MoHURD Eco-City Implementation Guideline for

Solid Waste Management

Preamble. This Eco-City Implementation Guideline has been developed with the assistance of the Europe-Chine Eco-Cities Link Project (EC Link), and been submitted by the Chinese Society for Urban Studies (CSUS). It draws on the work done by the EC Link project in the development of sectoral toolboxes[1] which present European and Chinese best practices, urban development standards, indicators and methodologies for verification. Further, the development of this Guideline is informed by project work of MoHURD-affiliated pilot cities which are implementing eco-cities activities, and piloting innovative practices. EC Link has provided as inputs toolboxes for the following 9 sectors: compact urban development (CUD), clean energy (CE), green building (GB), green transport (GT), water management (water supply, waste water treatment and flood control) (WM), solid waste management (SWM), urban renewal and revitalization (URR), municipal finance (MF), and green industries (GI).

Objectives. The objectives of this Eco-City Implementation Guideline is to provide guidance, and to ensure compliance. The document is meant for all Chinese cities which are participating in the national MoHURD-supported eco-cities programme. Besides guidance, the document will help to ensure compliance of cities with the normative part proposed under this guideline.

Legal Basis. This Eco-City Implementation Guideline is complementary to the existing urban planning legislation of the People´s Republic of China (PRC), and other guidelines of the Ministry of Housing, and Urban-Rural Development (MoHURD), particularly those pertaining to eco-city development. The relevant legal reference documents are:

- Urban Planning Law. 1984. In 2008 updated as "The Urban and Rural Planning Law of People's Republic of China"; latest revised in April 2015.
- Land Management Law. 1998.
  And based on the law, the detailed Enforcement Regulation has been developed, and undergone revisions for several times. The latest is the 2014 version.
- Environment Protection Law. 1990. Latest revised in 2014 and applied since 2015.
- MoHURD. March. 2013. The 12th 5-Year Plan on the Green Building and Green Ecological Districts.
- CCPCC and State Council. March, 2014. National New-type Urbanization Plan 2014-2020.
- State Council. April, 2015, Suggestions on Enhancing Eco-civilization.
- CCPCC and State Council. 2016. Central Government Guideline on Urban Planning.
- CCPCC and State Council. 2016. The thirteenth Five-Year Plan (2016-2020)

Specifically for the solid waste management sector, the following legal instruments apply:

- Law for Prevention of Solid Waste Pollution. 1996. Latest revised in April 2015.

[1] EC Link Toolbox. 2016. *Solid Waste Management*. Beijing. Draft English version. www.eclink.org.

- NDRC, MoHURD, MEP & MoA. 2010. Pilot Program for Recycling and Non-hazardous Treatment of Kitchen Waste in Urban Area.
- MoHURD, NDRC& MEP. 2010. Technical handbook for Municipal Waste Treatment
- State Council. 2014. Policy Guidelines for Enhancing the Municipal Waste Management
- MoHURD, NDRC, MoF, MEP, MoC. 2014. Pilot Programs for Municipal Waste Classification.

This Eco-City Implementation Guideline is *mandatory* for all Chinese cities which are participating in the national MoHURD-supported eco-cities programme. Compliance with its missions and technical targets will be monitored and reviewed by MoHURD. Compliance will be rewarded through special allocation of funding and technical implementation support.

Scope of this guideline. The geographical scope of this Eco-City Implementation Guideline are urban areas as defined by the existing legislation. The application of this Eco-City Implementation Guideline may be extended to Districts which are under the jurisdiction of a city (urban area), as applicable.

Substance of this guideline. This Eco-City Implementation Guideline is dedicated to Solid Waste Management (SWM). The implementation of eco-city development approaches concept makes it necessary to deal with these different dimensions of waste management. To implement the solid waste management agenda it will be necessary to have committed city and district governments so rules can be enforced.

Definition of Solid Waste Management. Solid Waste Management is a set of characteristic activities that include the following:

- Collection, transport, treatment and disposal of waste;
- Control, monitoring and regulation of the production, and;
- Prevention of waste generation through in-process modification, reuse and recycling.

Material Flows. The various waste flows for the different sources and the options for waste processing, treatment and disposal after collection need to be integrated into the solid waste management system to be employed in an Eco-City. The system is consistent with the solid waste management hierarchy, which gives precedence to the 3Rs (reduce – recycle – reuse) and less preference to direct treatment or disposal where practicable. The directly reusable segregated waste from residences, institutions, commercial establishments, industrial facilities and construction and demolition activities goes back to these sources.

Integrated Solid Waste Management. Solid waste management, or preferably Integrated Solid Waste Management (ISWM), is a comprehensive waste prevention, recycling, composting, and disposal program. An effective ISWM system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. The major ISWM activities are waste prevention, recycling and composting, and combustion and disposal in properly designed, constructed, and managed landfills. Each of these activities requires careful planning, financing, collection, and transport.

Terminology. The term of solid waste management (SWM) usually relates to all kinds of waste, whether generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, or other human activities, including municipal (residential, institutional, commercial), agricultural, and special (health care, household hazardous wastes, sewage sludge). Waste management is intended to reduce the effect of waste on health, the environment or aesthetics.

Climate Change. **错误!**未找到引用源。 describes the impacts caused by climate changes on the waste management activities. The impact, both short-term and long-term, from higher temperature and greater rainfall leading to possible rodent infestations, disease outbreak, and groundwater contamination is discussed.

