic composting
Aerobic microbial decomposition of organic wastes by micro-organisms, including bacteria and fungi that require oxygen to survive and metabolize organics.

Anaerobic digestion
Anaerobic microbial decomposition of organic wastes, that requires an anoxic environment for metabolism of organics.

Ash
The noncombustible solid by-products of incineration or other burning process.

Autoclaving
Sterilization via a pressurized, high-temperature steam process.

Baghouse
A combustion plant emission control device that consists of an array of fabric filters through which incineration flue gases pass. Particles are trapped and thus prevented from entering the atmosphere.

Basel Convention
An international agreement on the control of transboundary movements of hazardous wastes and their disposal, agreed to in March 1989 in Basel, Switzerland, with over 100 countries as signatories.

Bioaerosols
Particles in air stemming from living organisms.

Biodegradable material
Any organic material that can be broken down by microorganisms into simpler, more stable compounds. Most organic wastes (e.g., food, paper) are biodegradable.

Biodegradation
The breaking down of organic (carbon-containing) compounds into carbon dioxide, water and minerals by the action of microorganisms, such as bacteria.

Bottom ash
Relatively coarse, noncombustible residue of incineration that accumulates on the grate of a furnace.

Brownfields
Lands contaminated from inadequate waste disposal practices or spills.

Bulky waste
Large wastes such as appliances, furniture, and trees and branches that cannot be handled by normal MSW processing methods.

Cell
The basic unit by which a landfill is developed. It is the general area where incoming waste is tipped, spread, compacted, and covered; usually no more than 50x50 meters.

Clean Development Mechanism
An arrangement established under the Kyoto Protocol to assist countries to meet their obligations to reduce atmospheric emissions that contribute to global climate change. (See section 6)

Cleaner production
Processes designed to reduce the wastes generated by production.

Co-disposal
The disposal of different types of waste in the same area of a landfill or dump, for instance, sewage sludge might be disposed with regular solid wastes.

Cogeneration
Production of both electricity and steam from one facility, from the same fuel source.

Combustibles
Burnable materials in the waste stream, including paper, plastics, wood, and garden wastes.

Combustion
In MSW management, the burning of materials in an incinerator.

Commingled
Mixed recyclables that are collected together after having been separated from general MSW.

Communal collection
A system of collection in which individuals bring their waste directly to a central point, from which it is collected.

Compactor vehicle
A collection vehicle using high-power mechanical or hydraulic equipment to reduce the volume of collected waste.

Composite liner
A liner system for a landfill consisting of an engineered soil layer and/or a synthetic liner.

Compost
The finished material resulting from composting. Compost can be used as a soil conditioner and suppresses plant diseases, and can augment fertilizers (making them more available to plants).

Composting
Biological decomposition of solid organic materials by bacteria, fungi, and other organisms into a soil conditioner.

Construction and demolition debris
Waste generated by construction and demolition of buildings, such as bricks, concrete, drywall, lumber, miscellaneous metal, packaging materials, etc.

Controlled dump
A planned landfill that incorporates to some extent some of the features of a sanitary landfill: siting with respect to hydrogeological suitability, grading, compaction in some cases,

leachate control, partial gas management, regular (not usually daily) cover, access control, basic record-keeping, and controlled waste picking.

Curing
Allowing partially composted materials to sit in a pile for a period of time as part of the maturing process.

Disposal
The final handling of solid waste, following collection, processing, or incineration. Disposal most often means placement of wastes in a dump or a landfill.

Diversion rate
The proportion of waste material diverted for recycling, composting, or reuse and away from landfilling or incineration.

Drop-off center
An area or facility for receiving compostables or recyclables that are dropped off by waste generators.

Dump
see controlled dump and open dump.

Effluent
Wastewater, partially or completely treated, Effluent from a septic tank is the partially treated clearish liquid that flows into the absorption field for final treatment.

Emissions
Gases released into the atmosphere.

Energy recovery
The process of extracting useful energy from waste, typically from the heat produced by incineration or via methane gas from landfills.

Environmental impact assessment (EIA)
An evaluation designed to identify and predict the impact of an action or a project on the environment and human health and well-being. Can include risk assessment as a component, along with economic and land use assessment.

Environmental risk assessment (ERA)
An evaluation of the interactions of agents, humans, and ecological resources comprised of human health risk assessment and ecological risk assessment, typically evaluating the probabilities and magnitudes of harm that could come from environmental contaminants.

E Waste (Electronic Waste)
The waste associated with the use and disposal of electronic equipment such as computers, televisions, printers, etc.

Fabric filter
see baghouse.

Flaring
The burning of methane emitted from collection pipes at a landfill.

Fluidized-bed incinerator
A type of incinerator in which the stoker grate is replaced by a bed of limestone or sand that can withstand high temperatures. The heating of the bed and the high air velocities used cause the bed to bubble, which gives rise to the term fluidized.

Fly ash
The highly toxic particulate matter captured from the flue gas of an incinerator by the air pollution control system.

Garbage
In everyday usage, refuse in general. Some MSW management manuals use garbage to mean "food wastes," although this usage is not common.

Greenhouse Gas
A gas, such as carbon dioxide or methane, which contributes to potential climate change.

Groundwater
Water beneath the earth's surface (known as aquifers), that supply wells and springs.

Hazardous waste
Waste that is reactive, toxic, corrosive, or otherwise dangerous to living things and/or the environment. Many industrial by-products are hazardous.

Heavy metals
Metals of high atomic weight and density, such as mercury, lead, and cadmium, that are toxic to living organisms.

Household hazardous waste
Products used in residences, such as paints and some cleaning compounds, which are toxic to living organisms and/or the environment.

Humus
The end product of composting, also called compost.

Hydrocarbons (HC)
Chemical compounds that consist of carbon and hydrogen.

Incineration
The process of burning solid waste under controlled conditions to reduce its weight and volume, and often to produce energy.

Informal sector
The part of an economy that is characterized by private, usually small-scale, labor-intensive, largely unregulated, and unregistered manufacturing or provision of services.

Inorganic waste
Waste composed of material other than plant or animal matter, such as sand, dust, glass, and many synthetics.

Integrated solid waste management
Coordinated use of a set of waste management methods, each of which can play a role in an overall MSW management plan.

International NGO
An organization that has an international headquarters and branches in major world regions, often with the purpose of undertaking development assistance.

In-vessel composting
Composting in an enclosed vessel or drum with a controlled internal environment, mechanical mixing, and aeration.

Itinerant waste buyer
A person who informally buys (or barters) reusable and recyclable materials.

Landfill gases
Gases arising from the decomposition of organic wastes; principally methane, carbon dioxide, and hydrogen sulfide. Such gases may cause explosions at landfills.

Landfilling
The final disposal of solid waste by placing it in a controlled manner in a place intended to be permanent.

Leachate
Liquid (which may be partly produced by decomposition of organic matter) that has seeped through a landfill or a compost pile and has accumulated bacteria and other possibly harmful dissolved or suspended materials. If uncontrolled, leachate can contaminate both groundwater and surface water.

Leachate pond
A pond or tank constructed at a landfill to receive the leachate from the area. Usually the pond is designed to provide some treatment of the leachate, by allowing settlement of solids or aeration to promote biological processes.

Lift
The completed layer of compacted waste in a cell at a landfill.

Liner
A protective layer, made of soil and/or synthetic materials, installed along the bottom and sides of a landfill to prevent or reduce the flow of leachate into the environment.

Manual landfill
A landfill in which most operations are carried out without the use of mechanized equipment.

Market waste
Primarily organic waste, such as leaves, skins, and unsold food, discarded at or near food markets.

Mass-burn incinerator
A type of incinerator in which solid waste is burned without prior sorting or processing.

Materials recovery
Obtaining materials that can be reused or recycled.

Materials recovery facility (MRF)
A facility for separating commingled recyclables by manual or mechanical means. Some MRFs are designed to separate recyclables from mixed MSW. MRFs then bale and market the recovered materials.

Methane
An odorless, colorless, flammable, explosive gas, CH, produced by anaerobically decomposing MSW at landfills.

Microenterprise
A synonym for small-scale enterprise: a business, often family-based or a cooperative, that usually employs fewer than ten people and may operate "informally."

Mixed waste
Unsorted materials that have been discarded into the waste stream.

Modular incinerator
A relatively small type of prefabricated solid waste combustion unit.

Monofill
A landfill intended for one type of waste only.

MSW
Municipal solid waste

MSWM
Municipal solid waste management

Municipal solid waste
All solid waste generated in an area except industrial and agricultural wastes. Sometimes includes construction and demolition debris and other special wastes that may enter the municipal waste stream. Generally excludes hazardous wastes except to the extent that they enter the municipal waste stream. Sometimes defined to include all solid wastes that a city authority accepts responsibility for managing in some way.

Municipal solid waste management
Planning and implementation of systems to handle MSW.

NGO
Nongovernmental organization. May be used to refer to a range of organizations from small community groups, through national organizations, to international ones. Frequently these are not-for-profit organizations.

Night soil
Human excreta

NIMBY
"Not In My Back Yard." An expression of resident opposition to the siting of a solid waste facility based on the particular location proposed.

Nitrification
The process whereby ammonia in wastewater is oxidized to nitrite and then to nitrate by bacterial or chemical reactions.

Open dump
An unplanned "landfill" that incorporates few if any of the characteristics of a controlled landfill. There is typically no leachate control, no access control, no cover, no management, and many waste pickers.

Organic waste
Technically, waste containing carbon, including paper, plastics, wood, food wastes, and yard wastes. In practice in MSWM, the term is often used in a more restricted sense to mean material that is more directly derived from plant or animal sources, and which can generally be decomposed by microorganisms.

Particulates
Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions. 2. Very small solids suspended in water; they can vary in size, shape, density and electrical charge and can be gathered together by coagulation and flocculation.

Pathogen
An organism capable of causing disease.

Picker
see waste picker.

Pollution
The contamination of soil, water, or the atmosphere by the discharge of waste or other offensive materials.

Post-consumer materials
Materials that a consumer has finished using, which the consumer may sell, give away, or discard as wastes.

Primary material
A commercial material produced from virgin materials used for manufacturing basic products. Examples include wood pulp, iron ore, and silica sand.

Privatization
A general term referring to a range of contracts and other agreements that transfer the provision of some services or production from the public sector to private firms or organizations.

Processing
Preparing MSW materials for subsequent use or management, using processes such as baling, magnetic separation, crushing, and shredding. The term can also mean separation of recyclables from mixed MSW.

Producer responsibility
A system in which a producer of products or services takes greater responsibility for the waste that results from the products or services marketed, by reducing materials used in production, making repairable or recyclable goods, and/ or reducing packaging.

Putrescible
Material subject to decomposition or decay. Usually used in reference to food wastes and other organic wastes that decay quickly.

Pyrolysis
Chemical decomposition of a substance by heat in the absence of oxygen, resulting in various hydrocarbon gases and carbon-like residue.

Recyclables
Items that can be reprocessed into feedstock for new products. Common examples are paper, glass, aluminum, corrugated cardboard, and plastic containers.

Recycling
The process of transforming materials into raw materials for manufacturing new products, which may or may not be similar to the original product.

Refuse
A term often used interchangeably with solid waste.

Refuse-derived fuel (RDF)
Fuel produced from MSW that has undergone processing. Processing can include separation of recyclables and noncombustible materials, shredding, size reduction, and pelletizing.

Resource recovery
The extraction and utilization of materials and energy from wastes.

Reuse
The use of a product more than once in its original form, for the same or a new purpose.

Rubbish
A general term for solid waste. Sometimes excluding food wastes and ashes.

Sanitary landfill
An engineered method of disposing of solid waste on land, in a manner that meets most of the standard specifications, including sound siting, extensive site preparation, proper leachate and gas management and monitoring, compaction, daily and final cover, complete access control, and record-keeping.

Scrap
Materials discarded from manufacturing operations that may be suitable for reprocessing.

Scrubber
Emission control device in an incinerator, used primarily to control acid gases, but also to remove some heavy metals.

Secondary material
A material recovered from post-consumer wastes for use in place of a primary material in manufacturing a product.

Secure landfill
A disposal facility designed to permanently isolate wastes from the environment. This entails burial of the wastes in a landfill that includes clay and/ or synthetic liners, leachate collection, gas collection (in cases where gas is generated), and an impermeable cover.

Septage
Sludge removed from a septic tank (a chamber that holds human excreta).

Set-out container
A box or bucket used for residential waste that is placed outside for collection.

Sewage sludge
A semi-liquid residue that settles to the bottom of canals and pipes carrying sewage or industrial wastewaters, or in the bottom of tanks used in treating wastewaters.

Site remediation
Treatment of a contaminated site by removing contaminated solids or liquids or treating them on-site.

Sludge
A semi-solid residue from any of a number of air or water treatment processes; can be a hazardous waste.

Source reduction
The design, manufacture, acquisition, and reuse of materials so as to minimize the quantity and/or toxicity of waste produced.

Source separation
Setting aside of compostable and recyclable materials from the waste stream before they are collected with other MSW, to facilitate reuse, recycling, and composting.

Special wastes
Wastes that are usually considered to be outside of the typical MSW stream, but which sometimes enter it and must often be dealt with by municipal authorities. These include household hazardous waste, medical waste, construction and demolition debris, war and earthquake debris, tires, oils, wet batteries, sewage sludge, human excreta, discarded appliances, slaughterhouse waste, and industrial waste.

Subsidy
Direct or indirect payment from government to businesses, citizens, or institutions to encourage a desired activity.

Tipping fee
A fee for unloading or dumping waste at a landfill, transfer station, incinerator, or recycling facility.

Tipping floor
Unloading area for vehicles that are delivering MSW to a transfer station or incinerator.

Transfer
The act of moving waste from collection vehicles and individual waste collectors to a larger transport vehicle.

Transfer point
A designated point, often at the edge of a neighborhood, where small collection vehicles transfer waste to larger vehicles for transport to disposal sites.

Transfer station
A major facility at which MSW from collection vehicles is consolidated into loads that are transported by larger trucks or other means to more distant final disposal facilities; typically landfills.

Vectors
Organisms that carry disease causing pathogens. At landfills, rodents, flies, and birds are the main vectors that spread pathogens beyond the landfill site.

Vermiculture
see worm culture.

Virgin materials
Any basic material for industrial processes that has not previously been used, for example, wood-pulp trees, iron ore, crude oil, bauxite.

Waste characterization study
An analysis of samples from a waste stream to determine its composition.

Waste Collection
The process of picking up wastes from residences, businesses, or a collection point, loading them into a vehicle, and transporting them to a processing, transfer, or disposal site.

Waste collector
A person employed by a local authority or a private firm to collect waste from residences, businesses, and community bins.

Waste dealer
A middleman who buys recyclable materials from waste generators and itinerant buyers and sells them, after sorting and some processing, to wholesale brokers or recycling industries.

Waste Generation
The weight or volume of materials and products that enter the waste stream before recycling, composting, landfilling, or combustion takes place. Also can represent the amount of waste generated by a given source or category of sources

Waste management hierarchy
A ranking of waste management operations according to their environmental or energy benefits. The purpose of the waste management hierarchy is to make waste management practices as environmentally and economically sound as possible.

Waste picker
A person who picks out recyclables from mixed waste wherever it may be temporarily accessible or disposed of.

Waste reduction
All means of reducing the amount of waste that is produced initially and that must be collected by solid waste authorities. This ranges from legislation and product design to local programs designed to keep recyclables and compostables out of the final waste stream.

Waste stream
The total flow of waste from a community, region, or facility.

Waste-to-energy (WTE) plant
A facility that uses solid waste materials (processed or raw) to produce energy. WTE plants include incinerators that produce steam for district heating or industrial use, or that generate electricity; they also include facilities that convert landfill gas to electricity.

Wastewater
The spent or used water from an individual household, a community or commercial establishment which contains dissolved and suspended matter that is harmful to human health and the environment. Wastewater requires treatment to remove bacteria and pathogens, either through an onsite decentralized wastewater treatment system or a centralized municipal sewage system, before it can safely be released into the environment. Household wastewater includes liquid-solid mixtures from toilets, sinks, showers, bathtubs, washing machines, dishwashers and other drains.

Water table
Level below the earth's surface at which the ground becomes saturated with water.

Wetland
An area that is regularly wet or flooded and has a water table that stands at or above the land surface for at least part of the year.

Windrow
An elongated pile of aerobically composting materials that is turned periodically to expose the materials to oxygen and to control the temperature to promote biodegradation.

Working face
The length and width of the row in which waste is being deposited at a landfill. Also known as the tipping face.

Worm castings
The material produced from the digestive tracts of worms as they live in earth or compost piles. The castings are rich in nitrates, potassium, phosphorous, calcium, and magnesium.

Worm culture
A relatively cool, aerobic composting process that uses worms and microorganisms. Also known as vermiculture.

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Annex 1: Projected Municipal Waste Generation in Chinese Cities With Population Over 750,000

City	Province or Special Municipality	2000 Urban Population (thousands)	2000 MSW Generation (tonnes)	2005 Urban Population (thousands)	2005 MSW Generation (tonnes)	2010 Urban Population (thousands)	2010 MSW Generation (tonnes)	2015 Urban Population (thousands)	2015 MSW Generation (tonnes)	2020 Urban Population[1] (thousands)	2020 MSW Generation (tonnes)	2025 Urban Population[1] (thousands)	2025 MSW Generation (tonnes)	2030 Urban Population[1] (thousands)	2030 MSW Generation (tonnes)
Eastern Region															
Anshan	Liaoning	1,453	477,311	1,459	532,535	1,500	602,250	1,592	697,296	1,760	835,247	1,903	972,255	2,015	1,103,041
Beijing	Beijing	10,839	3,560,612	10,849	3,959,885	11,099	4,456,249	11,671	5,111,898	12,905	6,123,223	13,948	7,127,632	14,770	8,086,425
Benxi	Liaoning	957	314,375	967	352,955	1,000	401,500	1,065	466,470	1,178	558,755	1,273	650,409	1,348	737,901
Changzhou	Jiangsu	886	291,051	976	356,240	1,082	434,423	1,202	526,476	1,329	630,633	1,437	734,077	1,521	832,824
Dalian	Liaoning	2,628	863,298	2,709	988,785	2,843	1,141,465	3,048	1,335,024	3,370	1,599,142	3,643	1,861,453	3,857	2,111,852
Dongguan	Guangdong	1,319	433,292	1,150	419,750	1,179	473,369	1,250	547,500	1,382	655,816	1,494	763,391	1,582	866,081
Fushun	Guangdong	1,413	464,171	1,425	520,125	1,471	590,607	1,565	685,470	1,730	821,082	1,870	955,766	1,981	1,084,333
Fuxin	Liaoning	785	257,873	807	294,555	846	339,669	910	398,580	1,006	477,434	1,088	555,749	1,152	630,507
Fuzhou	Fujian	1,397	458,915	1,398	510,270	1,434	575,751	1,519	665,322	1,680	796,948	1,815	927,673	1,922	1,052,462
Guangzhou	Guangdong	3,893	1,278,851	3,881	1,416,565	3,973	1,595,160	4,192	1,836,096	4,635	2,199,344	5,010	2,560,109	5,305	2,904,489
Handan	Hebei	1,996	655,686	2,120	773,800	2,279	915,019	2,418	1,059,084	2,674	1,268,610	2,890	1,476,704	3,060	1,675,347
Hangzhou	Zhejiang	1,780	584,730	1,955	713,575	2,159	866,839	2,388	1,045,944	2,640	1,252,871	2,854	1,458,383	3,022	1,654,561
Heze	Shandong	1,600	525,600	1,847	674,155	2,123	852,385	2,406	1,053,828	2,660	1,262,315	2,875	1,469,376	3,045	1,667,033
Huaian	Jiangsu	1,232	404,712	1,297	473,405	1,385	556,078	1,504	658,752	1,663	789,078	1,797	918,512	1,903	1,042,069
Huzhou	Zhejiang	1,077	353,795	1,102	402,230	1,152	462,528	1,235	540,930	1,366	647,946	1,476	754,231	1,563	855,688
Jiaxing	Zhejiang	791	259,844	817	298,205	861	345,692	928	406,464	1,026	486,878	1,109	566,742	1,174	642,979
Jinan	Shandong	2,568	843,588	2,654	968,710	2,791	1,120,587	2,996	1,312,248	3,313	1,571,860	3,581	1,829,696	3,791	2,075,823
Jinzhou	Liaoning	834	273,969	888	324,120	958	384,637	1,047	458,586	1,158	549,311	1,251	639,417	1,325	725,429
Jixi	Liaoning	949	311,747	1,012	369,380	1,092	438,438	1,194	522,972	1,320	626,435	1,427	729,191	1,511	827,281
Linqing	Shandong	891	292,694	1,009	368,285	1,143	458,915	1,286	563,268	1,422	674,703	1,537	785,377	1,627	891,024
Linyi	Shandong	2,498	820,593	2,992	1,092,080	3,540	1,421,310	4,076	1,785,288	4,507	2,138,485	4,871	2,489,266	5,158	2,824,117
Nanjing	Jiangsu	2,740	900,090	2,806	1,024,190	2,931	1,176,797	3,132	1,371,816	3,463	1,643,213	3,743	1,912,753	3,964	2,170,053
Ningbo	Zhejiang	1,173	385,331	1,188	433,620	1,231	494,247	1,313	575,094	1,452	688,869	1,569	801,866	1,662	909,732
Qingdao	Shandong	2,316	760,806	2,431	887,315	2,589	1,039,484	2,801	1,226,838	3,097	1,469,552	3,348	1,710,607	3,545	1,940,714
Shanghai	Shanghai	12,887	4,233,380	12,665	4,622,725	12,944	5,197,016	13,598	5,955,924	15,035	7,134,229	16,251	8,304,476	17,208	9,421,576
Shantou	Guangdong	1,176	386,316	1,356	494,940	1,558	625,537	1,767	773,946	1,954	927,061	2,112	1,079,130	2,236	1,224,292
Shenyang	Liaoning	4,828	1,585,998	4,916	1,794,340	5,105	2,049,658	5,429	2,377,902	6,003	2,848,340	6,488	3,315,561	6,870	3,761,563
Shenzhen	Guangdong	1,131	371,534	1,285	469,025	1,460	586,190	1,645	720,510	1,819	863,054	1,966	1,004,623	2,082	1,139,763
Shijianzhuang	Hebei	1,603	526,586	1,733	632,545	1,890	758,835	2,076	909,288	2,295	1,089,179	2,481	1,267,840	2,627	1,438,387
Suqian	Jiangsu	1,189	390,587	1,258	459,170	1,350	542,025	1,470	643,860	1,625	771,240	1,757	897,748	1,860	1,018,511
Suzhou	Jiangsu	1,183	388,616	1,376	502,240	1,592	639,188	1,813	794,094	2,005	951,196	2,167	1,107,223	2,294	1,256,164
Taian	Shandong	1,503	493,736	1,550	565,750	1,628	653,642	1,749	766,062	1,934	917,618	2,090	1,068,137	2,213	1,211,821
Tangshan	Hebei	1,671	548,924	1,773	647,145	1,905	764,858	2,074	908,412	2,293	1,088,130	2,479	1,266,619	2,625	1,437,002
Tianjin	Tianjin	9,156	3,007,746	9,346	3,411,290	9,716	3,900,974	10,319	4,519,722	11,410	5,413,892	12,333	6,301,948	13,059	7,149,672
Weifang	Shandong	1,287	422,780	1,360	496,400	1,458	585,387	1,586	694,668	1,754	832,099	1,895	968,591	2,007	1,098,884
Wenzhou	Zhejiang	1,269	416,867	1,475	538,375	1,705	684,558	1,940	849,720	2,145	1,017,826	2,319	1,184,783	2,455	1,344,158
Wuxi	Jiangsu	1,127	370,220	1,192	435,080	1,278	513,117	1,391	609,258	1,538	729,792	1,662	849,502	1,760	963,775
Xiaoshan	Zhejiang	1,124	369,234	1,130	412,450	1,164	467,346	1,236	541,368	1,367	648,471	1,477	754,841	1,564	856,381
Xinghua	Jiangsu	1,556	511,146	1,587	579,255	1,652	663,278	1,766	773,508	1,953	926,537	2,111	1,078,519	2,235	1,223,599
Xintai	Hebei	1,325	435,263	1,334	486,910	1,375	552,063	1,461	639,918	1,615	766,518	1,746	892,252	1,849	1,012,276
Xinyi	Jiangsu	973	319,631	1,022	373,030	1,089	437,234	1,182	517,716	1,307	620,140	1,413	721,863	1,496	818,966
Xinyu	Guangdong	808	265,428	932	340,180	1,071	430,007	1,216	532,608	1,345	637,978	1,453	742,627	1,539	842,524
Xuzhou	Jiangsu	1,636	537,426	1,901	693,865	2,197	882,096	2,497	1,093,686	2,761	1,310,058	2,984	1,524,951	3,160	1,730,083
Yancheng	Jiangsu	1,562	513,117	1,678	612,470	1,823	731,935	1,997	874,686	2,208	1,047,732	2,387	1,219,594	2,527	1,383,651