Adaptation to impacts of climate change. Adaptation actions can be integrated into the upfront design, construction, operation, and maintenance of solid waste management systems. Integrating adaptation can prevent maladaptive decisions that increase the vulnerability of the infrastructure and people they are trying to serve.

Waste practices. Cities employ a variety of waste management systems based on available technical and financial resources, and the current level of environmental awareness. This is consistent with a city's transition from basic to the low-carbon city. Eco-Cities solid waste management adopts the 3R approach (Reduce, Reuse, and Recycle), which can be further reflected in the waste hierarchy.

3R approach to waste management. The adoption of these principles will occur in varying degrees at all stages of city development and status within the assessment framework (basic – eco – carbon positive).

Capacity of cities. Cities with low institutionally and financially capacity may only employ management techniques such as partial collection, open dumping, and reliance on the informal sector for collection and any reuse practices. The role of the informal sector, i.e., sorting and recovering recyclables, is often significant when cities are only able to adopt moderately low levels of solid waste management practices. As cities develop and when resources allow, waste collection coverage will increase, disposal of waste via sanitary landfills, develop composting facilities, increase recovery recyclables (including mechanization) and develop and operate waste-to-energy (WTE) plants are some initiatives that can be implemented.

Negative impacts of poor waste management. Poor waste management practices have negative impacts on human health and environment. Waste dumped in or near watercourses contaminate the water, restrict the water flow, and lead to a degraded aquatic environment; inappropriate treatment of industrial and medical waste poses great risks to human health and the natural environment, poor practices increase vermin in urban areas, and overall poor waste management practices are a visual blight.

Forward planning. Forward planning that considers waste management within the context of continued urbanization and population gain also needs to consider the spatial extent of the city, the appropriate sites for waste management facilities, and the potential for cross-boundary collaboration. Consideration to the ability for expansion as well as transition from lower technology to higher technology solutions is also required.

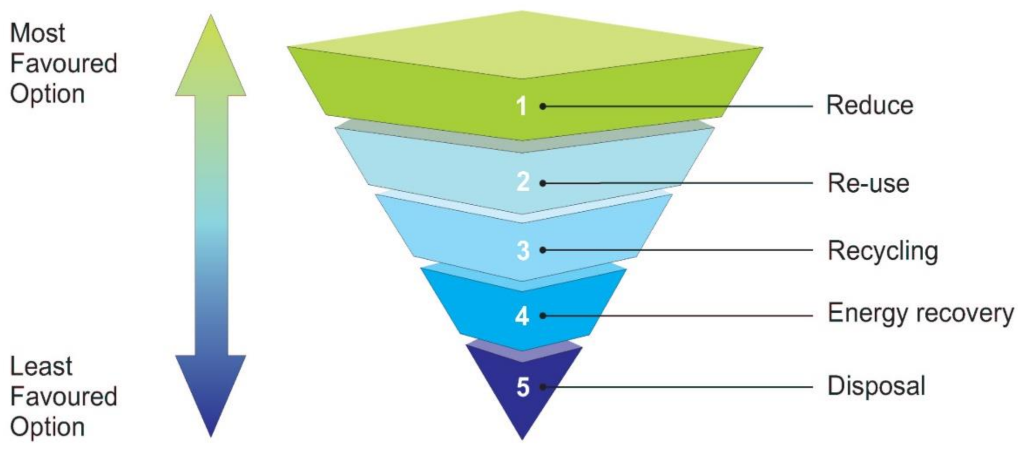
Population growth and waste. As the world's population continues to grow at a rapid pace, so does the problem of solid waste management. This reality, along with the consequent negative environmental impacts is very obvious in Chinese cities. At a conservative average per capita waste generation of 1.5 kilograms, about four (4) billion tons of waste per day, a huge amount of solid waste is being generated daily.

High end technologies for waste management. Incineration is used in large cities in China. High cost[2] and perceived negative impacts on the air environment and loss of resources serve as steep barriers for the use of this technology by less developed cities. Industrial waste is generally managed along with the ordinary municipal solid waste and as such is usually disposed in open dumps and landfills.[3] Evidently, the current methods for managing the bulk of the waste generated in Chinese cities would not be enough as the volume grows in response to population growth and economic development.

Sustainable solid waste management. The key to the sustainable management of solid waste in cities lies in the practical operationalization of the principles of reduce, reuse and recycle (the 3Rs) and the application of the appropriate technologies in the different stages of waste flow to attain acceptable sanitation conditions and facilitate recovery and use of materials4. This is what is envisioned for the Green City of the future. The following sections present the preferred flow of waste from the different generators and common methods and technologies which are consistent with Green City environmental standards as implemented in some Asian cities. The succeeding sections also highlight the features which must be present to sustain operation.

Solid waste management in Eco-Cities is anchored on avoidance and 3Rs (reduce, reuse and recycle practices) which occupy the upper tiers of the solid waste management hierarchy. The hierarchy serves as the general guide in the waste flow adopted at various levels of activities. It is based on the composition of the waste from various generators and the availability of conventional or available new technologies where practicable.

Solid Waste Management Hierarchy



Source: East Riding's Consultation Portal http://eastriding.limehouse.co.uk/portal/

[2] Visvanathan , C., J. Trankler. 2000. *Municipal Solid Waste Management in Asia: A Comparative Analysis*.
[3] United Nations Environment Programme. 2004. *State of Waste Management in South East Asia*.
[4] Ackerman, F. 2005. Special Feature on the Environmentally Sustainable City - Material Flows for a Sustainable City, *International Review for Environmental Strategies* Vol. 5, No. 2, pp. 499 – 510.

Waste Classification. The classified composition of waste from the different generators is presented in 1, below. The percentages of the different components vary with the level of economic development of cities. In cities with lower GDP, the bulk of the waste generated corresponds to food and other biodegradable materials. High income cities will have relatively higher non-biodegradable components. For each city, updated waste characterization data is a must as this will serve as the basis for the development of the appropriate solid waste management system.

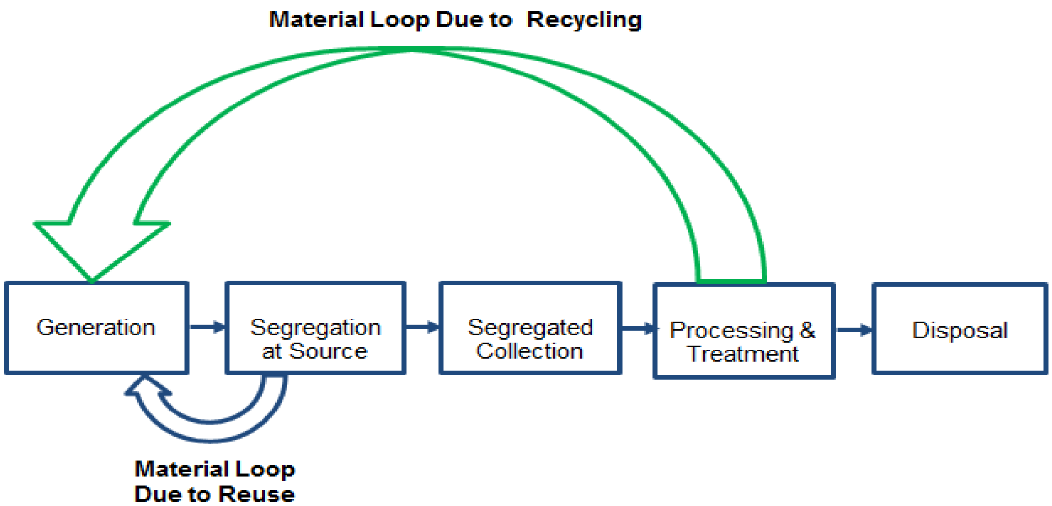
Sources and Types of Solid Wastes

Source	Typical waste generators	Biodegradable Components	Non-Biodegradable Components
Residential	Single and multifamily dwellings	Food waste, paper, cardboard, textiles, leather, yard wastes, wood,	Glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, appliances, batteries, oil, tires), and household hazardous wastes).plastics, Waste of Electrical and Electronic Equipment (WEEE)
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants.	Food waste	Housekeeping wastes, packaging, hazardous wastes, special wastes, WEEE, ashes,
Commercial	Stores, hotels, restaurants, markets, etc.	Paper, cardboard, plastics, wood, food wastes (unused and leftovers, expired food packages),	Glass, metals, special wastes, hazardous waste, WEEE
Institutional	Schools, hospitals, prisons, government centers, banks, offices	Paper, cardboard, plastics, wood, food waste	Glass, metals, special wastes, hazardous waste, WEEE
Construction and Demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood	Steel, concrete, dirt, wrapping and packaging materials
City services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas;	Sludge. WEEE

Source: Green City Solid Waste Management as modified from What a Waste: Solid Waste Management in Asia, 1999

Material flows. Depending on the waste composition and generator, various components follow a path, which takes these materials to various methods of segregation at source for possible reuse, collection, processing and treatment, and final disposal. The material look shows a material process from generation to recycling. Small material loops prevail at source due to the reuse of recyclable components while bigger material loops exist upon the processing and recycling of collected waste which facilitates their use by the various generators. The recycling of waste materials and subsequent reuse in various forms may not necessarily be undertaken within the same city. The indicated waste flow for the various waste sources show the preferred route that will be taken by the different segregated components in a solid waste management system of an Eco-City.

Generic Waste and Material Flow



Source: Rollan, R. R. Green City Solid Waste Management, in: Lindfield, M. and Steinberg, F. (eds.). 2012. *Green Cities*. Manila: Asian Development Bank. Urban Development Series. Manila. pp. 262-295. http://www.adb.org/publications/green-cities (retrieved 6. July 2015)
Note: "Segregated Collection" is collection of segregated materials.

Justification.

Sector overview China has been undergoing a rapid urbanization, resulting in the enormous generation of municipal solid waste (MSW). In terms of municipal solid waste management, no country has ever experienced such a rapid increase or such large in MSW quantities that China is now facing. Along with this rapidly growing waste stream, MSW treatment technology has been improved, environmental legal framework has been established and developed, and public environmental awareness has also been promoted in the past three decades, although the MSW management in China still facing many challenges.[5]

[5] Su Lianghu, Huang Sheng, Niu Dongjie, Chai Xiaoli, Nie Yongfeng, Zhao Youcai . 2014. Municipal Solid Waste Management in China. In: *Environmental Science and Engineering* (http://link.springer.com/bookseries/7487), Municipal Solid Waste Management in Asia and the Pacific Islands pp 95-112. (http://link.springer.com/chapter/10.1007/978-981-4451-73-4).