City	Province or Special Municipality	2000 Urban Population (thousands)	2000 MSW Generation (tonnes)	2005 Urban Population (thousands)	2005 MSW Generation (tonnes)	2010 Urban Population (thousands)	2010 MSW Generation (tonnes)	2015 Urban Population (thousands)	2015 MSW Generation (tonnes)	2020 Urban Population[1] (thousands)	2020 MSW Generation (tonnes)	2025 Urban Population[1] (thousands)	2025 MSW Generation (tonnes)	2030 Urban Population[1] (thousands)	2030 MSW Generation (tonnes)
Yixing	Jiangsu	1,108	363,978	1,129	412,085	1,177	472,566	1,259	551,442	1,392	660,538	1,505	768,888	1,593	872,317
Yuyao	Zhejiang	848	278,568	876	319,740	923	370,585	995	435,810	1,100	522,030	1,189	607,660	1,259	689,400
Zaozhuang	Shandong	2,048	672,768	2,189	798,985	2,365	949,548	2,582	1,130,916	2,855	1,354,653	3,086	1,576,861	3,268	1,788,977
Zhangjiakou	Hebei	880	289,080	973	355,145	1,082	434,423	1,204	527,352	1,331	631,682	1,439	735,299	1,524	834,209
Zhangjiagang	Jiangsu	886	291,051	936	341,640	1,004	403,106	1,094	479,172	1,210	573,970	1,307	668,120	1,384	757,994
Zhanjiang	Guangdong	1,368	449,388	1,562	570,130	1,780	714,670	2,008	879,504	2,220	1,053,503	2,400	1,226,312	2,541	1,391,273
Zibo	Shandong	2,675	878,738	2,775	1,012,875	2,928	1,175,592	3,148	1,378,824	3,481	1,651,607	3,762	1,922,525	3,984	2,181,138
	Subtotal	*106,822*	*35,091,027*	*111,048*	*40,532,520*	*117,880*	*47,328,820*	*127,240*	*55,731,120*	*140,689*	*66,756,821*	*152,069*	*77,707,131*	*161,023*	*88,160,120*
Central Region															
Changchun	Jilin	3,093	1,016,051	3,673	1,340,645	4,315	1,732,473	4,944	2,165,472	5,467	2,593,883	5,909	3,019,365	6,257	3,425,524
Changde	Hunan	1,374	451,359	1,483	541,295	1,615	648,423	1,774	777,012	1,962	930,734	2,120	1,083,405	2,245	1,229,142
Changsha	Hunan	1,775	583,088	2,051	748,615	2,359	947,139	2,674	1,171,212	2,957	1,402,922	3,196	1,633,047	3,384	1,852,721
Daqing	Heilongjiang	1,076	353,466	1,117	407,705	1,181	474,172	1,275	558,450	1,410	668,932	1,524	778,659	1,614	883,403
Datong	Shanxi	1,165	382,703	1,112	405,880	1,141	458,112	1,210	529,980	1,338	634,830	1,446	738,963	1,531	838,366
Fuyu	Jilin	1,025	336,713	1,068	389,820	1,131	454,097	1,223	535,674	1,352	641,650	1,462	746,902	1,548	847,374
Harbin	Heilongjiang	2,928	961,848	2,898	1,057,770	2,968	1,191,652	3,135	1,373,130	3,466	1,644,786	3,747	1,914,585	3,967	2,172,131
Hefei	Anhui	1,242	407,997	1,320	481,800	1,421	570,532	1,550	678,900	1,714	813,212	1,852	946,605	1,962	1,073,940
Hengyang	Hunan	799	262,472	853	311,345	921	369,782	1,008	441,504	1,115	528,850	1,205	615,599	1,276	698,408
Huaibei	Anhui	814	267,399	946	345,290	1,094	439,241	1,246	545,748	1,378	653,717	1,489	760,948	1,577	863,310
Huainan	Anhui	1,354	444,789	1,422	519,030	1,515	608,273	1,643	719,634	1,817	862,005	1,964	1,003,402	2,079	1,138,377
Hunjiang	Jilin	772	253,602	798	291,270	841	337,662	907	397,266	1,003	475,860	1,084	553,917	1,148	628,428
Jiamusi	Heilongjiang	874	287,109	1,006	367,190	1,155	463,733	1,311	574,218	1,450	687,820	1,567	800,645	1,659	908,346
Jilin	Jilin	1,435	471,398	1,496	546,040	1,585	636,378	1,712	749,856	1,893	898,206	2,046	1,045,541	2,167	1,186,185
Jingmen	Hubei	1,153	378,761	1,228	448,220	1,324	531,586	1,445	632,910	1,598	758,123	1,727	882,480	1,829	1,001,190
Kaifeng	Henan	769	252,617	810	295,650	866	347,699	942	412,596	1,042	494,223	1,126	575,292	1,192	652,679
Liuan	Anhui	1,818	597,213	2,015	735,475	2,242	900,163	2,491	1,091,058	2,754	1,306,910	2,977	1,521,286	3,152	1,725,926
Luoyang	Henan	1,451	476,654	1,594	581,810	1,762	707,443	1,951	854,538	2,157	1,023,598	2,332	1,191,501	2,469	1,351,779
Mudanjiang	Heilongjiang	801	263,129	827	301,855	871	349,707	939	411,282	1,038	492,649	1,122	573,460	1,188	650,600
Nanchang	Jiangxi	1,722	565,677	2,012	734,380	2,335	937,503	2,661	1,165,518	2,942	1,396,101	3,180	1,625,107	3,368	1,843,713
Pingxiang	Jiangxi	1,502	493,407	1,562	570,130	1,653	663,680	1,783	780,954	1,971	935,456	2,131	1,088,901	2,256	1,235,378
Qiqihar	Heilongjiang	1,435	471,398	1,452	529,980	1,503	603,455	1,601	701,238	1,770	839,969	1,913	977,752	2,026	1,109,277
Taiyuan	Shanxi	2,415	793,328	2,516	918,340	2,664	1,069,596	2,871	1,257,498	3,174	1,506,278	3,431	1,753,357	3,633	1,989,215
Tianmen	Hubei	1,779	584,402	1,948	711,020	2,146	861,619	2,371	1,038,498	2,622	1,243,952	2,834	1,448,001	3,001	1,642,782
Tongliao	Jilin	785	257,873	847	309,155	924	370,986	1,017	445,446	1,124	533,572	1,215	621,095	1,287	704,644
Wuhan	Hubei	5,169	1,698,017	6,003	2,191,095	6,923	2,779,585	7,833	3,430,854	8,661	4,109,605	9,361	4,783,715	9,913	5,427,210
Xiangxiang	Hunan	908	298,278	936	341,640	985	395,478	1,061	464,718	1,173	556,657	1,268	647,967	1,343	735,130
Xiantao	Hubei	1,614	530,199	1,758	641,670	1,929	774,494	2,126	931,188	2,351	1,115,412	2,541	1,298,376	2,690	1,473,031
Xuanzhou	Anhui	823	270,356	851	310,615	898	360,547	968	423,984	1,070	507,864	1,157	591,170	1,225	670,693
Yichun	Jilin	904	296,964	916	334,340	949	381,024	1,012	443,256	1,119	530,949	1,209	618,042	1,281	701,179
Yichun	Jiangxi	871	286,124	890	324,850	928	372,592	994	435,372	1,099	521,505	1,188	607,049	1,258	688,708
Yiyang	Hunan	1,343	441,176	1,510	551,150	1,700	682,550	1,904	833,952	2,105	998,939	2,276	1,162,798	2,410	1,319,215
Yongzhou	Hunan	1,097	360,365	1,182	431,430	1,287	516,731	1,413	618,894	1,562	741,334	1,689	862,938	1,788	979,018

(continued)

City	Province or Special Municipality	2000 Urban Population (thousands)	2000 MSW Generation (tonnes)	2005 Urban Population (thousands)	2005 MSW Generation (tonnes)	2010 Urban Population (thousands)	2010 MSW Generation (tonnes)	2015 Urban Population (thousands)	2015 MSW Generation (tonnes)	2020 Urban Population[1] (thousands)	2020 MSW Generation (tonnes)	2025 Urban Population[1] (thousands)	2025 MSW Generation (tonnes)	2030 Urban Population[1] (thousands)	2030 MSW Generation (tonnes)
Yueyang	Hunan	1,213	398,471	1,286	469,390	1,383	555,275	1,507	660,066	1,666	790,652	1,801	920,345	1,907	1,044,147
Yuzhou	Henan	1,173	385,331	1,226	447,490	1,303	523,155	1,411	618,018	1,560	740,285	1,686	861,716	1,786	977,632
Zaoyang	Hubei	1,121	368,249	1,210	441,650	1,319	529,579	1,450	635,100	1,603	760,747	1,733	885,534	1,835	1,004,654
Zhaodong	Heilongjiang	851	279,554	879	320,835	926	371,789	998	437,124	1,103	523,603	1,193	609,492	1,263	691,479
Zhengzhou	Henan	2,070	679,995	2,250	821,250	2,464	989,296	2,711	1,187,418	2,998	1,422,334	3,240	1,655,643	3,431	1,878,357
	Subtotal	*54,513*	*17,907,521*	*58,951*	*21,517,115*	*64,526*	*25,907,189*	*71,072*	*31,129,536*	*78,584*	*37,288,123*	*84,941*	*43,404,599*	*89,942*	*49,243,289*
Western Region															
Anshun	Guizhou	489	160,637	864	315,360	954	383,031	1,057	462,966	1,169	554,558	1,263	645,524	1,338	732,358
Baotou	Inner Mongolia	1,319	433,292	1,367	498,955	1,442	578,963	1,554	680,652	1,718	815,310	1,857	949,048	1,967	1,076,712
Chengdu	Sichuan	3,294	1,082,079	3,478	1,269,470	3,720	1,493,580	4,030	1,765,140	4,456	2,114,351	4,816	2,461,174	5,100	2,792,245
Chifeng	Inner Mongolia	1,087	357,080	1,140	416,100	1,215	487,823	1,318	577,284	1,457	691,492	1,575	804,920	1,668	913,196
Chongqing	Chongqing	4,900	1,609,650	5,695	2,078,675	6,572	2,638,658	7,440	3,258,720	8,226	3,903,417	8,892	4,543,705	9,415	5,154,914
Guiyang	Guizhou	2,533	832,091	3,124	1,140,260	3,784	1,519,276	4,418	1,935,084	4,885	2,317,916	5,280	2,698,130	5,591	3,061,077
Huhehaote	Inner Mongolia	978	321,273	998	364,270	1,040	417,560	1,114	487,932	1,232	584,463	1,331	680,334	1,410	771,851
Jining	Inner Mongolia	1,019	334,742	1,101	401,865	1,203	483,005	1,323	579,474	1,463	694,116	1,581	807,973	1,674	916,660
Kunming	Yunnan	1,701	558,779	1,748	638,020	1,830	734,745	1,962	859,356	2,169	1,029,369	2,345	1,198,219	2,483	1,359,401
Lanzhou	Gansu	1,730	568,305	1,788	652,620	1,882	755,623	2,024	886,512	2,238	1,061,897	2,419	1,236,083	2,561	1,402,358
Leshan	Sichuan	1,137	373,505	1,172	427,780	1,231	494,247	1,324	579,912	1,464	694,640	1,582	808,584	1,676	917,353
Liupanshui	Guizhou	2,023	664,556	2,118	773,070	2,252	904,178	2,435	1,066,530	2,692	1,277,530	2,910	1,487,086	3,082	1,687,126
Mianyang	Sichuan	1,065	349,853	1,174	428,510	1,302	522,753	1,446	633,348	1,599	758,648	1,728	883,091	1,830	1,001,883
Neijiang	Sichuan	1,393	457,601	1,449	528,885	1,532	615,098	1,653	724,014	1,828	867,251	1,976	1,009,509	2,092	1,145,306
Suining	Sichuan	1,428	469,098	1,520	554,800	1,639	658,059	1,788	783,144	1,977	938,079	2,137	1,091,955	2,263	1,238,842
Tianshui	Gansu	1,187	389,930	1,269	463,185	1,372	550,858	1,501	657,438	1,660	787,504	1,794	916,680	1,900	1,039,990
Wanxian	Chongqing	1,759	577,832	1,963	716,495	2,195	881,293	2,447	1,071,786	2,706	1,283,825	2,924	1,494,415	3,097	1,695,440
Wulumuqi	Xinjiang	1,415	464,828	1,562	570,130	1,733	695,800	1,924	842,712	2,127	1,009,432	2,299	1,175,012	2,435	1,333,072
Xian	Shaanxi	3,123	1,025,906	3,257	1,188,805	3,448	1,384,372	3,714	1,626,732	4,107	1,948,560	4,439	2,268,188	4,700	2,573,300
Xianyang	Shaanxi	896	294,336	988	360,620	1,096	440,044	1,218	533,484	1,347	639,027	1,456	743,849	1,541	843,909
Yulin	Guangxi	1,558	511,803	1,691	617,215	1,850	742,775	2,037	892,206	2,252	1,068,718	2,434	1,244,023	2,578	1,411,366
Zigong	Sichuan	1,072	352,152	1,123	409,895	1,195	479,793	1,295	567,210	1,432	679,425	1,548	790,873	1,639	897,260
	Subtotal	*37,106*	*12,189,321*	*40,589*	*14,814,985*	*44,487*	*17,861,531*	*49,022*	*21,471,636*	*54,203*	*25,719,529*	*58,588*	*29,938,376*	*62,038*	*33,965,619*

1 City population data provided by United Nations (2002) for the years 2000-2015. Assumed 5-year national urban growth rates to determine city population for the years 2020-2030.
Source: Laura Thomas, Su Liu and Wit Siemieniuk
AMEC Earth & Environmental

Annex 2: Asian Development Bank Report: Strengthening Urban Solid Waste Management, A Summary

The ADB prepared the above report in September 2001. The following is a short summary with key policy recommendations highlighted.

Municipal Solid Waste (MSW) within the People's Republic of China (PRC) is currently defined as:

'All waste generated from households, also referred to as 'living waste' and, in addition, waste that is similar in nature to household waste as collected from shops, institutions, enterprises, hospitals (some involving treatment), as well as wastes generated within small local commercial and industrial enterprises'

The Waste Management Hierarchy–Advanced technological solutions in the long term will provide a greater use and wider range of waste management solutions. Those options further up the hierarchy demonstrate an increasing focus for waste minimization and re-use of materials for ever-increasing proportions of total solid waste.

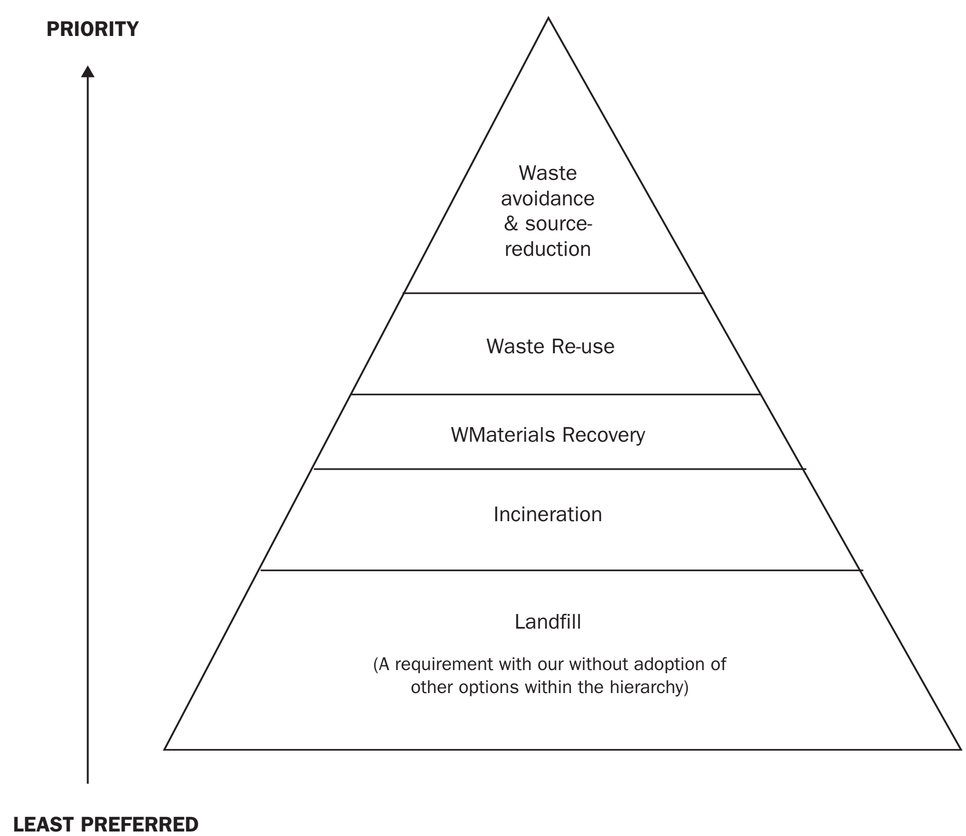
Need for Reform

Waste management services in the PRC have traditionally been managed through centrally planned economies . In order to achieve greater efficiency and higher standards, planning and delivery of waste management services must adapt progressively in line with the principles of a market-based socialist economy, calling for step-by step reforms in the relationship between management and operations at the city level

Functions and Responsibilities: national ministries

Institutional functions and responsibilities must be clarified at all levels of government with increases in professional SWM personnel and progressive transfer and consolidation

Figure A2.1:



of national ministry functions into MOC or SEPA. MOC should be the main non-regulatory national ministry where SWM activities and policies are consolidated. National Ministry activities however should be consolidated into a single unit.

MOC proposes a short term plan to establish an inter-ministry waste management forum that involves key ministries involved in SWM including SDPC, MOF, SEPA and SETC to discuss key issues and programs and transfer of ideas between ministries.

Functions and Responsibilities: provincial government

Provincial Government as a leader in city and town administrative areas, must ensure that national legislation is implemented, support sustainable development of waste management services; provide professional and technical support; encourage adoption of appropriate systems and technologies. Municipal authorities should work to provide a stable and attractive investment climate with reduced market risk.

Functions and Responsibilities: municipal government

Reforms should focus on local administrations to ensure single source responsibility and accountability of all SWM services. There should be clear legal distinction between management functions of municipal and district government from those of operations and services. Waste management operations should be progressively marketized and management staff within local government reduced, along with change to employment as they shift towards new enterprises.

Environmental Protection Bureaus

SEPA should consolidate and manage functions for facility/ practices, licenses, monitoring and enforcements and direct the local EPB under its administrative and financial control.

Marketization

A major goal of this strategy is to support widespread marketization of services by gradually exposing the provision of waste management to market forces in a step by step reform process.

Understanding Existing Costs

As a precursor to marketization, it is essential for municipal authorities to fully understand the costs of existing services; independent audits of the costs of all parts of waste management service should be carried out; identify all components forming management and operation costs of street sweeping, primary waste collection, transfer sanctions local collection points, secondary collection and haulage, treatment and disposal.