China is experiencing rapid economic growth. This country has a GDP of $8.8 trillion in terms of Purchasing Power Parity (PPP), which is the third largest in the world after the EU and the US. However, its population is over four times that of the US so the actual per capita GDP is only $6.800 and corresponds to a fraction of the US GDP per capita.

China recently surpassed the US as the world´s biggest municipal solid waste generator. In 2004, the urban areas of China produced approximately 190,000 tonnes of municipal solid waste. By 2030, this amount will increase to at least 480,000,000 tonnes. No country has ever seen as large or as rapid an increase in solid waste. The implications both for China and for the world are enormous.

Critical issues are:

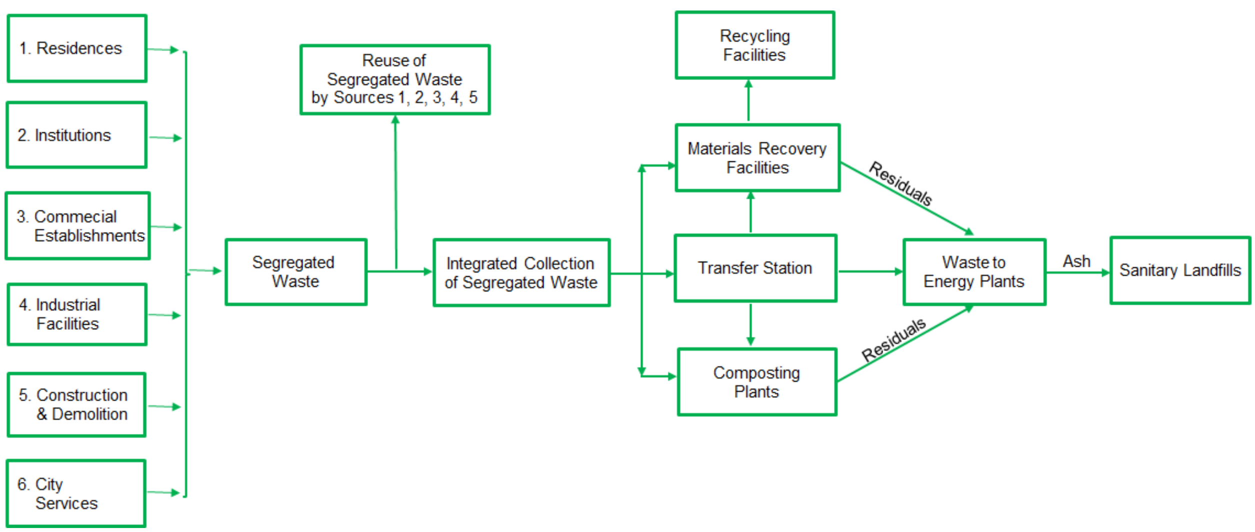
a) Waste Quantities: unsurpassed rate of growth in waste generation, dramatically changing composition, and minimal waste reduction efforts;
b) Information Availability: lack of reliable and consistent waste quantity and cost data makes planning for waste management strategies extremely difficult;
c) 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;
d) Operations: facilities do not always meet design standards, particularly in pollution control, and facility operations are deficient, waste collection operations are often not rationalized;
e) Financing: inadequate cost recovery through user charges and tipping fees;
f) 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;
g) 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; and
h) 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.

Integrated Waste Management. The various waste flows for the different sources and the options for waste processing, treatment and disposal after collection need to be integrated into the solid waste management system to be employed in a Green City. The system is consistent with the solid waste management hierarchy, which gives precedence to the 3Rs and less preference to direct treatment or disposal where practicable. The directly reusable segregated waste from residences, institutions, commercial establishments, industrial facilities and construction and demolition activities goes back to these sources. The bulk of the segregated waste is collected and transported directly to MRFs or composting plants or optionally to transfer stations for cities where the processing facilities are located at large distances from the centre of waste generation. The outputs of the

MRFs are directed to recycling plants within or outside the city which will subsequently turn out products which can be used for manufacturing processes. In the case of least developed, low income and middle income cities, the recyclable materials will likely pass through junkshops thence directly to recycling plants or go through MRFs via a buy back scheme.

Use of residuals. Compost can be used as soil conditioners for farms and gardens. It is expected that the quality of the compost will improve to saleable standards with time as proficiency in the chosen technology is attained. Residuals left out of the composting plants and MRFs are fed into waste to energy plants where available or disposed into sanitary landfills. The ash from these plants can be disposed to sanitary landfills or used as aggregate for concrete. Once the level of segregation and waste processing is able to process the bulk of the generated waste, the viability of operating WTE plants or incinerators or even landfills need to be evaluated.

Integrated Waste Flow Options



Source: Rollan, R. R. Green City Solid Waste Management, in: Lindfield, M. and Steinberg, F. (eds.). 2012. Green Cities. Manila: Asian Development Bank. Urban Development Series. Manila. pp. 262-295. http://www.adb.org/publications/green-cities

Development Objectives

What is an Eco-City? An Eco-City is a community of residents, neighbours, workers, and visitors who strive together to balance ecological, economic, and social needs to ensure a clean, healthy and safe environment for all members of society and for generations to come.