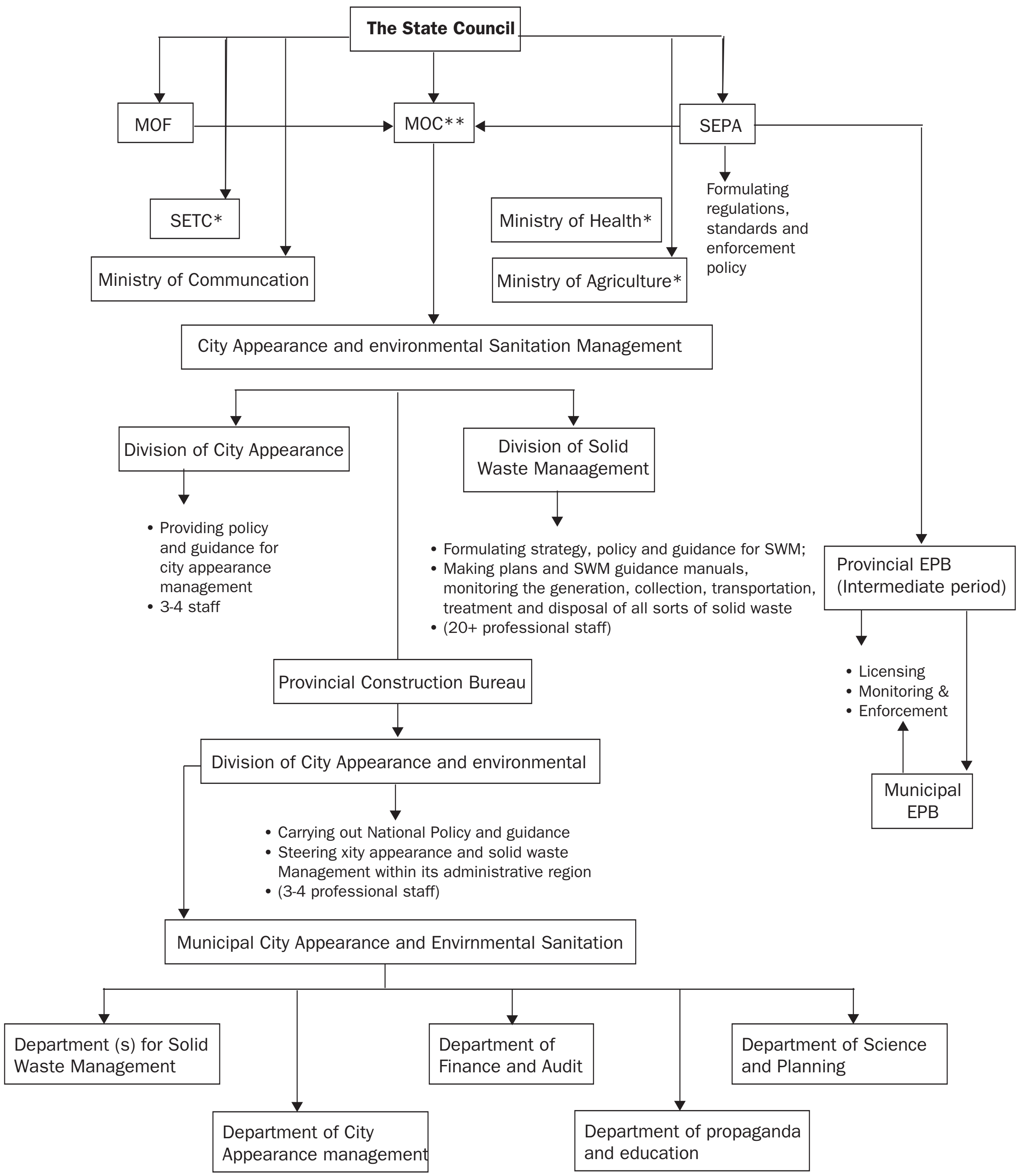
Separation of Management and Operations

The steps towards marketization should involve the following: 1) contracts between operational departments and existing ESBs and Municipal governments covering services provided; 2) legal separation of management units acting for municipal and district government from the operational parts of (current) urban appearance or ESBs. The operational units should eventually become fully privatized companies. MOC will prepare regulations and instructions to municipal authorities to progress with such reforms.

Service Agreement and Contracts

The SWM Department of the ESB should establish service contracts between urban appearance and sanitation bureaus operational units and external service providers. They should also advise on the separation of management from district government operations.

Figure A2.2: Long-term (by year 2010) Proposed Institutional Structure for SWM



Notes:

*Current roles & responsibilities for SWM to be placed directly within the SWM Division of MOC

**While MOC is shown as the long-term ministry responsibile for SWM (outside of SEPA roles and responsibilities), the Consultant recommends that all MOC functions and responsibilities for waste be placed within a single separate authority.

Payment Guarantees

Municipal governments must provide satisfactory guarantees of payment, set up contract documents that set out payment conditions and schedules, and establish procedures for payments for marketized waste management services .

Fair and Open Competition

Local government should regulate marketized services, and ensure fair and open competition. This is critical to the operation of future waste management services. The procurement of all waste management services must conform to the new standards that will result from the PRC's entry into the WTO for open market services.

SWM Industry Development

A key aim is to promote the waste management industry market and its advancement. Municipal authorities should provide a stable investment climate in order to reduce market risk and attract new entrants.

Local Government Capacity

Local government should focus on developing plans, establishing and monitoring contracted services, collecting service charges, and guiding and regulating the market.

Preferential Policies

Preferential policies will be implemented by municipal government to attract development of the waste management industry, such as financial incentives for market entry, risk reduction and infrastructure financing

Public Private Partnerships

The PRC Policy supports different forms of ownership and financing within a public-private partnership framework in operating waste management services, with options supporting progressive transfer of assets, profit sharing, and the establishment of joint ventures.

Consider Social Consequences

Social consequences must be addressed by both national and municipal governments and resolved in line with government policies. Where reforms result in job losses from reduced levels of government employment, public authorities should allocate severance pay as standard and negotiated agreements with re-training for alternative employment opportunities in place.

Sustainable Financing

The development of waste management practices across the PRC will require significant investment. Municipal authorities should promote concepts of sustainability in their finance management schemes, seek innovative financing methods and pursue government policies that will support balanced expenditure.

True Cost Accounting

Municipal and district authorities should introduce true cost accounting systems for waste management services. Itemized accounts should identify annual capital and operational cost and separate cost centers for each level off waste management services.

Long-term Financial Planning

The proposed SWM Department should prepare long-term Financial Plans outlining the following areas; capital and recurrent expenditure, projected annual costs of investment capital and operation and maintenance cost, sources and amounts of revenue including the level of required government subsidy and fees from waste generators. Financial plans should integrate and identify the affordability of proposed future developments for waste management services.

Economic Analysis

Waste management plans should include an economic analysis of alternative collection, treatment and disposal options that will ensure a mix of options that represent the best value-for-money for services and acceptable levels of environmental protection. Economic Analysis should include the following; a balanced assessment of capital, operation and maintenance cost of alternative scenarios, including costs of transportation and different treatment options, risk analysis, social costs and sensitivities.

Economic Efficiency

Development plans for improved services should address full direct cost of service provision, additional marginal cost, benefits derived from designed measures for optimal waste management and waste minimization.

Willingness and Ambiguity

Assessments of willingness and ability to pay for improved waste management services, demonstrating acceptability of proposed levels charged to waste generators, and charging revenues to support service improvement, should be included in financial plans.

Cost Recovery

The introduction of service charges for waste management is a key area to realize the 'polluter pays' principle and an essential basis for later agreements for government funds and service charges to be provided for marketized services. City governments should ensure that revenues from charges are directed to SWM Department of ESBs and solely used towards sustaining these services. Charges on households should be uniform, with those receiving socio-economic support as the only exception, and charges should be established through a contractual relationship directly with the service provider.

Future Cost Recovery Mechanism

Full cost-recovery includes all capital and operational and closure costs for all aspects of services provided. State government will continue to research development policies that provide a range of options to municipalities for introduction of service charges.

Widening Investment Sources

Municipal authorities should look into all possible sources of investment finance including; government bonds, commercial banks, development, private sector, stock market, environmental funds, environmental lotteries.

Planning

Integrated Waste Management Plans

Waste Management Plans should be designed by the SWM Department of ESB to cover 10-20 years and include balanced evaluations of relevant technical, financial, environmental and social aspects. They should also cover all stages of waste management service and indicated methods for waste reduction at source.

Inter-Municipal Cooperation

Waste management plans should consider opportunities for, and benefits of, inter-municipal and inter district cooperation.

Waste Data
Reliable, quality data on waste, quantities, composition and other characteristics must be gathered and maintained by SWM Departments and presented in SWM plans. The data should be used as a basis for selecting appropriate facilities and practices for waste collection, treatment and disposal.

The Waste Management Hierarchy
Standards for waste treatment and disposal should increase incrementally in accordance with local requirements while maintaining standards of minimum professional and financial resources to meet minimum acceptable environmental standards. Services development above these standards apply to areas of higher economic development.

Best Practical Environmental Option
'Best Practical Environmental Option' (BPEO) should be identified for each waste management plan, including an assessment of preferred waste management technologies and methods of the technical, financial, environmental and social cost in the treating of the whole waste stream.

Waste Facility Permits
The permit will cover all issues associated with Urban Planning and Environmental Assessment authorizations, and those based on evidence for technical and financial viability of the scheme and detailed documentation on all aspects of the proposed development. There is also need for facility specific Regulations that fully describe all design, construction, operations, monitoring and closure issues that apply throughout the life of the facility.

Access to Services
Progressive urbanization will impose new demands for expansion of waste collection coverage and new/expanded waste treatment and disposal services. All urban residents should be provided with waste management services.

Impacts on Society's Poor
Waste management plans must address potential impacts on the poor by including recommended options to enhance future livelihoods and employment opportunities for disadvantaged individuals and groups unable to pay future tariff charges.

Small Towns
The strategy recognizes the challenge faced by small towns to implement effective waste management and recommends low cost, appropriate technology options. Government will seek to identify support sharing expertise to provide such towns with assistance to meet minimum standards for waste management services.

Closure and Remediation of Dump Sites
All dump sites should be investigated in terms of their pollution risks and possible need for remediation. Waste management plans must contain technical, environmental assessment, financial and implementation plans for closure and re-habilitation or dump-sites.

Management of Other Wastes
Municipal authorities should include plans for management of all non-municipal solid waste generated within their administrative boundaries. Local authorities must provide arrangements for collection, treatment and disposal of all other solid wastes.

Emergency Response Plans

The SWM department within municipal government must be prepared for emergency situations (i.e. natural disasters and periods of critical stress on normal waste management services) and establish and integrate an emergency response system into Waste Management Plans.

Technology and Services

Sanitary Landfill

Landfill is an essential component of all waste management systems and must be the first development priority for municipal authorities with sufficiently designed, constructed and managed sanitary landfills to serve all urban residents within the PRC.

Integrated Waste Management Facilities

The SWM Department of Municipality Sanitation Bureaus should consider establishing integrated waste treatment and disposal facilities, that combine landfill with other forms of processing and treatment.

Waste Treatment Technologies

Waste treatment technologies must be developed where proven to be technically and financially sustainable. It is necessary to ensure that waste is of sufficient calorific value for effective incineration and sufficient quality for effective composting and that markets exist for the finished compost product.

Development of National Technologies

Government supports the continued development and manufacture of waste management technologies within the PRC. Key areas for technology development will be; sanitary landfills, incinerators and specialized vehicles and equipment and other appropriate technologies to Chinese conditions.

Technology Transfer

The PRC seeks the exchange of appropriate technologies and experiences from other countries for all parts of waste management services.

Mechanization and Efficiency of Collection Services

Waste collection accounts for the largest proportion of current expenditure on municipal waste management, therefore more attention should be placed on improving efficiency and performance of collection services by focusing on areas such as; use of containerized waste storage systems, progressive mechanization of collection systems and development of multi-district transfer stations.

Development of Recycling Industry

The PRC supports the introduction of waste recycling and recovery as it offers significant benefits to the environment and economy. Local governments should support the recycling industry and market developments and regularize activities and systems within appropriate environmental regulations.

Integrated Recycling Systems

Formalized recycling and recovery systems should be considered in developed cities with systems that are integrated into all other MSW management systems. Source segregation practices should be introduced as well as large centralized materials recovery and re-processing facilities. Classification should be in accordance with types or waste handling facilities available.

Environmental Monitoring

All new landfill sites should include environmental monitoring facilities for at minimum; groundwater and surface water quality, leachate emissions and landfill gas. Properties in close proximity to the boundary of a landfill should be monitored for the presence of landfill gas. Leacheate controls and treatment at landfill sites are also essential requirements and must be regularly monitored for continued effectiveness.

Illegal Dumping

All waste generators are legally obliged to ensure that wastes are treated and disposed only at authorized municipal waste management facilities. High penalties will be imposed for illegal dumping of waste.

Hazardous Waste

In the absence of a private sector service providers for the management of hazardous waste, local government and regional government must coordinate provision of this service. Affordable facilities must be developed and operated by specialist hazardous waste management service suppliers.

Health Care Wastes

Municipal Governments should ensure that effective plans and practices are introduced for the management of healthcare wastes, in particular the clinical and infectious waste fractions of those waste streams. All healthcare establishments have the responsibility to ensure proper management of these wastes. Municipal authorities should consider development of centralized incinerators to treat such waste arisings from hospitals, clinics and other waste generators.

Implement Existing Regulatory Framework

The SWM Department of ESBs on behalf of municipal authorities should ensure that all National Laws and Regulations are transposed through local regulations and ensure effective implementation of *'The Regulations of Urban Appearance and Environmental Sanitation Management'* issued by the State Council in 1992.

Consolidations & Standardization of Regulations

The regulatory framework for waste management at the state level will be progressively developed through MOC working in conjunction with SEPA. Consideration will be given to legislation associated with investment, operation and payback for marketized services and standard contracting procedures.

Guidance

SEPA will strengthen guidance documents for waste management legislation, which will include providing guidance to provincial and local authorities toward future sustainability of waste management services. Guidance is required on best practice options for collection, treatment and disposal, all under the authority of the MOC.

Enforcement

Enforcement of high operational standards and existing regulation is a key issue. In the longer term this will involve amendment of the law to support the progressive separation of EPB's with regulation and enforcement functions from financial control, which is currently under municipal government, and proposed to be transferred to SEPA responsibility.

Licensing

Licenses must be issued in addition to other planning permits and authorizations, without which no facility or practice may commence development. The local SWM

Department, following formal consultation and approval, will issue licenses from the local EPB.

Research

Improve and Develop Research

Research organizations are encouraged to strengthen and diversify their sources of income and focus research in key areas. National Government will provide financial support for information needs that must be improved over the Strategy period.

Technology Research & Development

Government supports research and development of in-country technologies to be used for collection, transportation, treatment and disposal of waste to meet high standards with regards to operational efficiency and emission standards.

Pilot Projects

Pilot projects may represent an important method of testing new ideas before widespread adoption. The MOC will support appropriate pilot projects and will disseminate successful information and experiences.

Data

Data and Reporting

The SWM Departments within the ESBs and EPBs acting for municipal authorities should maintain annual data records covering total waste arising, by type, quantity and composition for all waste types.

Training

Professional Training

MOC will issue regulations and prepare training courses for managers to ensure professional competence and achieve professional certification. Training centers will be established within Universities, technical colleges, and professional waste management associations.

Professional Networks

The Government, through the MOC, will encourage continued development of professional association and network's within the PRC to assist the transfer and exchange of skills, experiences, and organize conferences and lectures.

Information

MOC and SEPA will develop informative national websites on waste management issues to be central resource for shared experiences and developments in waste management.

Awareness and Participation

Importance of Awareness

Levels of awareness and participation will drive the pace of improvement of waste management practices. All citizens should become increasingly aware of the need to minimize wastes, improve the quality of the outside environment, and the positive impact of a clean environment on everyday life. Professional awareness is critical to support future developments in waste management.

Waste Minimization and Green Consumption

Per capita waste volumes are relatively low in PRC compared to those in many other countries, but are still likely to grow with economic development. Programs and measures should be taken to ensure that waste growth is kept to a minimum through 'green consumption'; minimize the use of packaging, adopting efficient methods for the manufacture of products, recycling, recovery and reuse.

Leaders Awareness

Leader's awareness of critical waste management issues is critical to improved and sustainable waste management practices and should be promoted by state government through seminars, conferences and networks.

Officers Awareness

All officers with responsibilities related to SWM aspects should have detailed awareness of all relevant issues.

Environmental Education in Universities and Schools

MOC will work with the Ministry of Education to ensure that waste management education is integrated within environmental components in school curricula.

Children's Awareness

The strategy calls for an intergenerational shift in awareness of waste management as a critical issue affecting society and should be given increased attention in children's education. Waste minimization and environmental protection should be key messages.

Public Awareness

Municipal authorities should ensure that the publics is aware of their responsibilities to ensure the affordability of effective waste management and protection of the environment.

Open Access to Information

Municipal authorities should ensure that the public has open access to information and decisions that concern waste management, and information in relation to information regarding the location of waste management programs and facilities.

Community Groups and NGO's

Community groups and NGOs are encouraged to take part in decision-making and local schemes to improve waste management practices and to contribute to environmental protection. Municipalities should register and act on any public complaints on poor performance of services.

Media and Events

Awareness about waste generation and prevention should be raised through all media vehicles such as; television, radio, newspapers and street propaganda.

Participation

Cities are encouraged to obtain participation from a broad range of key stakeholders in the waste management planning process to ensure that all perspectives are considered.

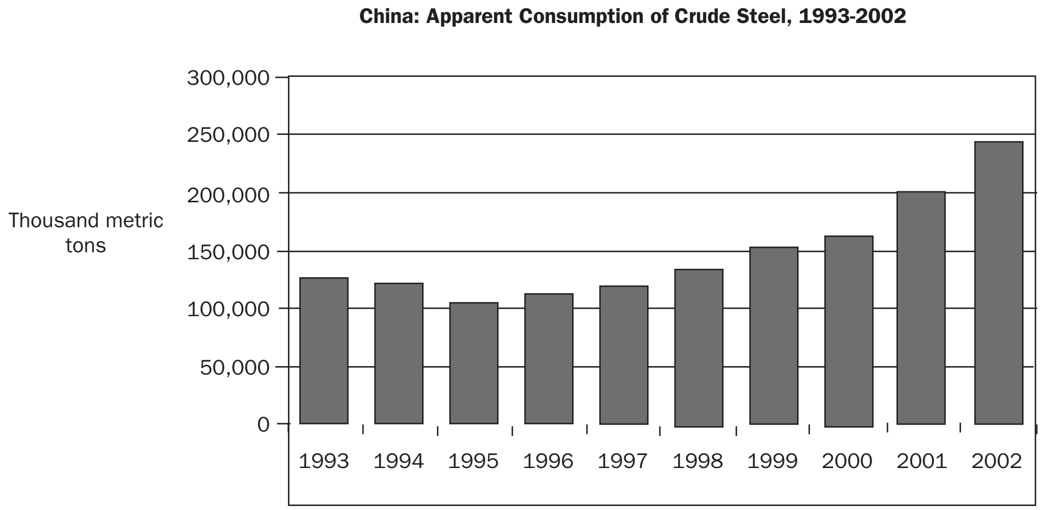
Public Consultation

Cities are encouraged to integrate a formal 3-month period of public consultation into their waste management planning process.

From: Cambel, 2001 ADB Report

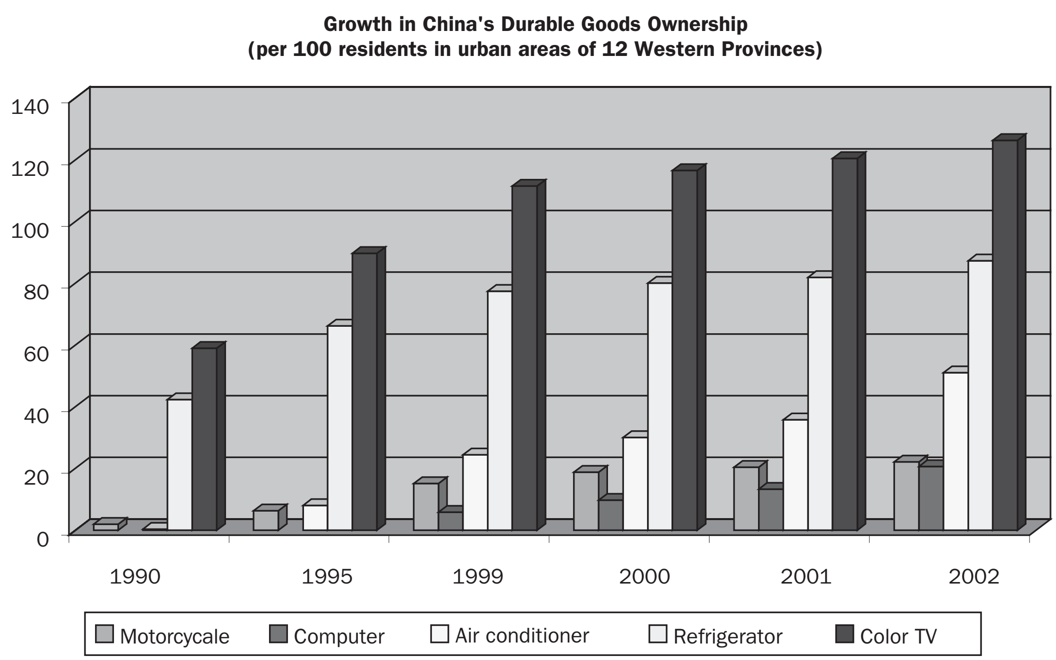
Annex 3: China's growing commodity demand

Figure A3.1:



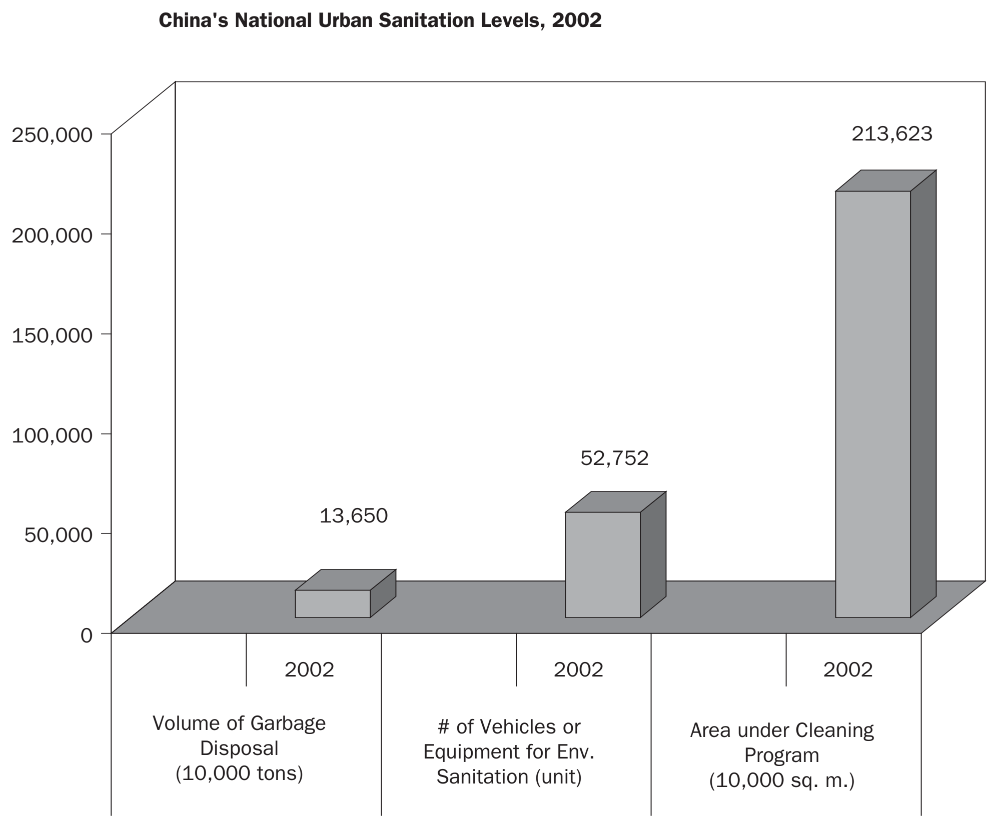
Source: China Statistical Yearbook (versions 2001 and 2003), National Bureau of Statistics of China, China Statistics Press, 2001 and 2003

Figure A3.2: Growth in China's Durable Goods Ownership



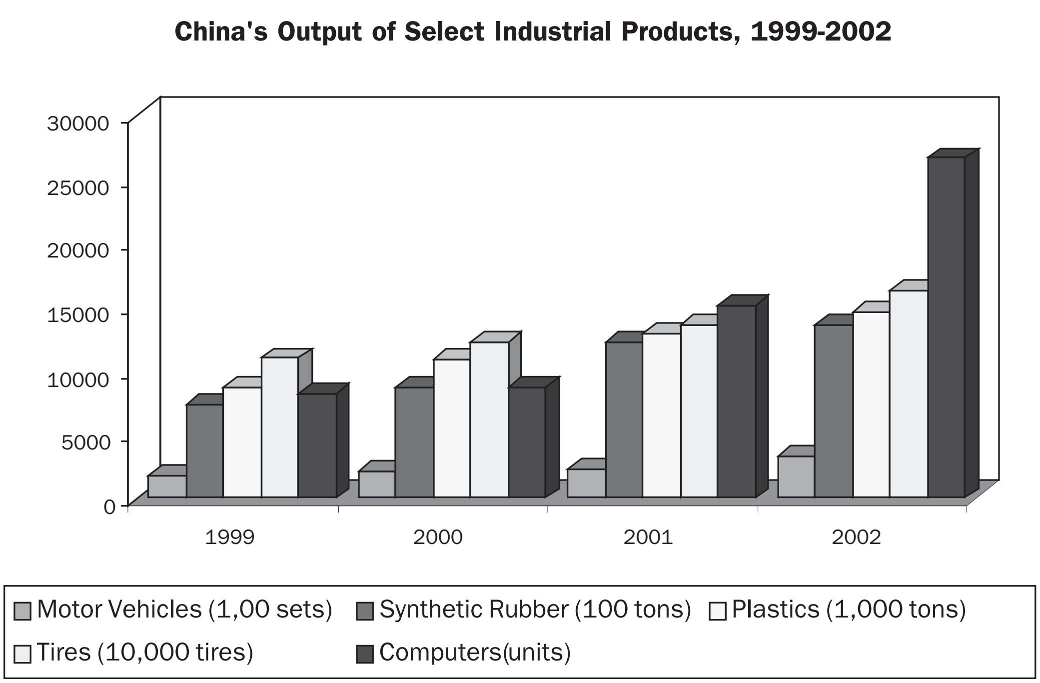
Source: China Statistical Yearbook (versions 2001 and 2003), National Bureau of Statistics of China, China Statistics Press, 2001 and 2003

Figure A3.3:



Source: China Statistical Yearbook (versions 2001 and 2003), National Bureau of Statistics of China, China Statistics Press, 2001 and 2003

Figure A3.4:



Source: China Statistical Yearbook (versions 2001 and 2003), National Bureau of Statistics of China, China Statistics Press, 2001 and 2003

Table A3.1: World Aluminum Consumption 2001

Country	World Refined Aluminum Consumption 2001[1]	Per capita GNI (thousand tons) 2001[2]
USA	5122.0	35,060
Japan	2014.0	33,550
Hong Kong	49.7	24,750
Germany	1552.0	22,670
United Kingdom	433.3	25,250
Australia	316.6	19,740
South Korea	849.6	9,930
Malaysia	92.2	3,540
Chile	14.5	4,260
Poland	138.9	4,570
Russia	786.3	2,140
Thailand	227.1	1,980
Brazil	552.8	2,830
Bulgaria	8.5	1,790
China	3545.4	950
Egypt	96.5	1,470
Indonesia	162.9	710

1 World Bureau of Metal Statistics 2001
2 World Bank

Table A3.2: A Comparison of resource consumption in China, USA, India and France

	CHINA	USA	INDIA	FRANCE
Area	3,705,820 square miles	3,717,796 square miles	3,287,590 sq km	547,030 sq km
Population	1,288,700,000	291,500,000	1,048,300,000	59,800,000
Persons per quare mile	348	78	842	281
Carbon Dioxide Emissions	2.5 metric tons	19.8 metric tons	1.1 metric tons	6.3 metric tons
Energy Consumption per person (kilograms oil equivalent)	880 kilograms oil equivalent	7,960 kilograms oil equivalent	482 kilograms oil equivalent	4,351
Tobacco Use	35.6%	23.6%		
Meat Consumption per person	104 pounds	269 pounds	9 pounds	220 pounds
Paper Consumption per person	73 pounds	730 pounds	10 pounds	408 pounds
Average Number of Persons per room	1.1	0.5		
Water Use per person (agricultural, industrial, domestic)	116,000 gallons	484,500 gallons		
TV sets per 1,000 persons	292	844		
Vehicles per 1,000 persons	16	774		469

National Geographic March 2004
http://www.odci.gov/cia/publications/factbook/fields/2147.html

Table A3.3: Per Capita Coca-Cola Consumption and Market Populations, 2002

Market	2002 Population (millions)	2002 Per capita consumption	1996 Population (millions)	1996 Per capita consumption
India	1,065		953	3
United States	293	436	266	363
Indonesia	238		201	9
Brazil	184	146	164	131
Japan	127	170	125	144
Philippines	65		69	117
Thailand	48	73	59	67
Korea, Repulic of	20	309	45	72
Australia	16	334	18	308
China	1,295	10	1,234	5

*8-ounce servings of Company beverages per person per year (excludes products distributed by The Minute Maid Company)
(Coca-Cola Company, 2002)

Table A3.4: Resource Consumption

	Passenger Cars per 1000 people		Total Annual Energy Consumption per capita		Annual Gasoline & Diesel Consumption per capita (liters per person)		Annual Electricity Consumption per capita (kg oil equivalent)		Annual Paper Consumption (kg per person)	
	1990	1999	1990	1999	1990	1999	1990	1999	1990	1999
USA	573	…	7.78	8.09	1,878	2,043	875	1,023	302.5	341.9
Japan	283	..	3.39	4.06	516	679	493	693	223.6	239.7
Germany	386	..	4.56	4.11	715	826	506	490	184.1	216.6
United Kingdom	341	..	3.69	3.89	739	789	405	465	167.8	200.3
Australia	450	..	5.12	5.70	1,261	1,258	634	765	161.6	183.8
South Korea										
Malaysia	101	170	1.17	1.96	281	535	89	222	40.7	94.3
Chile	52	88	1.01	1.69	232	377	100	199	28.1	51.0
Poland	138	240	3.20	2.24	224	284	233	206	39.5	58.7
Russia	…	..	..	4.12	..	285	..	349	..	19.5
Bulgaria	146	233	3.51	2.26	331	239	371	255	59.6	24.4
Thailand	14	..	0.70	1.14	156	268	52	113	13.4	29.9
Brazil	…	…	0.94	1.07	172	248	122	156	29.1	35.9
China	1	..	0.74	0.86	…	…	36	65	16.1	33.2
Egypt	21	..	0.56	0.67	80	95	54	73	8.6	19.2
Indonesia	7	..	0.48	0.65	54	98	11	29	6.0	20.0
India	2	…	0.42	0.48	28	44	20	33	2.8	4.4

Source: International Energy Agency (IEA), The World Bank, United Nations Population Division, Food and Agriculture Organization of the United Nations

Figure A3.5:

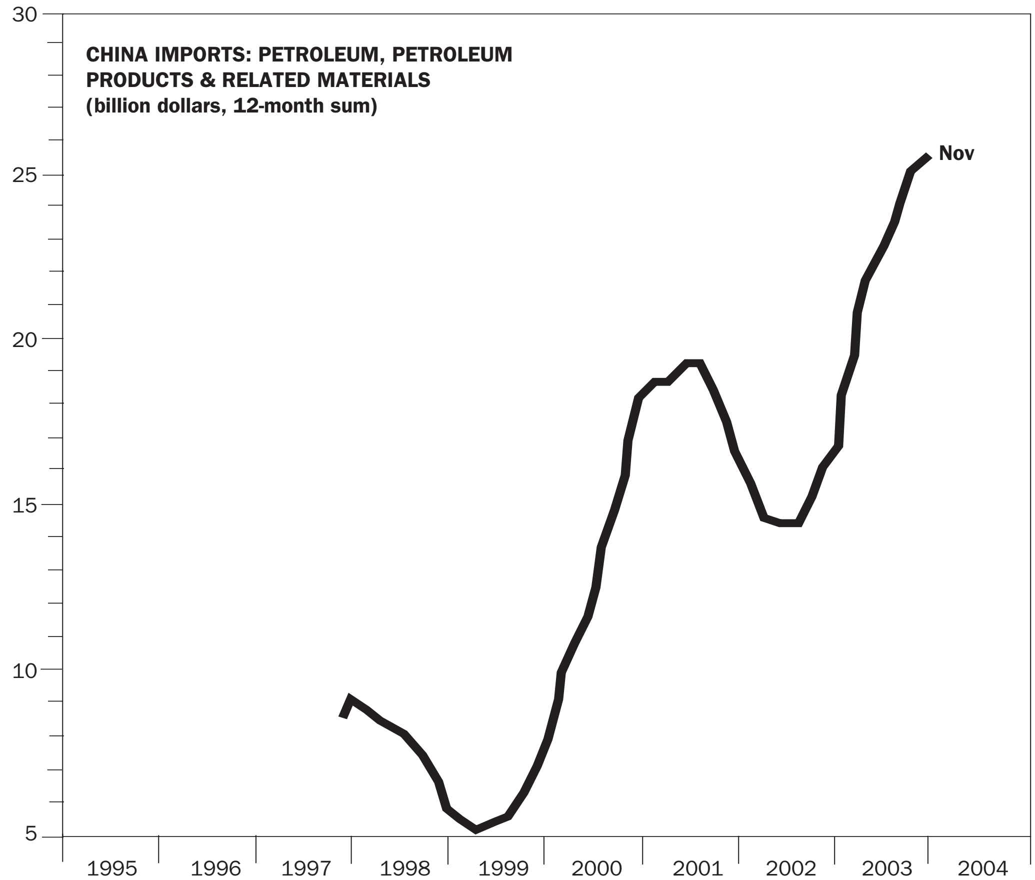


Figure A3.6:

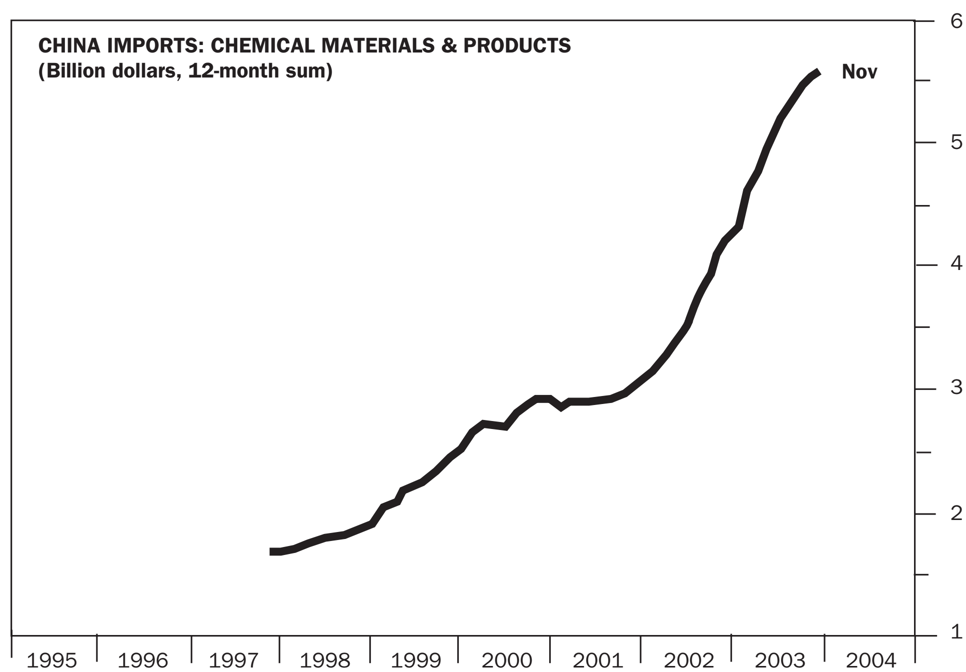


Figure A3.7:

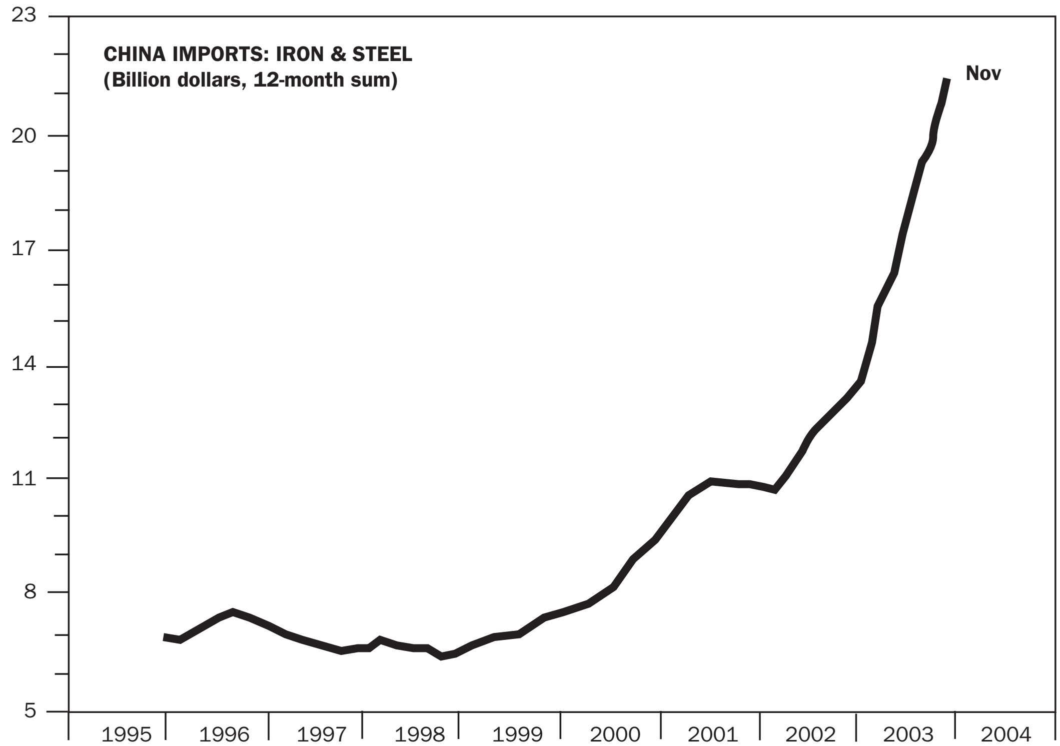


Figure A3.8:

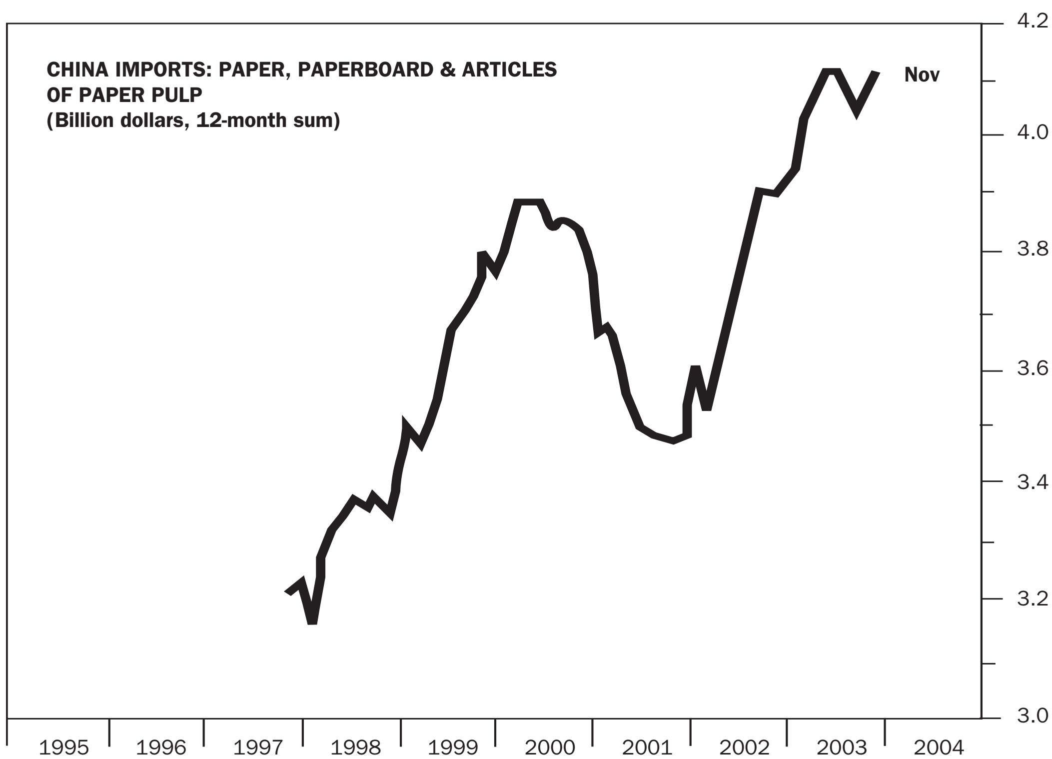
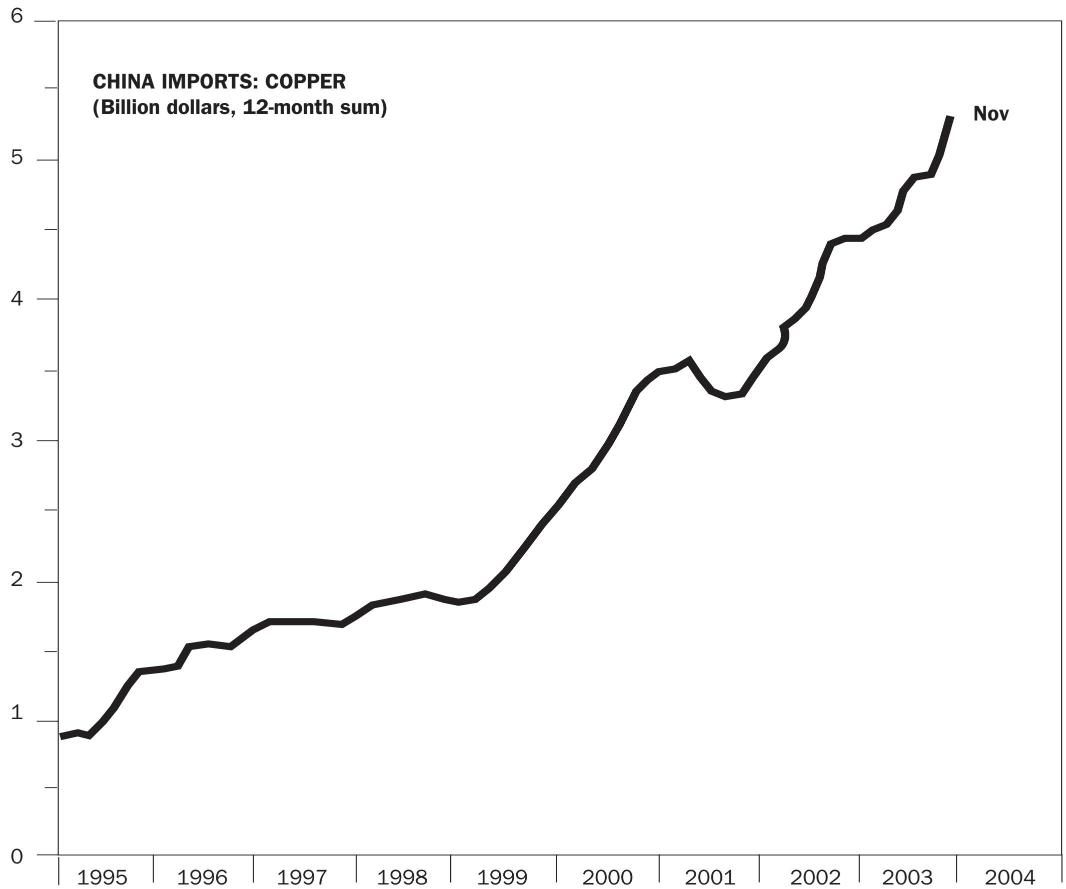


Figure A3.9:



From: Yardeni, Edward, China for Investors II: The Games, Prudential Equity Group Research, January 2004.