Why become an Eco-City? To ensure a viable future, the Eco-City must take a leadership role and address the impacts placed on the environment by urbanization and a growing population. These impacts include air, and water pollution, climate change, and habitat loss, as well as land and landscape protection.

ISWM is the essential for cities to become Eco-Cities. Developing a Plan for Integrated Solid Waste Management Planning is the first step in designing or improving a waste management system. Waste management planners should, for example, take into consideration institutional, social, financial, economic, technical, and environmental factors.

Development choices for solid waste management. Based on these factors, each community has the challenge of selecting the combination of waste management activities that best suits its needs. Because integrated solid waste management involves both short- and long-term choices, it is critical to set achievable goals.

Policy Direction from the 13th Five Year Plan. The Government´s pronouncement of the Five Year Plan objectives has stated three key objectives:

- Increased efficiency of energy resources development and utilization; effective control total aggregate of energy and water consumption, construction land, and carbon emissions. The total emissions of major pollutants shall be reduced significantly.
- City development shall be in accordance with the carrying capacity of resources and the cultural context. Green planning, design and construction standards shall be applied.
- Support reduced emission standards, and implement demonstration projects of ¨near-zero¨ carbon emission.

New Urbanization Policy 2016. Following the Central Urban Work Conference (20-21 December 2015) on 6 February 2016, the Communist Party of China Central Committee and the State Council issued a roadmap for city development which mentioned complete urban services. [6]

- **Build comfortable and livable environment.** Within 5 years, set up the system of collection and reutilization of kitchen and building waste. Until 2020, in all cities above prefecture level, waste water shall be 100% collected and treated.

China Development Bank Capital (CDBC) Policy for Green Urban Development. The CDBC´s policy document for Green Urban Development states several principles for the SWM sector:

- **Waste Management:** All buildings should have waste classification facilities. All household waste must be sorted and collection of hazardous waste must be prioritized. .At least 30-50% of waste should be composted and 35-50% recycled or reused.[7]
- **Smart waste management.** Smart Technologies can advance green city management: smart technologies can improve waste flows and contribute to the implementation of integrated waste management practices. [8]

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[6] Extracted and translated from: http://www.gov.cn/zhengce/2016-02/21/content_5044367.htm)

[7] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf

[8] Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

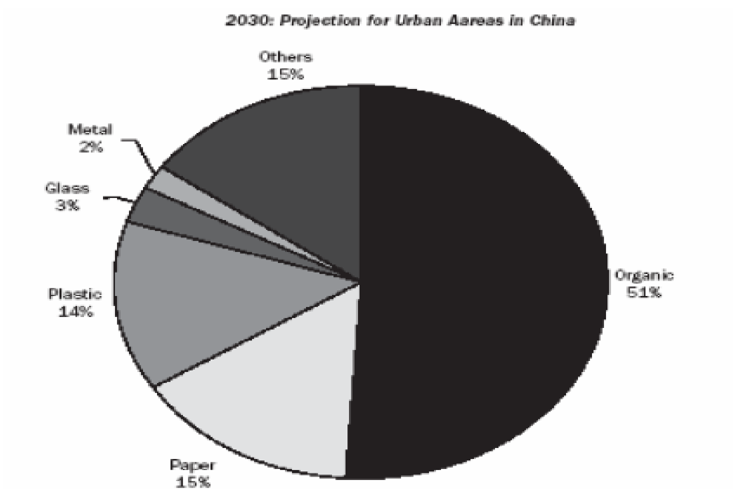
Relationship between Smart and Green Guidelines

Smart Guideline	Relevant Green Guidelines	Relationship	Relevant Smart Technologies
Smart Governance	Waste	Optimizing waste routes or understanding when to empty public waste bins can save on fuel and labor costs associated with waste management.	Smart Waste Collection

Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

Waste minimization as critical priority. China needs to achieve more waste reduction, recycling and reuse, and recovery (through composting and digestion), thus minimizing the amount of waste disposed. Particular emphasis is required for the organic waste (household waste, agricultural waste, etc.). Organic waste will be 50% of the total waste stream in the foreseeable future, and for paper which is the fastest-growing component of the waste stream. The recycling industry needs to be improved. Higher professionalization needs to be achieved through improved product standards, market development strategies, and better operating standards.

Waste management in China. Projection, year 2030



Source: Hoornweg, D. Waste Management in China: issues and Recommendations. http://siteresources.worldbank.org/INTEAPREGTOPURBDEV/Resources/China-Waste-Management1.pdf

Climate change resilience. Climate resilience can be generally defined as the capacity for a socio-ecological system to:

- Absorb stresses and maintain function in the face of external stresses imposed upon it by climate change and
- Adapt, reorganize, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts.

With the rising awareness of climate change impacts by both national and international bodies, building climate resilience has become a major goal for these institutions. The key focus of climate resilience efforts is to address the vulnerability that communities, states, and countries currently have with regards to the environmental consequences of climate change. Currently, climate resilience efforts encompass social, economic, technological, and political strategies that are being implemented at all scales of society.

Climate change will have an impact on solid waste management infrastructures and the surrounding environment. The impact may be temporary or long-lasting. If management of the waste facilities is poor the effects from the climate changes will lead to an even bigger impact with rodent infestations, disease outbreak, and groundwater contamination.