Annex 4: National Chinese Laws and Regulations on MSW – A Summary

Laws and Regulations (Chinese)	Laws and Regulations (English)	Brief Description	Issuer	Effective Time
中华人民共和国固体废弃物污染环境防治法	Law on Prevention and Control of Environmental Pollution Caused by Solid Waste of PRC	First law to regulate the management of MSW.	The Standing Committee of the National People's Congress	April 1, 1996
中华人民共和国清洁生产促进法	Law for Promotion of Cleaner Production of PRC	From each step of the production, the manufacturers should take measurements to reduce pollution.	The Standing Committee of the National People's Congress	January 1, 2003
中华人民共和国环境影响评价法	Law for Environment Impact Assessment of PRC	Emphasize the importance of preventing environmental pollution from source; any new construction must obtain EIA approval before breaking ground.	The Standing Committee of the National People's Congress	September 1, 2003
城市市容和环境卫生管理条例	City Appearance and Environmental Sanitary Management Ordinance	Principle guidelines on city appearance (outdoor advertisement & horticulture) and environmental sanitary (MSW & public latrines) management; Local work government would out practical measurements.	The State Council	August 1, 1992
城市生活垃圾管理办法	Regulations Regarding Municipal Residential Solid Waste	Regulations regarding the management of collecting, transferring and treating residential solid waste.	The Ministry of Construction of PRC	September 1, 1993
城市生活垃圾处理及污染防治技术政策	Technical Policies on the Disposal of Domestic Waste and the Prevention of Pollution	Guidance and standards of the technologies applied in the MSW treatment.	The Ministry of Construction of PRC	June, 2000
关于推进城市污水处理，垃圾处理产业发展的意见	Comments on Promoting the Industrialization of Municipal Waste Water Treatment and Municipal Solid Waste Treatment	An important signal for attracting private and foreign investment into municipal waste water and solid waste industry.	State Development & Planning Committee, The Ministry of Construction, and State Environmental Protection Administration	September, 2002
危险废物污染防治技术政策	Technical Policies on the Treatment and Pollution Prevention of Hazardous Waste	Guidance and standards of the technologies applied in hazardous waste treatment.	State Environmental Protection Administration	December, 2001
医疗废弃物管理条例	Management Regulations on Medical Waste	First regulation on the management of medical solid waste; Promulgated after the SARS attack in 2003.	The State Council	June 26, 2003
国家危险废物名录	National Catalogue of Hazardous Waste	National standard on the definition and classification of the hazardous waste.	State Environmental Protection Administration	
关于加强沿主要道路，河流和旅游景点塑料包装废弃物管理的意见	Proposals on Strengthening the Management of the Plastic Package Waste along the Main Roads, in River Basins and at Tourist Attractions	Measurement to control the "white pollution".	The Ministry of Construction of PRC	
危险废物转移联单管理办法	Measures on the Management of Duplicated Form for the Transfer of Hazardous Waste	Regulations regarding the registration, generation and transfer of hazardous solid waste.	State Environmental Protection Administration	1998

From: InterChina,, 2004

Annex 5: Trade Associations

Box A5.1: Brazilian Business Commitment for Recycling (CEMPRE)

The Brazilian Business Commitment for Recycling (Cempre) is a non-profit association dedicated to the promotion of recycling within the scope of integrated waste management. Established in 1992, Cempre is maintained by private companies from various sectors that have come together to ensure that their perspective on solid waste (particularly packaging issues) are considered by waste planners, and to help governments manage their waste efforts. Cempre's aim is to increase the societal conscientiousness about recycling, and waste as a whole, through publications, technical research, seminars and data banks. The awareness raising programs are directed principally at those who influence public opinion, like mayors, directors of companies, academics, and non-governmental organizations (NGO's). In addition the organization provides, via a World Wide Web, tips on how to sell recyclable material; economic indicators on, technical aspects of, waste collection and recycling; and a database on packaging and the environment.

Cempre's involvement has extended beyond Brazil. The Latin American Federation of Business Associations for the Promotion of Integrated Solid Waste Management was created to exchange information amongst its members. The Association for the Defense of the Environment and Nature (ADAN) in Venezuela, CEMPRE/Brazil, CEMPRE/Uruguay, the Industry and Commerce Pro-Recycling Organization (ICPRO) in Puerto Rico, and Sustena in Mexico, have formed similar partnerships.

Homepage: www.cempre.org.br

Box A5.2: Corporations in Support of Recycling (CSR)

CSR started in 1986 as OMMRI. OMMRI was a multi-industry body that helped capitalize Ontario's blue box network and is focused on improving the system. It was originally set up in 1986 by the soft-drink industries and their suppliers to help capitalize the budding blue box industry

OMMRI was established by bottlers, grocery product manufacturers and distributors, printed paper users, and packagers to established to broaden the blue box funding base.

OMMRI changed its name to CSR (Corporations in support of Recycling)as it had broadened its focus from provincial issues to issues at national level. CSR's mission is to provide focused, coordinated, private sector leadership for voluntary, multi-sectoral initiatives designed to reduce, in a cost-effective manner, the impact of our products on the solid waste stream.

CSR's objectives are to work to increase the range and quantities of materials recovered through curbside programs, to improve the cost-effectiveness of programs, to stimulate markets for recyclables and to encourage innovation in the field of waste management.

CSR/OMMRI developed a "self-assessment tool" to help municipalities and program operators monitor the cost effectiveness of their recycling programs to track where costs are incurred, and where improvements can be made.

The Recycling Council of Ontario: www.rco.on.ca

Box A5.3: CARI

The Canadian Association of Recycling Industries is the national organization of Canadian recycling industries. It was founded in 1941 after the federal government sent out an urgent request to Canada's leading scrap processors to help in the war effort by organizing into a unified force to collect and process scrap for Canadian metallurgical plants. Today it is comprised of companies ranging from individual scrap collectors to technologically advanced, capital intensive processing plants. Members are engaged in the recycling of all commodities, but the majority still deals primarily or exclusively in metals.

CARI is a classic industry association. Its functions are to promote the interests of the industry nationally and internationally; to work with governments on policies affecting recycling; to inform the public and to promote cooperation between member firms to solve common problems. CARI works closely with other industry groups across Canada and complementary associations in other countries. It develops promotional and educational materials and position papers that illustrate the industry and its significance in order to develop a better understanding of the value of recycling to Canadian society and the economy, and to ensure that legislation and regulations promote recycling.

Homepage: http://www.cari-acir.org

Box A5.4: ISTAC J.S. Co

Istanbul Greater Metropolitan City Municipality Environment Protection and Waste Material Recycling Industry and Trade J.S.Co is one of the economic associations of Istanbul, founded in 1994 within the "Solid Waste Project" of Istanbul Greater Metropolitan City Municipality. ISTAC J.S.Co regulates the transportation, recycling an destruction of solid wastes by the systematic storing method, production of electricity, production of compost, and transportation of medical wastes. ISTAC J.S.Co. has implemented the "Medical Waste Project" in 1995 replacing human and environmentally hazardous solid waste storage with hygienic and systematic storing areas. In 1995 two storing areas were established, five Solid Waste Transfer Centers. ISTAC J.S.Co. also has systematic tree planting campaigns, initiated in 1997. In 2001 ISTAC started the operation of Compost and Recycling Establishment, capable of processing 1000 tons of solid waste, which produces electricity from methane.

ISTAC J.S. Co, 2002

Annex 6: International Waste Legislation

Waste management strategies cannot be implemented without the support and guidance of legislative framework. Legislation should include a series of ordinances and regulations aimed at managing solid waste, including procedures and methodologies for monitoring and enforcing the regulations.

Following are brief descriptions of either current or draft legislation and action plans for some countries.

Table A6.1:International examples of waste legislation policies

Country	Legislation Policy	Date Implemented	Effectiveness
Taiwan	Article 51 of the Waste Clean Act- Shopping Bag use restriction policy	July 2002	–demonstrated public support between 70 and 90 percent –awareness of policy doubled from 44% in 2001 to 80 percent in 2002 –73% reduction in bag use since January 2003
Ireland	Plastax- 17 euro-cent per bag levy tax on every consumer plastic bag plastic bag litter to reduce amount of	March 2002	–reduced plastic bag consumption by over 90% –raising public awareness
	Waste Management Strategy for Northern Ireland	March 2002	25% Recycling and Composting by 2010[1]
India	Nation wide- (plastic bag waste was too thin for ragpicker to collect/recycle). Solution: made thicker- only bags of at least 20 microns thick could be manufactured	July 2003	Ragpickers may now collect plastic bags for recycling[2]
	-Uttar Pradesh state government banned plastic bags	July 2003	
UK	Producer Responsibility Obligations (Packaging Waste) Regulations, 1997 Recovery Recycling Targets for: Paper, glass, Aluminum, steel, plastic, wood	1997	

1 Source: www.hhlibdems.org.uk/ldys/policy/article/plasticbags.php

2 www.mindfully.org/Plastic/Polyethylene/Bags-Choking-India22oct00.htm

England	Waste Strategy 2000	May 2000	Statutory targets of 17% Recycling and Composting of Household waste by 2003/4 and 25% by 2005/6 Other goals of recycling and composting 30% of household waste by 2010 and 33% by 2015 By 2005 reduce amount of commercial and industrial waste sent to landfill to 85% of that landfilled in 1998
	Household Waste Recycling Act 2003	October 2003	Requiring all local authorities in England to provide a curbside collection of at least two recyclable materials from all households by 31 December 2010.
Scotland	National Waste Strategy	December 1999	By 2006, 25% recycling and composting, other targets based on Waste Strategy Areas and their waste plans (using guidance on plan preparation)
EU	The next set of European packaging waste recovery targets are likely to be: Overall recovery: 60% as a minimum by weight. Overall recycling: 55% (maximum 80%) Material-specific recycling: Glass - 60%; Paper and board - 60%; Metals - 50%; Plastics - 22.5%; Wood - 15%.		
Japan	Japan Recycling Law: Food and other industries obliged to promote use of recycled resources as raw packaging materials and encourage recycling of product packaging. Recycling and reuse of beverage containers	1991	Japan leads the world in the recycling and packaging such as paper, steel and aluminum, despite lack of quotas for recycling.
Germany	Under Recycling Law companies are required to take back and recycle all of their packaging-applies to everyone. Of materials collected: -90% of glass and metals must be recycled -80% of paper, board, plastics and laminates must be recycled -Incineration, even if used to generate power is ruled out		Most demanding recycling law in the world:[1]

1 www.pstc.org/technical_notes/to_recycle.php

(continue on next page)

Table A6.1:International examples of waste legislation policies (continued)

Country	Legislation Policy	Date Implemented	Effectiveness
Brazil	Brazil's National Environment Law- Manufacturers, formulators, fillers, retailers, re-packagers and importers of packaged products are all responsible for collecting and ensuring "environmentally adequate" final disposal of packaging and its final (landfilling or incineration would only be allowed where it can be demonstrated that reuse or recycling is not possible)		In 2002 Brazil: 3,017,400 metric tons of paper (61.7% from corrugated cardboard boxes), 128 recycling businesses, 28,347 direct jobs created and sales of R$3.27 billion
Belgium	New Eco-tax on Beverage containers	April 2004	
South Africa	Prohibits all plastic bags under 30 microns thick, in the hopes that customers will reuse sturdier bag	August 1997	People of South Africa have a right to an environment that is not detrimental to their health
	National Waste Management Plan promotes a strategy that gives effect to Constitution of South Africa, Act 108 of 1996	1998 1996	
	National Environmental Management Act 107 -Strategy aims to reduce the generation an environmental impact of solid waste.		
Bangladesh	Ban on polyethelne bags		Plastic bags were found to be clogging drainage and sewage lines thereby increasing flooding and incidence of water-borne disease[2]
Philippines	Ecological Solid Waste [3]Management Act of 2000		• Section 26: Inventory of Existing Markets for Recyclable Materials • Section 27: Requirement for Eco-Labeling • Section 28: Reclamation Programs and Buy-back Centers for Recyclables and Toxics • Section 29 Non-Environmentally Acceptable Products • Section 30: Prohibition on the Use of Non-Environmentally Acceptable Packaging • Section 31: Recycling Market Development • Section 32: Establishment of LGU Materials Recovery Facility

2 http://www.hhlibdems.org.uk/ldys/policy/article/plasticbags.php

3 http://www.psdn.org.ph/pienc/ra9003.htm

SECTION 30. Prohibition on the Use of Non-Environmentally Acceptable Packaging. - No person owning, operating or conducting a commercial establishment in the country shall sell or convey at retail or possess with the intent to sell or convey at retail any products that are placed, wrapped or packaged in or on packaging which is not environmentally acceptable packaging

Examples of Waste Management Efforts in Some Countries

Table A6.2: UK packaging business recovery and recycling targets 2004-08 (%)

Material	2004	2005	2006	2007	2008
Paper	65	66	68	69	70
Glass	49	55	61	66	71
Aluminum	26	28	30.5	33	35.5
Steel	52.5	55	58	60	61.5
Plastic	21.5	22	22.5	23	23.5
Wood	18	19	20	20.5	21
Overall recovery	63	65	67	69	70
Minimum recycling *	94	94	94	95	95

* The minimum percentage of recovery to be achieved through recycling.
Source: http://www.letsrecycle.com/materials/packaging/packaging_targets_2004.jsp

United Kingdom

Producer Responsibility Obligations (Packaging Waste) Regulations, 1997
SI 1997/648 (as amended)
A company involved in the production and sale of packaging or packaging materials has an obligation as a *producer* under the regulations where the company owns and handles more than 50 tonnes of packaging material in a year and the annual turnover of the company or the group exceeds £2 million. A producer can be a *manufacturer, converter, packer/filler, seller or importer* of packaging or packaging material. The obligations can be discharged individually or by joining a registered scheme.

Packaging (Essential Requirements) Regulations 1998
SI 1998/1165
These regulations implement Directive 94/62/EC on packaging and packaging waste, which relate to the essential requirements to be satisfied by packaging. The regulations apply to all packaging placed on the market in the UK, and are enforced by trading standards officers of local authorities. The regulations place a responsibility on any company that introduces packaging onto the marketplace to ensure that it is minimal, safe, and is either reusable, recoverable, or recyclable.

Japan

Japan leads the world in the recycling of packaging, such as glass, paper, steel and aluminum, despite the fact that it has no established quotas for recycling. The pressure of limited landfill space and a tradition of energy conservation pushed Japan into environmental leadership. Tokyo's last landfill will close within a year, and Japan is also dependent upon imports of raw materials. Until 1991, Japan had no law in place to encourage recycling. A temporary surge of waste in the late 1980s lead to landfill expansions. Japan has now recruited its engineering, scientific and technologies to its environmental campaign. They believe protecting the global environment became a number one issue among the general public as well as in government policy and diplomacy. Under the Japan recycling law, food and other industries are obligated to promote the use of recycled resources as raw packaging materials and to encourage consumers to recycle product packaging. While beverage containers are a top priority for recycling and reuse, recycled food packaging usage carries restrictions under Japan's Food Sanitation Law.

From:http://www.wiu.edu/users/mscn/sp2001/trash/china.html

Brazil

Brazil's National Environment Council (CONAMA) has the power to enact packaging regulations with the force of law without any new legislation. The state of Rio de Janeiro already has enacted its own plastic law, and a more stringent bill has already cleared one house of the federal legislature. The proposals are causing disquiet in the Brazilian packaging community, at how closely the CONAMA concept follows European packaging waste laws. In line with the overarching National Waste Policy outlined by CONAMA in June 1999, the Packaging Resolution would have at its core the concept of producer responsibility. Unlike other sectors singled out for special CONAMA resolutions under the National Waste Policy, responsibility in this case is to be distributed throughout the packaging chain. The primary article says that "manufacturers, formulators, fillers, retailers, re-packagers and importers of packaged products placed on the Brazilian market" are all responsible for collecting and ensuring "environmentally adequate" final disposal of "packaging and its wastes." ["Environmentally adequate" final disposal is not yet defined, but if it follows CONAMA drafts on other waste issues, it will be defined in such a manner that landfilling or incineration would only be allowed where it can be demonstrated that reuse or recycling is not possible.

Table A6.3: Evolution of the recovery rate in recyclable paper- 1980-2002

Year	Visible paper consumption (all types)	Recovery of recyclable paper (1,000 tons)	Recovery rate (%)
1980	3,428	1,052	30.7
1990	4,053	1,479	36.5
2000	6,814	2,612	38.3
2002	6,879	3,017	43.9

· In the above table, recycling of sanitary and special paper has not been considered, due to lack of technical feasibility. If they are eliminated from total visible consumption, the recovery rate rises to 49%.

South Africa

South Africa's National Waste Management Strategy presents a long-term plan (up to the year 2010) for addressing key issues, needs and problems experienced with waste management. The strategy gives effect to the Bill of Rights, Constitution of South Africa, on the basis of which the people of South Africa have the right to an environment that is not detrimental to their health. The strategy translates into action Government's policy on waste as set out in the Draft White Paper on Integrated Pollution and Waste Management for South Africa (published in 1998). The objective of integrated pollution and waste management is to move away from fragmented and uncoordinated waste management to integrated waste management. Such a holistic and integrated management approach extends over the entire waste cycle from cradle to grave, and covers the prevention, generation, collection, transportation, treatment and final disposal of waste. Integrated waste management thus represents a paradigm shift in South Africa's approach to waste management, by moving away from waste management through impact management and remediation and establishing instead a waste management system which focuses on waste prevention and waste minimization.

CANADA–container recovery programs

- 80% recovery goal. The program should establish a mandatory goal of 80% material recovery, consistent with BEAR core principles (the report shows that while most bottle bill states recover at a level close to or greater than 80%, the overall average U.S. recovery rate for all containers is 41%):
    - The recovery goal should cover all types of beverages (all carbonated and non-carbonated beverages such as soft drinks, beer, wine, liquor, juices, waters, and milk) and all types of beverage containers (all metal, glass, plastic, aseptic and composite containers), as well as associated packaging.
    - The recovery goal should be based upon container units sold, excluding exported new containers and imported scrap containers.
    - The recovery goal should focus on material recovery (reuse and recycling) and should not include burning (waste-to-energy, pyrolysis, etc.) or other treatments to produce fuel.
    - The recovery goal should be achieved on an aggregate basis over a 2-year period from program implementation, but should ultimately apply as a minimum for each material type.
    - The recovery goal should increase over time to ensure that the recovery rate continually improves.
- Consumer redemption incentive. The program should establish a redemption incentive (deposit refund or other financial mechanism) paid to consumers when the container is recycled to encourage recycling.
- Beverage container returns. Returns of beverage containers should be allowed through a variety of options, ensuring consumer convenience while minimizing costs.
- Internalization of costs. The cost of beverage container recovery should be internalized, with producers and consumers paying the full cost of recovering their containers, and no part of the cost being borne by the public.
- Refillables incentive. A redemption system should include incentives for the use of refillable bottles, such as economic incentives and market share set-asides. A return to the refillable packaging systems developed by the beverage industry in the early 20th Century and later dismantled in response to subsidies that made mass-production and long-distance distribution more economical will create opportunities for local business and reduce environmental costs that are now being borne by the public.
- Closed-loop recycling. A deposit system should encourage bottle-into-bottle recycling in order to reduce environmentally damaging emissions from virgin material extraction and production and minimize market disruptions during periods of rapid increase in container recovery.
- Centralized fund. Since the program would involve all beverage brands, it may be more cost-efficient to be managed through a centralized fund similar to the industry-managed fund in British Columbia or the state-managed fund in California, so brand sorting is not necessary.

- Responsibility for compliance. As the party in the value chain with control over packaging design and product marketing, the brand-owner should be ultimately responsible for meeting the 80% recovery goal and ensuring that the members of the supply chain and consumers share responsibility for the cost of recycling. Government would impose corrective measures should the system fail to perform.
- System design flexibility. The overall program design would depend upon whether it was managed by government or beverage producers (see key issues discussion below); however, producers should be given flexibility to design the system in a manner which minimizes costs. Producers may choose to operate their own programs or to contract with other private or public entities on their behalf, so long as the so long as the full costs of recovering the resources and managing products at the end of life are internalized into the costs of producing and selling products and are not borne by taxpayers.
- Market development. Producers should be encouraged to actively participate in development of value-added markets for recovered containers.

Source: http://www.grrn.org/beverage/deposits/essential_elements.htm

Annex 7: Recyclable Material Prices in Shanghai

Material	Selling Price (RMB/Kg)
Papers	
Paperboard	0.70
Newspaper	0.95
Books and periodicals	0.70
Plastics	
Plastic bottle of Cola	0.22/unit
Plastic bottle (other drinks)	0.10
Other plastic	0.80
Polyethylene	0.60
Polypropylene	0.80
Plexiglas	0.95
Other plastics	0.40
Plastic drum of point	1.20
Electric Appliances	
Television	5~ 280/ piece
Refrigerator	30~150/ piece
Washing machine	10~90/ piece
Air-conditioner	110~800 /piece
VCD Player	50~100/ piece
Metals	
Waste iron	0.90
Iron sheet	0.20
Pig iron	0.70
Brass	9.30
Brass fillings	6.80
Red copper	12~15
Sundry red copper	10.50
Aluminum can	0.11/ unit
Aluminum alloy	10.00
Raw aluminum	8.00
Other aluminum	10.00
Aluminum for civil use	7.00
Others	
Beer bottle (glass)	0.10
Cotton wadding (for quilt etc.)	0.70

Price data for January- February 2004
From InterChina Report, 2004

Annex 8: Content of Waste Management Plans

An integrated Solid Waste Management plan should contain:

- A section covering all municipal policies, aims and objectives, related to waste management, including waste minimization initiatives;
- A section covering the character and scale of the city, natural conditions, development and distribution of population;
- A section covering data on all waste generation, including data covering both recent years and projections over the lifetime of the plan (usually 15-25 years). This should include data on MSW composition and other characteristics, such as moisture content and density (dry weight), present and predicted
- A section identifying all proposed options (and combination of options) for waste collection, transportation, treatment and disposal of the defined types and quantities of solid wastes (this must address options for all types of solid waste arising);
- A section presenting the evaluation of the Best Practical Environmental Option(s), integrating balanced assessments of all technical, environmental, social and financial issues;
- A section presenting the proposed plan, specifying the amount, scale and distribution of collection, transportation, treatment and disposal systems to be developed, with proposed waste mass flows proposed through each;
- A section clearly specifying the proposed on-going monitoring and controls that will be implemented in conjunction with facilities and practices and ways in which this information will be regularly reported;
- A section identifying the associated institutional reforms and regulatory arrangements needed to support the plan;
- A section presenting a financial assessment of the plan, including analysis of both investment and recurrent costs associated with the proposed facilities and services, over the lifetime of the plan (or facilities);
- A section identifying all the sources of finance and revenue associated with developing and operating the plan including estimated subsidy transfers and user fees;
- A section separately covering the requirements for managing all non-MSW arisings, what facilities are required, whom will provide them and the related services, and how such facilities and services will be paid for.
- A section presenting the proposed implementation plan covering a period for at least 5-10 years, with an immediate action plan detailing actions set out for the first 2-3 years.
- A section outlining public consultation carried out during preparation of the plan and proposed in future
- A section outlining the detailed program to be used to site key waste management facilities e.g. landfills, compost plants and transfer stations.

Annex 9: Municipal Solid Waste Incineration- A summary

Waste As Fuel

- The average lower calorific value of the waste must not be lower than 6 MJ/kg throughout all seasons. The annual average lower calorific value must not be less than 7 MJ/kg.
- Forecasts of waste generation and composition are established on the basis of actual waste surveys in the collection area for the planned incineration plant, and should be carried out by an experienced and independent institution.
- Assumptions on the delivery of combustible industrial and commercial waste to an incineration plant should be founded on an assessment of positive and negative incentives for the various stakeholders to use the incineration facility.
- The annual amount of waste for incineration should not be less than 50,000 metric tons and the weekly variations in the waste supply to the plant should not exceed 20 percent. (see tables A10.1 and A10.2)

Institutional Framework

- A well-functioning solid waste management system, including a properly designed and operated sanitary landfill, has been present for at least three years.
- Solid waste collection and transportation (domestic, commercial, and industrial) are managed by a limited number of well-regulated and controlled organizations.
- There are signed and approved letters of intent or agreements for waste supply and energy sale.
- Consumers and public authorities are able and willing to pay for the increased cost of waste incineration.
- Authorities responsible for control, monitoring, and enforcing facility operations are present.
- The authorities responsible for control, monitoring, and enforcement are independent of the ownership and operation of the plant.
- Skilled staff for plant operation are available at affordable salaries. Otherwise, reliable operation and/or maintenance contracts are in place either in the form of operation and service contracts or via BO/DBO/BOOT/BOO schemes.

Incineration Plant Economics and Finance

- There is a stable planning environment with relatively constant pries for consumables, spare parts, disposal of residues, and sale of energy. Furthermore, the capital costs (large share of foreign currency) can be predicted
- Financing the net treatment costs must ensure a waste stream as intended in the overall waste management system. Consequently, the waste incineration tipping free must be lower than (or at least, no greater than) the fee at the landfill (net of transportation costs). Willingness and ability to pay must be addressed.
- Foreign currency is available for purchasing critical spare parts.
- To be economically feasible, the capacity of the individual incineration lines should be at least 240 t/d (10t/h). Plant should have at least two individual lines.
- When surplus energy is to be used for district heating, the incineration plant must be located near an existing grid to avoid costly new transmission systems.
- If a regular market for the sale of hot water (district heating or similar) or steam is present, the plant should be based on the sale of heat only- both in terms of technical complexity and economic feasibility. A certain extent of cooling to the environment during the warm season may be preferable to costlier solutions.

The Project Cycle

- A skilled, independent consultant with experience in similar projects should be employed at the onset of the planning.

- The public perception of waste incineration should be taken into consideration. The public should be involved in, and informed about all phases- but particularly the feasibility and project preparation phases.

Plant Location

- A controlled and well-operated landfill must be available for disposing residues.
- In relation to the air quality in the site area, frequent and prolonged inversion and smog situations are not acceptable.
- MSW incineration plants should be located in land-use zones dedicated to medium or heavy industry.
- MSW incineration plants should be located in industrial areas close to power plants.
- It should take no longer than one hour to drive a truck from the waste generation area to the plant.
- MSW incineration plants should be at least 300 to 500 meters from residential zones.
- MSW incineration plants should be located near suitable energy consumers.

Incineration Technology

- The technology must be based on well-proven technology. The chosen (or proposed) supplier must have numerous reference plants already in successful operation for a number of years.
- The further must be designated for stable and continuous operation and complete-out of the waste and flue gases.
- The annual amount of waste for incineration should be no less than 50,000 metric tons, and the weekly variations in the waste supply to the plant should not exceed 20 percent.

Energy Recovery

- The flue gases from the furnace must be cooled to 200 degrees C or lower in a boiler in order to apply available flue gas treatment technology
- The plant economy should be optimized through energy recovery and sale.
- Irrevocable agreements for energy sale (type and quantity) should be in place before and final decision is made on the design of the energy recovery section of an MSW incineration plant.
- When surplus energy is to be used for district heating, the incineration plant must be located near an existing grid to avoid costly new transmission systems.
- If there is a regular market for the sale of hot water (district heating or similar), or if steam is present, the plant should be based on production of hot water or steam only. These configurations are normally preferable both in terms of technical complexity and economic feasibility. During the warm season, a certain extent of cooling to the environment may be preferable to solutions demanding greater investments.

Air Pollution Control

- The furnace must be designed for stable and continuous operation and complete burnout of the waste and flue gases.
- The flue gases from the furnace must be cooled to 200 C or lower in a boiler before flue gas treatment technology can be applied.
- The flue gas treatment installation must be capable or removing dust at least as efficiently as a two-stage electrostatic precipitator.
- A controlled and well-operated landfill must be available for residue disposal.
- Elimination of hydrogen chloride (HCL) from the flue gases should be considered.

Incineration Residues

- A controlled and well-operated landfill must be available for residue disposal. The landfill must be large enough to receive the entire quantity of solid residual products generated at the incineration plant.
- The landfill must be located, designed, and operated in such a way as to prevent water pollution resulting from the leachate from the residues.
- Scrap iron may be recovered for recycling by magnetic separation of the slag.
- By sorting or sieving the slag a "synthetic gravel" fraction may be recovered for utilization.
- The dry residues should be prevented from generating dust at the landfill site.
- Flue gas residues should be treated as hazardous waste and not mixed with bottom ash.

Operation and Maintenance

- Foreign currency is available for purchasing critical spare parts.
- Skilled plant operation staff are available to the plant owner at affordable salaries. Otherwise, reliable operation and/or maintenance contracts must be in place in the form of operation and service contracts.

Environmental Impact and Occupation Health

- The flue gas treatment installation must be capable of removing dust at least as efficiently as a two-stage electrostatic precipitator.
- A controlled and well- operated landfill must be available for the disposal of residues
- To avoid noise, dust, and odor in residential areas, MSW incineration plants should be located in land-use zones dedicated to medium or heavy industry.
- The stack should be twice the height of the tallest building within 1.0 km, or at least 70 meters high.

From: Rand, T., Haukohl, J., Marxen, U. , Municipal Solid Waste Incineration; Requirements for a Successful Project, June 2000.

Table A9.1: Fuel Characteristics of Municipal Wastes

		Guangzhou China			
			8 districts- 93	5 districts- 94	Philippines
Parameter	Units	Range	Mean	Mean	Manila- '97
Combustible	%	14.6-25.5	22.3	31.4	37.6
Ash	%	13.8-43.1	28.8	22.0	15.6
Moisture	%	39.2-63.5	48.9	46.6	46.7
Lower calorific value	kJ/kg	2555-3662	33359	5750	6800

Table A9.2: Example of Calculation of Lower Calorific Value from Analysis of Waste Fractions and H_{awf} Values

Mass basis		*Fraction basis*				*Calorific values*	
Fraction	% of Waste	Moisture W%	Solids TS%	Ash A%	Combustible C%	H_{awf} kJkg	H_{inf} kJ/kg
Food and organic waste	45.0	66	34	13.3	20.7	17,000	1,912
Plastics	23.1	28	71	7.8	63.2	33,000	20,144
Textiles	3.5	33	67	4.0	63.0	20,000	11,789
Paper and cardboard	12.0	47	53	5.6	47.4	16,000	6,440
Leather and rubber	1.4	11	89	25.8	63.2	23,000	14,265
Wood	8.0	35	65	5.2	59.8	17,000	9,310
Metals	4.1	6	94	94.0	0.0	0	–147
Glass	1.3	3	97	97.0	0.0	0	–73
Inerts	1.0	10	90	90.0	0.0	0	–245
Fines	0.6	32	68	45.6	22.4	15,000	2,584
Weighted average	100.0	46.7	53.3	10.2	43.1		7,650

Annex 10: OECD Waste Generation and Disposal Data

	Municipal Waste	Year	Sewage	End of Life Vehicles	Life Tires	Packaging Waste	Municipal Waste (2000 Totals)	Household Waste (2000 Totals)	Municipal Waste (2000 in kg/capita)	% of M.W - Paper and Cardboard	% of M.W - Organic Material	% of M.W - Plastics	% of M.W - Glass	% of M.W - Metals	% of M.W - Textiles and Other	% of Population Served by Municipal Waste Services	Incineration Total	% Landfill in 1995
Canada		1998	976			8,800		9,926		28.0	32.0					99.0		
Mexico	30,730	2000				8,375	30733	25,714	310	14.0	52.0	4.0	6.0	3.0	20.0	83.5		99.0
USA	208,520	1999	6,700	12500		68,956	208520	125,112	760	38.0	23.0	11.0	5.0	8.0	15.0	100.0	30,881	57.0
Japan	51,450	1999	74,804				51446	33,968	410	33.0	34.0	13.0	5.0	3.0	12.0	100.0	39,992	27.0
Korea	16,950	2000	1,378		235	6,198	16,950	14,375	360	26.0	25.0	7.0	4.0	9.0	29.0	98.7	1,956	72.0
Australia		2000		195	170					22.0	50.0	7.0	9.0	5.0	8.0			100.0
New Zealand	1,450	2000				582		1,450		21.0	56.0	8.0	3.0	7.0	5.0	100.0	456	
Austria	4,500	1999	393	150	50	1,794	4,496	3,096	560	23.0	23.0	10.0	7.0	7.0	30.0	100.0	1,488	49.0
Belgium	5,470	1999	78	154	153	911	5,588	4,574	550	17.0	20.0	6.0	3.0	4.0	51.0	100.0		
Czech Rep.	3,370	2000	198	5	12	132	3,434		330	8.0	18.0	4.0	4.0	2.0	63.0	100.0	1,852	17.0
Denmark	3,080	2000	156	156	34	852	3,546	3,084	660	21.0	33.0	0.5	5.0	2.0	38.0	100.0	196	65.0
Finland	2,200	1999	136		30	423	2,400	960	460	26.0						100.0	10,180	47.0
France	30,740	1997	814	1400	353	11,100	30,744	22,041	510	25.0	29.0	11.0	13.0	4.0	18.0	100.0	9,140	49.0
Germany	44,090	2000	3,927	253		14,109	44,094	35,177	540	41.0	23.0	3.0	22.0	8.0	3.0	85.0		
Greece	3,900	1997	59	4	43	686	4,550		430	20.0	47.0	9.0	5.0	5.0	16.0	85.1	348	91.0
Hungary	4,980	1998	295		53	700	4,552	2,674	450	14.0	41.0	11.0	3.0	2.0	30.0	99.0	17	79.0
Iceland	200	1999	0.3		4	65	198	74	710									92.0
Ireland	2,060	1999	38	30	29	683	2,057	1,221	560	33.0	24.0	10.0	6.0	3.0	24.0	100.0	1,746	93.0
Italy	26,610	1998		2300		7,271	29,000		500							100.0	133	31.0
Luzembourg	280	1999	17		1		278	221	640	19.0	44.0	8.0	7.0	3.0	20.0	100.0	3,944	33.0
Netherlands	9,220	1998	580	267	87	2,876	9,691	8,495	610	28.0	39.0	5.0	6.0	3.0	19.0	99.0	405	73.0
Norway	1,400	1999	104	126	18	389	2,755	1,452	620	36.0	30.0	9.0	3.0	4.0	18.0			98.0
Poland	12,230	2000	1,063			13	12,226	8,480	320							98.0	930	
Portugal	4,300	1999	245	150	50		4,531		450	23.0	35.0	12.0	5.0	3.0	23.0	96.0	209	77.0
Slovak Rep.	1,700	2000	568	28			1,706	1,093	320	13.0	38.0	7.0	8.0	3.0	31.0		1,039	81.0
Spain	24,470	1999	689				26,505	20,664	670	21.0	49.0	12.0	8.0	4.0	7.0	100.0	1,400	38.0
Sweden	4,000	1999	229	130	59		4,000		450							99.0	2,261	
Switzerland	4,680	2000	200	97	50	556	4,681	3,229	650	29.0	38.0	15.0	3.0	3.0	12.0	71.9	15	96.0
Turkey	24,940	1997	2,838				24,945		390	6.0	64.0	3.0	2.0	1.0	24.0		2,590	83.0
UK	33,200	2000	1,000				33,200	28,460	560							73.0	950	

Annex 11: Health Care Waste Management –A Summary

The health care sector includes a wide range of activities and facilities, from medical laboratories, research facilities, mortuary centers and blood banks. All Health care facilities generate a variety of wastes that present common environmental, health and safety issues. Such wastes include wastewater effluents, hazardous health care waste and municipal solid waste. Approximately 75-90% of health care waste is general health care waste, and the remaining 10-25% of waste is considered hazardous and may pose health risks. Contact with such hazardous healthcare waste could result in disease, injury, and even death. A properly designed management system eliminate, to the extent feasible environmental and health hazards for patients, employees and the general public. Health Care facilities should maintain sustainable management practices for all hazardous health care waste, adhering to the measures suggested by the1992 United Nations Conference on Environment and Development (UNCED) as principles of waste management (See Box A12.1).

Box A11.1: Principles of Waste Management

1) Prevent and minimize the production of waste (integrate systems and practices to avoid the creation of waste into facility design and management and equipment and consumables purchasing);
2) Reuse or recycle waste to the degree feasible employing:
    a. Source reduction (measures such as purchasing restrictions to ensure the selection of methods or supplies that are less wasteful or generate less hazardous health care water;
    b. Recyclable products (use materials that may be recycled either on- or off-site);
    c. Good management practices rigorously applied to purchase and control of chemicals and pharmaceuticals, and
    d. Segregation of wastes into different categories- essential to control quantities generated and associated management and disposal costs.
3) Treat or arrange for treatment of waste by environmentally sound methods;
4) Dispose of residues in permitted, controlled, and properly designed disposal sites, and

Phase out the use of polyvinyl chloride (PVC) materials consistent with the availability of suitable replacement material in the marketplace.

International Finance Corporation; Environmental, Health and Safety Guidelines. Health Care Facilities. January 2002

Table A11.1: Air Emission concentration limits for health care facilities

Parameter	Averaging period	Unit	Maximum Value
Total Particulate matter (PM)	24 hours	mg/Nm3	10
Total Gaseous and vaporous organic substances, as total organic carbon	24 hours	mg/Nm3	10
Hydrogen Chloride (HCl)	24 hours	mg/Nm3	10
Hydrogen Fluoride (HF)	24 hours	mg/Nm3	1
Sulphur dioxide (SO2)	24 hours	mg/Nm3	50
Carbon Monoxide (CO)	24 hours	mg/Nm3	50
Nitrogen monoxide (NO) and nitrogen dioxide (NO2) expressed as nitrogen dioxide	24 hours	mg/Nm3	400
Mercury (hg) mg/Nm3	½–8 hours	mg/Nm3	0.05
Cadmium + Thallium and their compounds, expressed as (Cd +Tl)	½–8 hours	mg/Nm3	0.05
The sum of the following metals and their compounds: Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V	½–8 hours	mg/Nm3	0.5
Dioxins/furans (CDD/CDF)	6–8 hours	mg/Nm3	0.1*

International Finance Corporation; Environmental, Health and Safety Guidelines. Health Care Facilities. January 2002

Table A11.2: Liquid Effluent concentration limits for health care facilities

Parameter	Units	Limit
pH	mg/l	6–9
Biochemical oxygen demand (COD)	mg/l	50
Chemical oxygen demand (CO)	mg/l	250
Oil and grease	mg/l	10
Total suspended solids (TSS)	mg/l	20
Cadmium (Cd)	mg/l	0.1
Chromium (Cr)	mg/l	0.5
Lead (Pb)	mg/l	0.1
Mercury (Hg)	mg/l	0.01
Chlorine, total residual	mg/l	0.2
Phenols	mg/l	0.5
Fecal Coliform	MNP/ 100ml	400
Dioxins and furans	ng/l	0.3
IFC, 2002		

International Finance Corporation; Environmental, Health and Safety Guidelines. Health Care Facilities. January 2002

Annex 12: Electronic Waste

E-Waste[1]

The advent of computers and increasingly advanced electronic equipment has radically improved the ability of people, businesses, and governments to communicate, share and store knowledge, and increase productivity and efficiency. Yet, there is a dark side to the electronic revolution—managing the massive and hazardous disposal of obsolete and discarded computers and other electronic equipment, or "e-waste." Televisions and computer parts, such as Cathode Ray Tube (CRT) monitors, wire insulation, and circuit boards, contain hazardous chemicals that threaten human and environmental health.

Worse, developed countries have failed to adequately manage their own e-waste problems headfirst. Instead, a dangerous e-waste "export" market ships thousands of pounds of discarded waste each year to communities in China, India, and other Asian countries. These communities are ill prepared to manage such imports and to confront the accompanying pollution and risks to human health, especially resulting from the unprotected "recycling" of computer material by the poor. This crisis is drawing increasing attention from leaders in both the developed and developing world as the magnitude of the e-waste threat comes clear and people perceive the inequity of using Asia as an e-waste dumping ground.

The problem: Too much e-waste, toxicity, and inadequate regulation

Solid waste disposal systems in developed countries are being flooded with old computers, televisions, and other electronic equipment as rapid innovations in new technology render old equipment obsolete at unprecedented rates. In the United States, the average computer's lifespan is only two years and the e-waste growth rate is three times that of the municipal waste stream generally.[2]

An intricate e-waste market in New Delhi, India

The e-waste trade is thriving in New Delhi. Dealers bid on shipping containers, often funneled from the Western countries through Dubai, full of scrap computer and electronic equipment at the inland depot of Okhala. The waste is sorted and distributed to dealers in Mandali, Sadar, Bazar, and other areas in Delhi. Child labor is often used to separate parts from circuit boards, and, after valuable items are kept, the boards are placed in outdoor fires to melt and extract metals. Acid baths involving nitric acid are also used to remove the gold and platinum on circuit boards. Both methods pose human health risks.

Source: The Basel Action Network and the Silicon Valley Toxics Coalition, *Exporting Harm, The High Tech Trashing of Asia*, February 25, 2002

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1 Most of the descriptive information for this annex is assumed valid as of late 2001and is taken from a report, published February 25, 2002, by the The Basel Action Network and the Silicon Valley Toxics Coalition, entitled *Exporting Harm, The High Tech Trashing of Asia*. This report detailed these two organizations' own direct observations, anecdotal studies of, and missions to several e-waste affected communities in China and India, in addition to their own compilations of research from other primary sources.

2 Russ Arensma, *"Ready for Recycling?", Electronic Business, the Business Magazine for the Electronics Industry,* November 2000.

To make matters worse, the disposal of e-waste and especially of computers poses significant environmental and human health risks. Harmful materials—such as lead and barium in cathode ray tubes, mercury and beryllium in circuit boards, and brominated flame retardants in plastics—can leach out into ground waters and/or pose significant risks to human health when handled improperly.

Many developed countries have passed regulations classifying computers as hazardous waste and limiting how they can be disposed. Many rich countries have also signed the Basel Convention that prohibits the export of hazardous e-waste from OECD countries to non-OECD countries. Yet, some developed countries, especially the United States, forwent the Basel convention and continue to export enormous amounts of computer and other electronic scrap. Though the United States has its own laws prohibiting export of certain types of hazardous waste, a legal loophole allows export of e-waste under the guise of "recycling".[3] Indeed, insiders in the American recycling business have estimated that between 50 to 80 percent of e-waste to be "recycled" in the Western United States is actually exported to Asia, with the bulk of this material destined for China.[4]

Millions of pounds of old computer equipment shipped to Asia each year are funneled through stages of strip shops and e-waste merchants who cull the most valuable components for resale. In many e-waste dumping grounds, the poor make the last cull from leftover carcasses of computers and monitors lying along streets and riverbeds in and outside towns. Often villages sprout up to serve the "recycling" process. Making a few dollars a day, poor villagers or townsfolk dismantle computers, scrape for toner, gather

Over 100,000 people active in e-waste recycling in Guiyu, China

Guiyu is a group of four villages lying along the Lianjiang River in the Greater Guangdong Province in China. An estimated 100,000 people in Guiyu are involved in the e-waste recycling business, most apparently from agrarian regions. "Recylers" make on average $1.50 a day dismantling computers and printers, collecting toner, burning copper wires, and using fires and acid baths on circuit boards. Drinking water has been trucked into the province for several years because some residents claim the groundwater is foul tasting. Hundreds of trucks flow in and out of the region each day, full of scraps from printers, computers, monitors, television sets, and other e-waste. The e-waste clearly originates from North America, with some scraps from Japan, Europe, and South Korea. Computer shells and fragments pile up in streets, along riverbeds, and in makeshift recycling villages outside of towns. Fires that melt copper wire likely emit hazardous gases due to brominated flame retardants in wire insulation. Acid-treated circuit boards lie along riverbeds, one whose groundwater lead levels tested in 2000 over 2,400 times higher than the WHO's Drinking Water Guidelines. Moreover, e-waste pollution and is rampant and the poor are clearly unprotected from its hazardous impacts.

Source: The Basel Action Network and the Silicon Valley Toxics Coalition, *Exporting Harm, The High Tech Trashing of Asia*, February 25, 2002

3 The Basel Action Network and the Silicon Valley Toxics Coalition, *Exporting Harm, The High Tech Trashing of Asia*, February 25, 2002, p. 28

4 Ibid, p. 11

copper wire, mix acid baths, and burn rudimentary fires to extract metals, without adequate protection, oblivious to or accepting of the risks they endure. Piles of computer equipment haphazardly discarded near water sources and populated areas further pollute the air and leach harmful elements into ground waters, posing a chronic threat to residents.

Arguably, it may be possible to recycle e-waste with minimal health and environmental risks using expensive facilities, controlled techniques, and protective clothing and equipment. But much e-waste exported to China, India, Bangladesh, and other Asian countries is handled by poor people who possess little or none of the above.

The problem's roots: Poor regulation, design, producer unaccountability, poverty

The roots of the e-waste disposal, recycling, and export problems are intertwined and are generated or exacerbated by:

- ***Inadequate passage or enforcement of waste management laws and protections in both developed and developing countries:*** Developed countries, particularly, the United States, continue to export e-waste to Asian countries through legal loopholes, and often lack the political will to manage e-waste generation and disposal justly and safely. Developing countries, even those whose laws forbid or regulate the import of e-waste, usually have limited capacity to enforce their regulations, or are too overloaded with other more pressing concerns to make e-waste management a priority.
- ***The "toxic" design and manufacture of computer equipment:*** Contemporary computer designs and computer manufacturing processes incorporate myriad hazardous materials including lead, mercury, arsenic, beryllium, brominated flame retardants, and others. Without such chemicals, e-waste would be a massive disposal problem, but would be more irritating than hazardous.
- ***Computer and electronic company unaccountability:*** In most e-waste generating countries, local governments bear the cost of e-waste disposal, freeing companies that create hazardous electronic goods from legal, financial, and community responsibility. This lack of accountability acts as a company disincentive to design and manufacture less toxic products and to make products more recyclable and durable. Greater durability and recyclability would increase the lifespans of electronic products, slowing or even decreasing e-waste generation rates.
- ***The poor will accept terrible risks to meet basic needs:*** The poor are generally desperate for adequate means to feed, clothe, and shelter themselves and their families. They lack much political clout, and are more willing to run the risk of e-waste poisoning to fulfill their basic needs.