Solid waste collection, processing, and disposal is critical for development of practical priorities in the environment and health sector, including maintaining clean air, soil, and water, particularly in urban settings. Waste collection is important for maintaining sanitary conditions, particularly in residential and business areas where food debris can attract rodents and insects while decaying organic matter can cause unpleasant odours. It is critical that all new and existing solid waste management systems are designed and maintained to be resilient to climate change.

Climate stressors can impact solid waste facilities both directly and indirectly. For example, while higher temperatures may directly alter decomposition rates, climate change may also affect access to roads, ports, and energy, indirectly limiting the collection of waste and operation of waste management sites.

Flooding poses the biggest threat to solid waste infrastructure. Without proper water catchment systems around a landfill, heavy rain events can degrade the landfill, causing breaks in the containment structure, allowing debris and leachate to escape from the landfill and contaminate local resources. Flooding from extreme storms may undermine landfill foundations, releasing leachate into groundwater or block collection routes, sweep waste into waterways, and cause waste to clog other infrastructure. Landfills near the coast or in low-lying areas are vulnerable to sea level rise and storm surge. Water infiltration of the pit can lead to an overflow of waste from the landfill. Saltwater infiltration from below can deteriorate the impermeable lining of the sanitary landfill facilities.

Temperature increases may necessitate more frequent waste collection schedules and rigorous landfill management practices, as odours will be stronger. Higher temperatures and drought may also increase the risks of fire at waste facilities.

These and other climate change risks vary in relative importance, with a range of cost implications, compounding effects, and impacts on development objectives. **错误!未找到引用源。** gives examples of Potential Climate Change Impacts on Solid Waste Management Infrastructure and Services.

Examples of Potential Climate Change Impacts on Solid Waste Management Infrastructure and Services

	Collection	Processing	Disposal
Temperature Change	• Increased odour and pest activity requiring more frequent waste collection • Overheating of collection vehicles requiring additional cooling capacity, including to extend engine life	• Overheating of sorting equipment	• Altered decomposition rates • Increased maintenance and construction costs due to thawing permafrost • Increased risk of fire at disposal sites
	• Greater exposure of workers to flies, which are a major cause of infectious diseases (flies breed more quickly in warm temperatures and are attracted to organic waste)		
Precipitation Change	• Flooding of collection routes and landfill access roads, making them inaccessible • Increased stress on collection vehicles and workers from waterlogged waste	• Increased need for enclosed or covered sorting facilities	• Increased flooding in/around sites • Increased leachate that needs to be collected and treated • Potential risk of fire if conditions become too dry and hot
Sea Level Rise	• Narrowed collection routes • Potentially increased waste in a concentrated area as people crowd into higher elevations within an urban area	• Damage to low-lying processing facilities • Increased need for sorting and recycling to minimize waste storage needs	• Deterioration of impermeable lining • Water infiltration of pit leading to possible overflow of waste
	• Permanent inundation of collection, processing, and disposal infrastructure		
Storm Surge	• Temporary flooding of and diminished access to roadways, rails, and ports for waste collection, sorting, and disposal • Closure of facilities due to infrastructure damage		
Extreme Wind	• Dispersal of waste from collection sites, collection vehicles, processing sites, and landfills • Reduced access to collection and landfill access routes due to damage and debris		

Source: ADDRESSING CLIMATE CHANGE IMPACTS ON INFRASTRUCTURE: PREPARING FOR CHANGE
http://www.usaid.gov/sites/default/files/documents/1865/Infrastructure_SolidWasteManagement.pdf

Waste collection and disposal facilities are critical for protection of human health and local resources (particularly water and soil resources). Regularly collection reduces exposure to contaminated waste and disease-carrying rodents and insects. Properly sited, constructed, and maintained waste treatment facilities is the only way to minimize the risk of contamination of water, soil and air from the consequences of climate change impacts.

Reducing the amount of solid waste deposited in landfills is one of the easiest ways to reduce their vulnerability. Proper location of landfills is another low-cost adaptation option. Landfills should be sited in areas where there is reliable access to the site but away from bodies of water and areas with high water tables.

Through a screening process, action priorities for adaptation of climate changes can be selected based upon the following four key factors:

a) **Criticality** – How important is the infrastructure to the community or region? How large is the population served by the waste management system? Are backup services available?

b) **Likelihood** – Given climate projections, what is the probability that the collection, processing, or disposal infrastructure will be affected?

c) **Consequences** – How significant is the impact? Will the impacts complicate solid waste management? Will the impacts have health implications?

d) **Resources available** – Can changes be made to collection, processing, or disposal using a reallocation of existing time and resources? Are additional resources, such as additional workers, required?

By understanding the answers to these questions, adaptation actions can be integrated into the upfront design, construction, operation, and maintenance of solid waste management systems. Integrating adaptation can prevent maladaptive decisions that increase the vulnerability of the infrastructure and people they are trying to serve. **错误!**未找到引用源。 illustrates this approach.