The solution: Banning, Redesign, and Accountability

In a joint report entitled *Exporting Harm, The High Tech Trashing of Asia,* the Silicon Valley Toxics Coalition and the Basel Action Network recommend several measures to address the growing e-waste problem:

- ***Ban Hazardous Waste Exports:*** The U.S. and developed countries should ban the exportation of all hazardous e-waste from their own homelands as matters of waste disposal equity, environmental stewardship, and human health preservation. It is simply unfair for poor countries to serve as the dumping grounds for the mess of the developed world.
- ***Design computers to eliminate the use of toxics:*** Changing the design and manufacturing processes that employ toxic materials is the best, long-term solution to the hazards of e-waste disposal and recycling. Efforts should be made to require companies through legal and other means to innovate new technologies and manufacturing processes that reduce toxic materials.

- ***Design computers and electronic equipment to extend lifespans and to enhance component upgrading and recycling:*** Computers and related equipment designed to both last longer and facilitate upgrades and recycling of shells and components would help decrease e-waste generation.
- ***Increase the accountability of e-waste generating companies:*** Changes to laws and regulations holding e-waste producing companies legally and financially responsible for the disposal of their products ("end-of-life management") would provide major incentives for these companies to design less toxic and more durable products with better upgrade and recycling potential. Part of these efforts might be to require companies to "take back" their own hazardous products, like computers, and pass disposal costs along to users in increased fees.

Annex 13: Promoting Methane Recovery and Utilization from Mixed Municipal Waste

GEF/UNDP Methane Recovery Project

In 1997, the GEF supported landfill gas (LFG) project, "Promoting Methane Recovery and Utilization from Mixed Municipal Refuse" was launched in China, following the implementation of two other related projects, namely, Development of Coalbed Methane Resources in China and Issues of Greenhouse Gas Emissions Control.

The ultimate objective of this LFG project is to reduce global climate change through the capture of methane, which is released from municipal solid waste landfills in China. Through field demonstrations at three sites, the project was designed to illustrate the feasibility of technologies to capture, recover and utilize methane directly as fuel and for electricity generation. The project was also designed to set up institutional mechanisms for the sale of recovered methane to neighboring users and electricity to the grid system. In so doing, the project plans to demonstrate ways to overcome barriers to the use of landfill gas technologies and to the fully competitive sale of methane and electricity to the energy sector. The demonstrations and training activities were designed to strengthening the capacity of the implementing agencies, nationally and locally, thereby enabling them to disseminate the results and to undertake similar projects elsewhere in China.

The overall cost for this GEF supported project was estimated at US $19,565,000, of which GEF funding is US$ US$ 5,285,000. Input from government is estimated at US $14,280.000, of which US$ 10,770,000 is baseline financing with the remaining US $3,510,000 being co-financing for direct project cost. Specific financing arrangements for each demonstration city will be discussed in more detail later in this report.

The project consists of five specific components:

1. Three demonstration landfill gas recovery and utilization sites, one in each of three cities, namely, Nanjing, Anshan and Ma'anshan;
2. The development of a National Action Plan, which is to serve as a proposed policy framework document for the national government, in order to promote the widespread adoption of similar LFG projects in China, and
3. The establishment of a training facility in China.

The project design was well conceived and prepared, from the recognition of the problem statements, the definitions of project objectives and finally to the project strategies including expected outputs and activities.

The Project Document also presented a strong linkage between the five project components. The successful implementation of all of the five project components, along with an effective dissemination effort will provide China with the necessary focus and core competencies to develop further LFG projects in China on a sustainable basis.

The three cities of Nanjing, Anshan and Ma'anshan are strategically selected with respect to their size, geographic locations, economic base, natural conditions, baseline competencies, etc. Nanjing is a major municipality with a total population in the order of 5 to 6 million. It is also a major commercial centre with a diverse industrial base, located in the Yangtze River basin in mid-east China, with humid and warm weather conditions. Anshan is a medium size municipality with a population of about 1.5 million, located in the northeastern part of China. Anshan is known for its heavy industrial base and home to one of the largest iron and steel industries in China. Anshan has a colder climate and much lower precipitation than Nanjing. The city of Ma'anshan has a total population of just about 500,000 and is considered as a small municipality in China. However, Ma'anshan also has a major iron and steel plant. It is hoped that the experience learned by these three demonstration cities can act as models to other Chinese cities of various sizes and capabilities.

- First, through the design, implementation of demonstration projects at three cities, it is believed that the benefits, economic and technical viability of LFG recovery and utilization can be demonstrated in China. The three demonstration projects will serve as models for many other urban centres in a similar situation.

- Through the implementation of the demonstration projects in these three cities, China will be able to develop a core group of technical and management staff experienced in the complete spectrum of LFG recovery and utilization, from feasibility study to technology selection, from economic assessment to institutional capacity building and business negotiation with domestic and international partners.
- The three cities were also strategically selected with respect to size, local geology, climate conditions, degree of urbanization and potentially different waste characterization. This was specifically planned at the outset, to derive maximum benefits from the demonstration projects as they will be serving as models for the rest of China,
- A basic structure of institutional capacity and arrangements to push further development in this area, including the development of independent "Energy Service Companies", domestic or international.
- The development of an action plan to analyze and make recommendations to SEPA, national policies in the areas of economic and financial incentives, education and awareness promotion, taxation and institutional structures as well as standards and regulations for landfill gas control and recovery. This action plan will be able to serve as a foundation for further policy development on a national level. Through supportive policy mechanisms, the program will be able to develop institutional capacities and promote the widespread adoption of landfill gas recovery and utilization projects in China.
- A training facility, the Anshan Landfill Technology Development and Training Centre, will serve as a focal point for providing training, information depository and dissemination for widespread adoption of LFG projects in China. It is expected that this centre will continue to operate long after the GEF project has been completed.
- In short, there is excellent linkage between project objectives and the implementation strategies and the implementation processes were well defined and structured to achieve the expected project results.

From: Wong, H., *Promoting Methane Recovery and Utilization from Mixed Municipal Refuse in China*, 2004.

Annex 14 - Private Sector Participation in Solid Waste Management: An International and Chinese Perspective[1]

I. Introduction

This annex is a brief summary of two reports, "International and Local Private Sector Participation in Solid Waste Management in China: An Overview," written by World Bank consultant Gabriela Prunier, and "Strengthening Urban Solid Waste Management Supplementary Study, Developing Public-Private Partnerships in Solid Waste Management," published by the ADB in 2003. Francis Charles, Project Manager, CGEA ONYX, Paris reviewed the Annex and provided important input.

China's solid waste infrastructure is struggling to cope with unprecedented levels of waste generation (see section 2). At the end of 2001, there were only 740 waste treatment facilities for China's 664 cities.[1] Today, MSW treatment rates are less than half of the generated waste, with treatment predominantly through substandard landfills and composting, which have severe negative impacts on the environment and public health.[2] At this treatment rate, approximately 60 million tons of MSW are untreated.

Aware of these issues, China's government (GOC) is seeking to address the situation through tightening environmental regulations, increasing public investment, introducing "marketization" reforms, and encouraging private sector participation (PSP). It is hoped that operational, managerial, financial and legislative reform will improve the investment climate sufficiently enough to attract funding, technology, and managerial expertise from the private sector.

This annex first gives a brief overview of the status of PSP in MSW internationally and in China. The annex also briefly describes the general conditions necessary for PSP, providing background for other sections, which include a description of China's barriers to PSP in China's MSW market. The chapter concludes with policy recommendations for action.

II. Current Status of PSP in MSW

In the past most governments, considering SWM as a public service, undertook all activities in the SWM chain, including planning, investing, and operation. However, with increasing investment and operational costs, market reform, and acceptance of user fees, SWM is following other public services and developing partnerships with the private sector.

Common Forms of Contract

Common forms of individual contracts in SWM are as follows. Combinations of contract forms are increasingly used as municipalities develop integrated MSW strategies.

- Household and commercial collections services (including curbside and/or drop off point collection, sweeping, and transportation). Service contracts under this category are generally for shorter durations, such as 5 years, and are frequently re-tendered. Equipment is often procured by municipal government and leased to service providers with a maintenance contractthis not.
- Operation of transfer stations, compaction and transport to treatment and disposal facilities (may or may not include material separation and/or recycling activities). Contracts in which infrastructure provision is required are longer in duration and generally correspond to the financial payback period of the capital investment.

1 ADB TA 3447-PRC. *Strengthening Urban Solid Waste Management Supplementary Study Developing Public Private Partnerships in Solid Waste Management*. December 2003, pg. 29.

2 Prunier, Gabriela. *International and Local Private Sector Participation in Solid Waste Management in China: An Overview.* February 2004 Draft, pg. 9.

Service/management contracts are also common. The use of guaranteed minimum supply is a common method of guaranteeing cashflow.

- Material separation and recyclingIn Europe much of this function is performed by non-profit organizations or the state due to low financial viability. In the US and Canada much of this is contracted to the private sector through service contracts. e.g. often The scale of programs varies by city and by country.
- Treatment and disposal (including development and operation of landfills and incinerators). Contracts are commonly BOT or DBFO due to the significant investment requirements. Service and management contracts are also common if the public authority decides to finance and keep ownership/control of the infrastructure is usually 's preferance.

International PSP in SWM

There are 11 leading companies in the world that handle more than a quarter of the world wide solid waste market.[3] These companies are American or European and mainly operate in those markets. The following table lists the companies, along with their 2002 turnover and estimated emerging market turnover.

It can be seen from the table that four companies are active in emerging markets. Onyx, the company with the largest presence, has significant operations in China, Egypt, Morocco, Tunisia, India, Thailand, Philippines, Brazil, Mexico, Colombia, Argentina, Venezuela, and Central and Eastern European countries (CEEC). Sita operates in CEEC, Brazil, and Argentina. RWE Umwelt operates in CEEC and Turkey, and Rethman operates in CEEC. In addition to these four internationals, two smaller companies, Lobbe (Germany) and Saubermacher (Austria), have an emerging market presence mainly in CEEC.

In general, international private operators are disengaging from emerging countries, mainly due to low profitability and high levels of financial risk. For instance Clima, Sita's subsidiary in Argentina, claims that it lost 30% of the MSW volume is was collecting before that country's economic crisis. In addition, collapse of local currencies in the Philippines and Indonesia, coupled with refusal of contracting parties to uphold their

Table A14.1 Estimated Emerging Market Turnover

Area	Operating Company	2002 Turnover (mn Euros)	Estimated Emerging Market Turnover (mn Euros)
North America	Waste Management	12,100	0
	Allied Waste	5,800	0
	Safety-Kleen	…	0
	Republic Services	2,300	0
England	Cleanaway	1,400	0
	Shanks	800	0
	Biffa	700	0
France	Sita (Suez subsidiary)	5,800	200
	Onyx (Veolia subsidiary)	6,100	250
Germany	Rethmann	900	70
	RWE Umwelt (RWE subsidiary)	2,100	70

3 The solid waste market covers all collection services and treatment related to domestic, commercial, and industrial waste as well as urban and industrial cleansing.

commitments (particularly on rate adjustments), has made Sita highly risk averse and now favors organic growth over acquisitions in emerging countries.

Similarly, RWE and Seche are extremely cautious and tending towards disengagement in emerging countries. RWE had an active strategy of development abroad, but has dropped it because of financial problems due to global recession. Seche is being extremely careful as well, preferring to engage only in stable localities with similar legislation, culture, and geography to that of France.

Onyx stands out from its competitors by still investing widely in emerging markets. Onyx is growing market share, especially in China (see table A15.2), although emerging markets still account for less than 3% of ONYX's revenues. Despite major growth potential in emerging countries, the general trend among large international private operators is disengagement and a high aversion to risk. It should be noted that it may be easier to attract smaller international private operators in emerging countries, especially those who are not subject to financial market fluctuations. These smaller operators are usually more opportunistic. For this reason, they may be better suited to higher risk environments like those in emerging countries.

PSP in SWM in China

The scope for PSP in SWM in China is large and opportunities significant. Environmental Business International estimates that in 1997 the size of the MSW management market in China was US$ 600 million, the hazardous waste management market was US$ 120 million, and the market for waste management equipment was US$ 100 million.[4] Today, 85% of MSW is treated through landfilling, 12% through composting, and 3% by incineration.[5] Most landfills do not meet national standards and, due to urban space shortage, demand for incineration is increasing. Furthermore, given the growing concern over hazardous waste (37% of industrial and hazardous waste is dumped in uncontrolled landfills with no treatment), China will spend US$ 1.8 billion in the coming three years to safely dispose of hazardous, medical, and radioactive waste.[6] The market is concentrated on the east coast where industrial activity and demographic growth is concentrated.

Despite the large market size and significant opportunities, international PSP in China's MSW market is embryonic. Collection and treatment is still operated primarily by municipal and district governments. There are only a small number of local and international private operators actively pursuing business in the country. GOC favors the local private sector over international operators, who must go through a partnership with a local agent or import-export company for machines or equipment. Similarly, for operational projects (O&M, DBO, and concessions), they must set up joint ventures with local companies.

The main private actors in China can be classified accordingly:

- Small local private operators, present in collection and recycling of MSW through formal (collection and recycling brokers) and informal (waste pickers, street recyclers) agents.
- Medium/large local private operators, present in mechanized collection and treatment including transfer stations, landfill management, and incinerators. They are also involved in joint ventures with international private operators for operational work, primarily incinerators and landfills.

4 Prunier, Gabriela. *International and Local Private Sector Participation in Solid Waste Management in China: An Overview*. February 2004 Draft, pg. 8.

5 *Ibid*, 9.

6 *Ibid*, 9.

- International private operators, mainly present in treatment, which is capital and technology intensive. There are only a few international private operators active in China, expressing interest mainly in construction or O&M of sanitary landfills and/or incinerators. Onyx is the most active player, obtaining several O&M and DBO contracts for landfills and incinerators. Other international private operators are active through technical assistance, feasibility studies, or specialized equipment sales.

III. Private Sector Requirements for Entry in Solid Waste

Although each opportunity is unique and potential private sector participants may have different goals in each case, general requirements for entry do exist. First, there must be the potential to derive a reasonable level of profit that is commensurate with the level of risk. If profit potential does not immediately exist, then there must be an element of strategic importance. In waste management, profit potential is positively correlated to the size of the accessible market, a notion based on population and GNI growth, average expenses per person for collection, treatment, and urban services, and on expected growth of volume and value of waste. Second, there must be clear legal and regulatory structures. This includes strict environmental regulations, effective enforcement, and a relatively well regulated and organized market. Third, there must be reasonable levels of political support and stability, particularly on issuing clear sector policies, reforming policies to allow cost recovery and on providing risk coverage. It is important to note that there is no such thing as a general acceptable level of risk in which international businesses will invest; each investment decision is made on a specific project basis. However, the main business criteria used in investment decisions remains financial and strategic.

IV. Barriers to PSP in SWM in China

Legal Issues

Although a series of policies, laws and regulations have been issued by central government, these cannot be regarded as constituting a complete or effective guiding framework.

Despite recent efforts by central government, the sector does not have a clear or comprehensive legal framework. A clear, comprehensive legal framework requires substantial cooperation between all responsible bodies. However, cooperation is particularly challenging given China's complex division of roles and responsibilities. Many existing laws and regulations have been developed and issued by individual administrative bodies with no consideration given others, resulting in inconsistencies and conflicts. In addition, central government often fails to account for local government capacity and deliver government support where needed. For instance, although central government has clearly stated that local administrations are responsible for marketization directives, it is questionable whether they have the expertise to implement the policies at the local level.

There are a number of conflicts between existing laws, one of which involves the issue of guarantees. China does not have a consistent or coherent set of laws or guidance concerning the type and extent of guarantees that can be offered. Current law, regulations, and circulars give contradictory statements regarding this issue. For example, public bodies are not allowed to offer or guarantee a fixed rate of financial return. In practice, however, it is recognized that many investments will be compromised if investors cannot obtain a certain minimum rate of return. As a result, a number of government directives discuss the appropriate rate of return on investment, suggesting rates based on long term bank lending rates or return on fixed assets. Such directives conflict with previous policies, making the legal environment unclear to the private sector and creating uncertainty about the value of a government guarantee.

There is an additional legal conflict between the definition of asset ownership and land use rights. While the law recognizes the ownership of assets developed by a company through its investments, the Land Law states that ownership of assets on or below ground can only be obtained without the usufruct rights of the land itself. At present private investors can only obtain land use rights through tenancy, government transfer or as a remittance. Under the tenancy and transfer options, the investor will not be able to enjoy ownership of assets on the land and will therefore not be able to use assets as loan guarantees, severely restricting the ability of the potential investor to raise financing.

In addition, there is also lack of supporting policies for implementing new methods of project financing. In public private partnerships (PPPs), where a range of financing options are needed, it is common to mix equity and loan financing and to use the revenue flow over the concession period or the concession right as a means to secure loans. However, in China there is still no defined policy and regulation on the legality and ability to do so. As a result, many banks do not accept this form of collateral and instead revert to the creditworthiness of the project sponsor. This restricts loan financing to short to medium term loans for smaller sized projects.

Awareness

A lack of awareness and understanding by public sector practitioners impede Government's efforts to introduce and develop marketization principles in China's SWM market. Main examples of this are:

- Many local officials still hold misconceptions as to the roles of the public and private sectors in SWM service provision particularly with respect to the true purpose of marketization policy and the future commitment of government to SWM services.
- There is a reluctance of local officials to impose user fees on the belief that SWM is a public service and households will be unwilling to pay.
- Local practitioners focus solely on the new financing marketization provides, ignoring other benefits of PSP and objectives of marketization.
- Overemphasis on technology and process rather than on financial viability and sustainability

The introduction of marketization will require more effort on defining its objectives and policies, and on making them known to local practitioners and the paying public.

Management Systems

Management issues of various forms are a constraint to government's implementation of marketization reforms. The majority of current management structures are not capable of designing and implementing a holistic, well coordinated SWM strategy for their cities. This leads to bad spatial and service planning, misallocation of funds, unclear roles and responsibilities, and low credibility and poor partners for private investors. Also, there is a need for management to introduce fair and transparent competition and tendering for projects, as well as to adopt true cost accounting so that the systems they are in charge of do not provide unfair competition to potential private investors.

Financial Issues

Potential for profit remains the most critical issue for private investors considering entry into the Chinese MSW market. For this reason, the financial framework is of utmost importance. Currently, the numerous perceived financial barriers are as follows:

- User charges are still not established or widely implemented. Some local administrators are reluctant to introduce them, but investors will not commit until they are given a consistent revenue stream to invest against.

- Indirect payments, such as tax breaks or concessional financing terms, are underutilized and not well developed. Until user fees are accepted, direct and indirect payments may be necessary.
- Inconsistent messages regarding permissible levels of profit, damaging the perceived investment value of SWM. These conflicting views reflect the divergent views of sector ministries. This debate must be settled in order for credibility to be enhanced in the private sector.
- Related the above, there is little perception of the true cost of SWM service provision. This leaves the public sector unable to properly assess proposals and will most likely result in financially unsustainable outcomes.
- Local banks are unwilling to commit funds because of the public sector's inability to provide an effective PPP framework.
- Risk mitigation and insurance tools are not available in China's rudimentary financial markets. Complex PPPs require sophisticated financial tools which China cannot currently provide.

V. Policy Recommendations

Applicable PPP Models in China SWM

Given the significant issues, it is clear that China is not yet in the position to heavily engage in complex PPPs (such as BOTs) in which private parties bear substantial risk. The concerns in doing so at this stage are improperly designed, regulated, and controlled contracts which could diminish future private sector interest. BOT contracts, because of their ability to attract alternative financing, are particularly susceptible to premature engagement. However, in light of the rising interest in the market and availability of funds, government should not neglect this opportunity entirely. Rather, government should move prudently, engaging in limited BOT contracts and seeking technical assistance particularly on project structuring and development of independent assessments.

Complex contracts, such as BOTs, are often misunderstood in that there is too much focus on the alternative financing and not enough on other advantages of PPP. Simpler forms of PPP in the short to medium term are recommended until some of the main sector issues are remedied. Management and service contracts are particularly useful in introducing the necessary changes to management and institutional structures through potential increases in private sector efficiencies. They also represent an effective method of determining true operational costs and revenue possibilities for future projects. Although they still require an effective public sector to design and control them, they are far less demanding.

Building Capacity

Measures to increase the skill level and understanding of marketization among key public sector staff is a key priority. In order for the public sector to be effective in fulfilling their role in PPPs, it is imperative that these officials fully understand the long term direction and rationale for marketization as well as the tools needed to implement it. To this end, specific measures could include:

- Development of PPP Understanding. This could take the form of short courses about PPP or private sector investment management at key universities for public sector managerial staff. Knowledge regarding financial engineering tools is particularly needed. Also, regular interactions with the private sector should take place through investment forums which would increase understanding of each party's objectives and working practices as well as match projects with potential investors. Lastly, development of case studies and best practice practical guidelines regarding PPP in

SWM will be extremely helpful as smaller government attempt to implement marketization policies.

- Implementation of a PPP Support Unit. Because of a lack of expertise to guide the public and private sectors, it is worth considering setting up a specialized PPP support unit combining local and expatriate public and private sector experts. This unit could fill the need of a unified reference point for all stakeholders.
- Creation of a PPP Investment Fund. Such a fund has been successful in other countries in lowering private investors' risk burden. The fund could promote projects by either supplying additional financing to make the project viable, or to reduce project risk through its involvement. It could also allow the application of PPP in less economically developed areas or in municipalities with less financial viability. The proposed fund should receive counterpart financing from government.