Examples of Solid Waste Management－Related Actions by Project Cycle Stage

<table>
<tr><td>Project Cycle Stage</td><td colspan="3">Project Cycle Actions</td></tr>
<tr><td>Scope</td><td colspan="3">• Identify solid waste-related development goals important to the country, community, or sector you are working with
• Identify inputs and enabling conditions necessary to achieving those goals
• Consider the impacts of climate and non-climate stressors on those inputs</td></tr>
<tr><td>Assess</td><td colspan="3">• Assess climate threats, vulnerabilities, and impacts to solid waste collection, processing, and storage to understand adaptation needs
• Evaluate climate-related risks in light of all existing risks to solid waste</td></tr>
<tr><td rowspan="3">Planning
Policy
Changes
Project
Development</td><td colspan="3">Adaptation Options (Examples)</td></tr>
<tr><td>ACCOMMODATE / MANAGE</td><td>PROTECT / HARDEN</td><td>RETREAT / RELOCATE</td></tr>
<tr><td>• Properly site landfills away from floodplains, wetlands, or areas with high water tables
• Site landfills away from drinking water supplies
• Develop sites large enough to accommodate projected population growth and corresponding waste generation
• Design sites with sorting, recycling, and composting facilities to reduce waste storage needs</td><td>• Update design standards to elevate and strengthen containment walls to accommodate future sea level rise and high winds
• Design water catchment systems that can keep pace with projected rainfall patterns
• Update equipment design standards to increase efficiency and reduce maintenance costs in changing climate, particularly for complex, HVAC-dependent</td><td>• Plan for secure landfill closure and/or relocation
• Plan for extreme event evacuation</td></tr>
</table>

		equipment	
Construction Operation Maintenance Program Activities	ACCOMMODATE /MANAGE	PROTECT / HARDEN	RETREAT / RELOCATE
	• Increase financial and technical resources for more frequent maintenance and repairs • Train waste sorters and educate the public about separating recyclable and compostable material from other waste • Maintain collection vehicles to minimize disruptions due to mechanical failures	• Prevent erosion of landfill slopes, covers and roads into and around landfills • Maintain storm water catchment systems to ensure proper function	• Cover threatened landfills and develop new sites in more secure locations
Evaluate and adjust	• Regularly inspect the integrity of water catchment systems and containment walls, particularly following extreme rain or storm events • Continue to monitor landfills for groundwater contamination and cover erosion		
Source: ADDRESSING CLIMATE CHANGE IMPACTS ON INFRASTRUCTURE: PREPARING FOR CHANGE http://www.usaid.gov/sites/default/files/documents/1865/Infrastructure_SolidWasteManagement.pdf			

Outlook. With regard to the SWM sector, UNEP has observed that:

- the increasing volume and complexity of waste associates with economic growth are posing major risks to ecosystems and health;
- the growth of the waste market, increasing resource scarcity and the availability of new technologies offer opportunities for greening the waste sector;
- there is no one-size-fits all when it comes to greening the waste sector, bit there are commonalities;
- investing in greening the waste sector can generate multiple economic benefits; and
- greening the waste sector requires financing, economic incentives, policy and regulatory measures, and institutional arrangements.[9]

Thus, an integrated waste management approach with consistent and holistic concept; waste minimization, collection, transfer, treatment, recycling, resource recovery and final disposal are necessary for eco-city development.

[9] UNEP. 2011. *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*, pp. 290-327. http://www.unep.org/greeneconmy

Eco-Cities need to be encouraged to develop integrated waste management plans in order to pursue waste minimization strategies, generate credible and comprehensive waste management data (especially costs and quantities), and to implement new concepts for sorting, collection and treatment of waste and recyclable materials. Eco-Cities must serve as 'centers of excellence' for waste management technologies, and best waste practices.

Special attentions also need to be given to the technical issues of composting, processing of biomass, incineration, special waste treatment, and clean-up of brownfields and old dump sites:

a) Composting
The processing of biodegradable materials through Composting could increase substantially. However, Composting needs to be supported by the public sector, for instance in parks and public spaces, and in agriculture both as providers of waste but also as receivers of compost material as fertiliser and soil conditioner.

b) Biomass
Processing of biomass from human and animal waste (sewage sludge, manure, slaughterhouse waste and other wastes from food processing), and other biodegradable materials can be utilized as alternative form of energy (gas, heat and electricity) that can be used in public facilities. It is important to mention recycling of the fertiliser units in our organic waste will become the biggest challenge during the following decades, because chemical elements like phosphorous has become a limited resource and we cannot afford to flush this with the toilet water into the ocean or burn it in an incinerator.

c) Incinerators
The technology of incinerators is receiving more popularity. Its growth is usually driven by subsidies, and often the financing structures are not financially viable. Incinerators should meet EU emission standards for dioxin and mercury, and should have sufficient level of operating training. Cost-benefit analysis should be undertaken before committing to this technology.

d) Special Wastes
When introducing new waste treatment methods, attention have to be given to the waste fractions that may harm the treatment process. For instance: chemical substances in re-chargeable batteries that end up in an incinerator may harm the emission.

e) Brownfields and old dump sites
Old industrial sites and inactive waste dumping sites are considered as ¨brownfields¨. They will grow in number and (negative) importance in cities since these affect the environmental quality, health and land values. There are approximately 5,000 such brownfield sites in Chinese cities. The costs of cleaning these sites will be significant, and these will be higher than disposing wastes properly.

Features of Eco-City Waste Management. The various features of eco-city waste management can be classified in terms of legal aspects, practices, system employed, funding, and facilities used. It shows the progression from manual to mechanical, community based to private, and use of technology with the level of economic development.

Solid Waste Management Features

SOLID WASTE MANAGEMENT COMPONENTS	Least Developed Cities	Low Income Cities	Middle Income Cities	High Income Cities
SWM ORDINANCES/REGULATIONS/ACTS/PROGRAMS				
3R Strategy Programs	x	x	x	x
Garbage Collection Fees			x	x
Penalties for non-segregation	x	x	x	x
Ban on open dumping, littering, waste burning	x	x	x	x
Extended producer responsibility	x	x	x	x
PRACTICES AT SOURCE				
Waste Avoidance/Minimization	x	x	x	x
Segregation at Source	x	x	x	x
Food waste as animal feed	x	x		
Reuse of dry recyclables and paper	x	x	x	x
Reuse of construction and demolition waste	x	x	x	x
SYSTEM				
Segregated Collection	x	x	x	x
No segregation - no collection	x	x	x	x
FUNDING				
Subsidy from government	x	x		
Private sector initiative			x	x
EQUIPMENT AND FACILITIES				
Various waste bins (metal, plastic, concrete)	x	x		
High-density polyethylene (HDPE) waste bins		x	x	x
Waste collection vehicles	x	x	x	x
Transfer Stations			x	x
Food waste processing plants			x	x
Community managed composting plants	x	x		
Privately managed composting plants			x	x
Community managed Material Recovery Facilities (MRFs)	x	x		
Privately managed MRFs			x	x

Privately Managed Recycling Facilities			x	x
Sanitary Landfills		x	x	x
Landfill gas (LFG) Power plants	x	x	x	x
Waste to Energy Plants			x	x

Adopted from: Rollan, R. R. Green City Solid Waste Management, in: Lindfield, M. and Steinberg, F. (eds.). 2012. Green Cities. Manila: Asian Development Bank. Urban Development Series. Manila. pp. 262-295. http://www.adb.org/publications/green-cities

Proposed Solid Waste Management KPIs [10]

	Solid Waste Management		
	Indicator Category	**Indicators: indicative values**	**Current achievements / Time frame for accomplishment**
1	Domestic waste generation [1]	≤ 0.8 kg / day / person [1]	By 2013 [1]
2	Garbage collation ratio [2] - Household waste - Businesses, institutions - Other activities	100% [2]	
3	Treatment to render hazardous and domestic solid waste non-toxic [1]	100% [1]	Immediate [1]
4	Rate of reuse of domestic waste [3]	Non-hazardous waste: 100% Recycling rate: ≥50% [3] reuse rate ≥50% [3] [5]	
5	Overall Solid waste recycling rate [1]	≥60% [1]	By 2013 [1]
6	Waste conversion to energy [4]	__ % of total waste __ KW of energy produced	
7	Recycling of building waste [4]	≥98% [4]	

Sources:
[1] World Bank. 2009. *Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China.* Technical Assistance Report. Beijing. www-wds.worldbank.org/.../PDF/590120WP0P114811REPORT0FINAL1EN1WEB.pdf
[2] SWECO. No date. Caofeidian - Detailed ecological indicators system [unpublished document].
[3] Qiu Baoxing. 2012. Combine idealism and pragmatism – a primary exploration of setting up and implementing low
[4] CSUS. 2015. Zhuhai Indicator System for Livability. Beijing. [unpublished report].
[5] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf

Verification methodology. The above parameters and values will be used for verification of the adoption of eco-cities´ solid waste management performance.

[10] These key performance indicators were prepared and compiled by the EC-Link Project. See: EC-Link. 2016. *Sino-EU Key Performance Indicators for Eco-Cities*. Beijing (unpublished draft)

Expected impact. The application of the solid waste management approaches and technologies are expected to achieve a substantially higher, measurable impacts on urban environmental performance. It will trigger increased investment, reduce energy consumption and CO_2 emissions, and augment the number of jobs in the sector.

Responsibilities for Implementation. The responsibility for use and application of this Eco-City Implementation Guideline rests with the city administrations, provincial agencies, and the local MoHURD offices. MoHURD and CSUS will provide technical support and specific guidance where required. In its intention to pursue consistency of eco-city development, MoHURD is committed to verify the achievement of targets and to ensure improved performance on an annual basis.

Monitoring and review. MoHURD will monitor and review periodically (i.e. annually) the results of the application of this Eco-City Implementation Guideline. For monitoring and periodic review it will utilize indicators as provided above. The city administrations (and district administrations), supported by the local MoHURD offices, will make regular use of these indicators as a means to measure performance.

Date issued: _____ 201_

ANNEX

Annex 1 – Technical Annex

(still to be added, once work in EC-Link cities completed)

Annex 3

MoHURD. 2015. *Appraisal Standards for Green Eco-Districts.* Beijing. (draft).

Excerpt

Resource & Carbon Emission	Controlled Criteria	Develop energy conservation plan, integrated use of various energy.			
		Solid Waste & Material	10. utilization percentage of recycled resource reaches 70%		3
			11-1. percentage of household waste which has been turned into resource reaches 50%		3
			11-2. building waste is standard managed and the comprehensive utilization percentage reaches 30%		3
			12-1. Utilization percentage of green building materials	>5%	3
				>10%	4
			12-2. Utilization percentage of local building materials > 60%		2
			14. 3 Indicators of carbon emission per unit GDP, per capita, per area meet the local goals.		10