Continued Institutional Reform

There is also a need to deepen and strengthen the reform process in order to develop an effective PPP environment for SWM. The reforms below are based on the ADB's SWM strategy which was written to promote marketization. Specific areas of strengthening include:

- Strengthening the Supervisory Role of Government. PPP requires a shift in responsibility for the public sector from that of operator to monitor/manager. It must also retain sole responsibility for policy and market guidance. Being effective in this new role requires a greater ability to develop, implement, and enforce policies, as well as to monitor local governments and the private sector. The first step in this process is to develop a clear policy and regulatory direction that is communicated to local government and private sector. Government must then give guidance to local government on its monitoring role.
- Creating Sustainable Market Development. Until user fees cover costs, GOC must develop coherent strategies to supply alternative means of support, possibly in the form of direct payments or tariff subsidies. GOC must also come to agreement on revenue and profit guarantees, clearly defining what it can and cannot offer to potential investors.
- Protecting the Public Interest. Not only should the public be properly informed, but they also should be integrated into the decision making and monitoring process. This is especially crucial if they are expected to pay user charges and accept private provision of services. Through involving the public, municipalities will be better able to harness the ability of the public to be a means of monitoring and enforcement.
- Adapting to Local Conditions. GOC must stress that each locality is different and that there is no one solution or template that is applicable across cities. Each PPP must be tailored to specific party needs and objectives. Local government must have the capacity and the time to assess how requirements differ from one city to another.
- Regulated and Transparent Implementation. GOC should introduce greater clarity in tendering and award procedures in order to build credibility and attract private bidders. Doing so decreases project risk and cost. Most critical in this regard is providing a justification for all government action.

Table A14.2 : Presence of some major private operators in China[7]

City	Company	Turnover/cost of the project (in US$ Million)	Contract / Activity / Investment
Zhejiang : MSW incinerators with WTE facility planned	Hangzhou Boiler Works (HBW), China	Project cost : 1.5	–Still planning phase –Treatment capacity 150TDP –Import of foreign technology is
Hangzhou Incinerator	Hangzhou Luneng, China Environment Protection Electricity Generation Co., Ltd (capital : US$6M, of which US$2.4 is financed by Hangzhou City's Construction Development Company)	Project cost : 25	–Incinerator for biological waste –450 TPD in phase I, 1050 TPD in phase II –O&M contract
Pudong, biochemical treatment plant, Shanghai	Meisheng International Group, Honk Kong	Total investment cost: 27,6 100% financed by the private company.	–BOT contract –Operates since 2003 –Treatment capacity 1000TPD
Pudong Municipal WTEincinerator, Shanghai	Alstom and Ingerop, French Companies	NA	Responsible for all aspects of engineering for the launch of the incinerator in 2002 (was in operation since 1999)
	Impregilo, Italian Company JV (50%) with the Shanghai Pudong Development (Group) Company Ltd, owned and controlled by the Shanghai Pudong New District Government	Investment: 80,4 Detail of costs: - Engineering: 11,4 (14,2 %) - Equipment: 37 (46,3 %) - Installation: 9,3 (11,6 %) - Other (studies, land, relocation) : 22,4 (27,9 %) - Total cost : 80,1	–O&M contract signed in December 2003 –Treatment capacity: 1000 TPD The incinerating plant has three MSW incinerators and two 8500 kilowatt power units –Treatment capacity: 1000TPD –Energy generation: 100 million kilowatt-hours /yr –Total surface: 80.000m2 –Designed heating value of MSW is 6060 kJ/kg and fluctuates from 4600 to 7500 kJ/kg in the real operation = low calorific value[8]
Laogang Municipal Waste Landfill, Shanghai	60/40 JV contract between Onyx/CITIC Pacific consortium and Shanghai Chengtou Environmental Industries Development Co. Ltd	Estimated total contract value: 312 Investment 61,2 M (loan facility of WB of 27,6)	–Contract awarded in 2004 –Concession contract for design, construction, O&M and transfer of waste to landfill
Jiangqiao Incinerator, Puxi, Shaghai	JV signed in 2002 between Onyx (investment US$2,4 million) and Shanghai Huancheng Waste-To-Energy Co. Ltd	Investment: 90 Expected turnover over 20 years: 80	–Contract awarded in 2003 –O&M contract –20-year contract –Treatment capacity : 1000TPD of MSW in 2003 (to be increased to 1500TPD in 2004) –Biggest incinerator in China

(continue on next page)

7 Based on data gathered through the press or locally.

8 The MSW has to be deposited in the waste pit for two or three days before it is fed into the furnace. It is necessary for the incinerator to add auxiliary fuel to enhance combustion during operation and leachate needs to be treated. This has affected initial plant operating costs.

Table A14.2 : Presence of some major private operators in China (continued)

City	Company	Turnover/cost of the project (in US$ Million)	Contract / Activity / Investment
Guangzhou landfill,	JV between Golder Associates	NA	–Responsible for all aspects of engineering for construction
Guangdong province	(Canada) and Waste Management Onyx HK Ltd. (JV?)	NA	–8 year contract awarded in 2002 –DBO of the Guangzhou Xingfeng municipal landfill with WTE –Double liner system, comprehensive leachate collection and treatment system and WTE plan. –Treatment capacity: 6,000 TPD
Tianjin Hazardous and toxic waste treatment and disposal center	JV contract between Onyx (44%) , two Chinese partners and The city of Tianjin	Estimated cost of the project: : 12 The State Development Planning Commission has has authorized government bond funds for it.	–Signed in 2001 –Technical assistance –Hazardous and toxic waste treatment and disposal center –Incineration technology with recovery of usable materials from waste products and safe burial of hazardous wastes.
In December 2002, Veolia Environnement (VE) set up a JV with Beijing Capital Co. registered capital USD 30 million. VE holds 49% but controls 51% share when it comes to plant O&M in real projects (Water, Sanitation and Waste)			
Guizhou province, Waste-to-gas plant	Hudson Electek, America[9]	NA	–Responsible for engineering for construction –300TPD waste turned into gas
Ningbo MSW incineration plant, Zhejiang province	Technology imported from Novel, Germany	Investment : 90	–Put into operation in August 2001 –Three incinerators were imported from Germany –Each incinerator can treat 350 TPD –Diesel oil injected into the furnace to keep waste burning due to low heating value
Longgang MSW incineration plant, Guangdong province	Technology imported from Richway, Canada	NA	–Built and put into operation in November 1999 –Treatment capacity: 300 TPD –Electricity generated: 70 to 80 MW per hour –The plant has to add diesel oil to support combustion and consumes 5 tons of diesel oils daily.
Shenzhen MSW incineration plant, Guangdong province	echnology imported from Mitsubishi, Japan	NA	–Built in 1988 –Equipment imported from Japan
Changzhou's Industrial incinerator, Jiangsu Province	Technology imported from JFE Holdings Inc, Japan	Changzhou Lucky Environmental Protection Equipment Engineering Co Ltd, a Hong Kong-Changzhou JV, which is the main investor of the project, has poured an initial US$1.2 million into the plant.	–Located in Changzhou State Environmental Protection Industry Park –6.7-hectare plant –Japanese technology –Processing capacities vary between 30 to 450 TPD

9. Guiyang Evening News in www.amcham-china.org.cns

Annex 15: Level of Environmental Services in Selected Chinese Cities, 2001

	Industrial Wastewater Disposal Rate(%)	Sewage Treatment Rate(%)	Per Capita of GDP(yuan)	Per Capita Annual Disposal Expenditure of Urban Households(yuan)	Per Capita Living Space(mxm)	Level of Urbanization	Infant Mortality Rate(/1000)	Per Capita Electricity Consumption for Daily Life(kwh/y)
Beijing	94	39	24077.39	8493	16.5	68.69	5.63	432
Shanghai	93		36206.43	8868	15.2			
Shijiazhuang	98	25	25476.06	5247	15.9	38	8	208
Harbin	84		18244.04	4508	12.6			
Kunming	93		6654.652	6845	12.6			
Chengdu	89	44	20110.93	6423	17.4	33.1	17.6	810
Guangzhou	88		38568.37	11349	18.9			
Wuhan	88	31	16205.67	6075	12.6	59	0.9	271
Urumqi	84	58	17654.71	5644	13.9	81.37	16.28	342
Xi'an	67		15493.25	5446	13.7			
Lanzhou	84		15051.39	5048	12.3			
Yinchuan	58		11975.38	5369	14.2	77	10.5	466
Guiyang	65		11727.62	5550	12.9	69.8	27.36	414
Nanning	74	49	16121.12	6705	14.5	46.55	11.95	323
Haikou	100	68	23919.67	5424	16.8	84	7.5	188
Changsha	100	55	23941.84	7370	14.8	38	6.1	300
Zhenzhou	95	7	16028.33	5444	13.9	55.07	16.22	509
Xining	86		6676.12	4245	12.8			
Hangzhou	94		38246.9	7790	14.8			
Hefei	97	77	17770.11	5040	12.1	79.94	18.4	407
Nanchang	57	18387.61	3925	10.99				
Jinan	92		25191.77	6892	16.7	47		435
Huhhot	77		11788.62	4613	13.9			
Fuzhou	95		31582.03	6417	18.8			
Chongqing	77	49	9038.24	5570	14.6	53.1		467.1
Guiyang	65		11727.62	550	12.9			
Nanjing	86		27128.08	7047	13.7			
Changchun	96		21335.72	5113	14.4			
Taiyuan	80	32	12821.13	5341	14.4	75.5	7	187.38
Tianjin	98		20433.24	6121	13.9		10.9	

Source: The Yearbook of China's Cities 2001

Annex 16: Landfill Design and Operations: Minimum Standards (Adapted from ONYX Industries, 2003)

Purpose

These standards were prepared by Onyx to define appropriate landfill design and minimum operating standards. They are particularly relevant for facilities located in countries with limited or no requirements concerning landfill design and operations. They apply to active non-hazardous solid waste and hazardous waste landfills.

In addition to the following standards, landfill environmental protection systems shall be designed in accordance with all applicable regulations when available. Enhancement to these minimum standards requirements should be incorporated into the design if it is determined through value engineering techniques that such enhancements improve environmental protection, reduce construction / operating cost without any adverse effect on the environment.

I. Landfill Design Standards

Preliminary Site Investigation and Hydrogeological Study

Prior to beginning site design and construction an appropriate site investigation and hydrogeological study must be conducted. These studies will define the existing environmental conditions in order to assess potential environmental impact. The basic information and parameters to be obtained by these studies are listed in Table A7.1 at the end of this annex.

Landfill Design Plans

Engineering design plans must be prepared for each landfill site taking into account site-specific conditions and requirements. The general approach is to apply sound engineering judgment to satisfy the following general considerations throughout the design process:

- Environmental Protection
- Regulatory and permit requirements
- Efficient landfill construction and operation
- Restoration, aftercare and end-use planning

The minimum standards listed herein must be considered as part of the preparation of landfill design plans. These standards are not intended to replace the need for preparing site specific design plans and calculations.

The engineering design plans must consider items such as :

- Site Layout
- Area and Volume calculations
- Soil Balance and Site Life calculations
- Geotechnical considerations (slope stability, subgrade settlement…)
- Surfacewater Management
- Lining System design
- Leachate Management System design
- Final Cover system design

Landfill Liner Design Requirements

Objective: Groundwater Protection

MSW Landfill Minimum Standards
- 1.5 mm HDPE liner
- 50 cm material k $\leq 10^{-8}$ m/s
- base grade slope ≥2%

All new landfill facilities or expansions designed and constructed should be designed as containment facilities, equipped with both liner and leachate collection. The purpose of the liner system is to provide a barrier to prevent leachate from leaving the landfill and possibly contaminating soil and groundwater. The liner system also prevents water from entering the landfill to create additional leachate. Some site-specific conditions may require more stringent designs.

All non-hazardous solid waste landfills must be designed with a composite liner system. The composite liner shall consist of a high density polyethylene (HDPE) geomembrane with a minimum thickness of 1.5 mm placed over a layer of recompacted soil or soil admixture (such as bentonite) of 50 cm thickness (minimum) and a recompacted saturated hydraulic conductivity of 1 x 10 -8 m/sec or less or equivalent.

The base grades should be designed with a minimum of 2 % slope.

Leachate Collection System Design Requirements

Objective Control leachate head and allow for leachate extraction control

Minimum Standards
- 30 cm of granular material $\geq 10^{-4}$ m/s
- piping networks

All landfills must install a leachate collection system above the liner system. The purpose of the leachate collection system is to control leachate head and allow for proper leachate extraction.

All landfill facilities must install a leachate collection system above the liner that meets the equivalence of a 30 cm thick granular drainage layer with a minimum saturated hydraulic conductivity of 1 x 10-4 m/s. The leachate collection system must be designed to direct leachate towards evacuation sumps or manholes. The design of the leachate collection system must also ensure the protection and integrity of the liner system during construction and operation.

The leachate collection system is constructed using gravel drainage layer and piping

Landfill Biogas Management System Design Requirements

The primary objective of the biogas collection system is to control the accumulation and migration of landfill biogas beyond the site boundary and releases into the atmosphere. Landfill biogas must be collected and treated.

All landfill facilities that accept biodegradable wastes must install an active biogas collection system unless it can be demonstrated that the site will not generate sufficient volumes of landfill biogas.

The active collection system must be installed following final closure of a disposal area. Active collection systems must also be installed on areas of the landfill that will remain inactive for a period greater than 18 months. At a minimum, all landfill biogas extracted with an active collection system must be flared. The collection system should be designed to account for the anticipated settlement of the waste mass.

Objective: Prevent biogas mirgration and fugitive emissions

Minimum Standards
- Active collection system
- Flare

Final Cover System Design

The primary purpose of the final cover is to reduce infiltration into the waste mass in order to minimise leachate production. The final cover system also assists in the control of landfill biogas emissions, the mitigation of odours, encourages the establishment of vegetation to minimise soil erosion and enables integration of the site with the surrounding environment.

All solid waste landfills must install an appropriate final cover system which includes a minimum of 60 cm of soil having a saturated hydraulic conductivity of 1x 10 -8m/sec or less or equivalent.

The final grading plan for the landfill must take into account the eventual settlement in the waste mass following closure.

Objective Reduction of rainwater infiltration

Minimum Standards
- 60 cm of $\leq 10^{-8}$ m/s material
- slope > 5%
- 20 cm of vegetative soil

A minimum slope of 5% is required for the topslopes in order to allow for proper surfacewater run-off. The sideslopes should not exceed slopes 3:1 (horizontal/vertical) unless a slope stability analysis can demonstrate that the configuration will be stable. The final cover system must include a minimum of 20 cm vegetative soil layer that will support the establishment of vegetation.

Surface Water Management Design

Proper surfacewater management is vital to the operation of a landfill. The purpose of a surfacewater management system is to:

- Control the stormwater run-on and run-off and keep them separate from the waste and any contaminated water originating from the waste;
- Minimise leachate generation;
- Minimise environmental impacts to surfacewater.

The component features of a surfacewater management system must be designed to accommodate the volume of water associated with a precipitation event of particular intensity. The designer must select the design storm frequency most appropriate for the facility given the site location and climate.

Design of Environmental Monitoring System

The design of appropriate environmental monitoring systems must be addressed as part of a landfill design project. There must be adequate monitoring systems of groundwater, landfill biogas, leachate, effluent and surfacewater to detect potential environmental contamination.

Based on the initial hydrogeologic study of the site, a groundwater monitoring well network comprised of a minimum of three (3) monitoring wells must be designed. The monitoring well location and depth must be sufficient to allow comparison of upgradient and downgradient groundwater quality and enable early detection of a release.

Landfills that accept biodegradable waste will generate landfill biogas, and a monitoring plan must be developed. The plan should address the type and location of monitoring points that will allow :

- Monitoring for the presence of subsurface landfill biogas migration outside the perimeter of the landfill and
- Monitoring the potential for biogas accumulation within onsite structures.

II. Minimum Operating Standards

The following is a set of minimum operating standards. These requirements are not meant to address all aspects of landfill operation. The aim is to provide standards for those areas where there is typically the highest potential for environmental impact. These standards should be integrated into the facilities operating procedures.

Leachate Management Standards

Leacheate Level. The primary objective of the leachate management system is to ensure that leachate accumulation at the base of the landfill is kept to a minimum. For any facility where the seasonal prevailing water table is below the top of the liner, leachate must be removed from the primary leachate collection system until a maximum head of 1 m or less is obtained. The leachate levels are relative to the liner elevation and not to leachate trenches or sumps.

For exceptional cases where geologic and hydrogeologic conditions are appropriate allowing the top of the liner system to be below the seasonal prevailing water table surface elevation (i.e. inward gradient), the maximum leachate level must be maintained below the water table surface elevation.

Active landfills must measure and record leachate levels in all sumps on a quarterly basis or more frequently if required by the facility permit. Leachate levels at closed sites must be measured and recorded at least yearly.

Leachate Treatment and Disposal. Leachate that meets statutory wastewater discharge standards can be discharged with the permission of relevant regulatory authorities. Leachate that fails to meet such standards must be subjected to additional treatment on or offsite. Direct land application of untreated leachate is prohibited.

For non-hazardous landfills, where effective liner and leachate collection systems are in-place which meet the standards defined in Section I above, re-circulation may be permitted as a leachate management practice.

Leachate Storage. Leachate must be stored in either sealed storage tanks or in tanks that afford a minimum of 30 cm "freeboard" to compensate for the possible impact of wind action or additional precipitation. The above ground storage tanks must have secondary containment which is sized for the volume of the largest tank plus sufficient freeboard to allow for precipitation.

Leachate storage basins should be designed with a composite liner system in accordance with the standard for the corresponding landfill type defined in Section I above.

Storm Water Management

Segregation of clean and contaminated run off through the use of temporary berms should be ensured to minimise the volume of water that must be treated as leachate. Precipitation, which comes into contact with exposed waste, should be collected separately, tested and where necessary managed as leachate. Accumulation of surface or stormwater in an empty cell in which waste has not been deposited should not generally require treatment and can, unless otherwise specified, be managed as non-contaminated runoff. Run-off should be diverted by means of ditches, dykes and/or grading, as appropriate.

Temporary/Intermediate/Final Cover

Temporary cover should be applied as needed to minimise wind blown litter, odours, rodent or bird scavenging problems and any additional leachate generation.

Synthetic cover materials should be considered (geomembranes, geotextiles or foam), where legally and practically possible, as a substitute for soils or other bulk materials as an effective means of conserving landfill air space and controlling leachate. Alternate temporary cover materials (or revenue generating cover materials) such as auto fluff, select construction and demolition waste, slightly contaminated soils, should also be considered, where legally and practically possible to conserve natural soil resources.

In order to minimise leachate generation and landfill gas emissions, intermediate cover must be placed on the surface of the waste disposal areas that will not receive waste for a period of greater than 180 days.

Cover materials that prevent leachate circulation should be removed prior to waste placement.

Final cover placement should commence after areas have reached their final grades. Final cover seeding must be completed during the first growing season after placement of the final cover system.

Waste Acceptance Procedures

All landfills must implement appropriate Waste Acceptance Procedures to ensure that all wastes accepted for treatment or disposal are managed in accordance with all applicable national, regional, or local regulations, permits or other legal requirements.

The following are minimum requirements to be addressed in the site specific Waste Acceptance Procedures:

- Description of all wastes which can be accepted at the facility;
- Procedures and methods to evaluate, assess and approve all waste managed by the facility;
- Procedure for submittal of information concerning a waste prior to acceptance;
- Procedure for advance notification and approval of waste acceptance to appropriate regulatory agency, if required;
- Procedure for onsite verification of waste including:
    - documentation control upon entry into the site,
    - measurement of waste input on a calibrated weighbridge,
    - visual inspection of waste at entrance or when off loaded,
    - laboratory screening test for special and hazardous waste as specified in the approved admission procedures
- The facility must maintain appropriate documentation to confirm compliance.

Operations Manual

An operations manual must be prepared for all landfills. The purpose of the manual is to describe the critical landfill operating procedures for the site. This site-specific manual must include, at a minimum, the following subjects:

Landfill Phasing. Narratives and plans describing the planned phasing of landfill operations and development from the site's opening until final closure. This data allows for proper planning including material balance, material storage, traffic routing, progression of tipping areas, etc.

Site Access Roads. Describes sites internal access road system and traffic control.

Tipping Area. Describe methods to ensure that the tipping area is kept to a minimum to avoid odours, minimise leachate production and maximise compaction.

Compaction. Describe compaction equipment and methods to be used to ensure maximum compaction and void utilisation.

Topographic Survey/Monitoring of Landfill Density. Description of the planned measures to monitor compaction efficiency and compliance with the approved grading plans using regular topographic surveys.

Odor Control. Measures to be taken to reduce or eliminate odours.

Dust Control. Measures taken to reduce dust emissions due to vehicular traffic.

Disease Vectors Control. Measures taken to reduce propagation from vermin, rats and birds.

Litter Control. Strategy to prevent and/or reduce litter using engineered solutions (litter screens) or management options (manual collection).

Fire Control. Description of fire prevention measures and remedial action plan needed to localise and extinguish surface and /or subsurface fires.

Contingency Plans. Planned management procedures in the event of an incident or anomaly (fire, deposit of unauthorised waste…)

Environmental Monitoring. Describe planned monitoring programme including groundwater, surfacewater, leachate, and landfill gas.

Table A16.1: Preliminary Site Investigation Data Checklist

A. Maps, Cross Sections and Fence Diagrams
1. Planimetric
2. Topographic
3. Geologic
(a) Sructive
(b) Stratigraphy
(c) Lithology
4. Hydrologic
(a) Location of wells, observation holes, and springs
(b) Ground water table and piezometric contours
(c) Depth to water
(d) Quality of water
(e) Recharge, discharge and contributing areas
5. Vegetative cover
6. Soils
7. Aerial photographs
B. Data on wells, observation holes and springs
1. Location, depth, diameter, types of well and logs
2. Static and pumping water level, hydrographs, yield, specific capacity, quality of water
3. Present and projected ground water development and use
4. Corrosion, incrustation, well interference and similar operation and maintenance problems
5. Location, type, geologic, setting and hydrographs of springs
6. Observation well networks
7. Water sampling sites
C. Aquifer data
1. Type, such as unconfined, artesian or perched
2. Thickness, depths and formational designation
3. Boundaries
4. Transmissivity, storativity and permeability
5. Specific retention
6. Discharge and recharge
7. Ground and surface water relationships
8. Aquifer models
D. Climatic Data
1. Precipitation
2. Temperature
3. Evapotranspiration
4. Wind velocities, directions and intensities
E. Surface water
1. Use
2. Quality
3. Runoff distribution, reservoiric capacities, inflow and outflow data
4. Return flows, section gain or loss
5. Recording stations