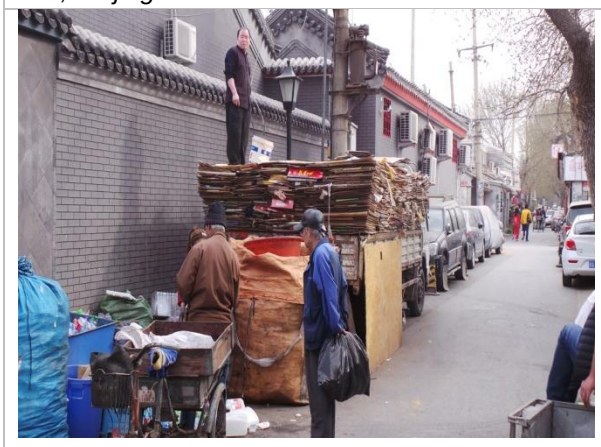
EC-LINK 中欧生态城
Europe-China Eco-Cities Link
中欧低碳生态城市合作项目

Sector Overview

Solid Waste Management

Due to rising living standards and consumption levels, solid waste is increasing rapidly. The current conventional standards are low, and majority of waste ends up in uncontrolled dump sites, with little recycling and reuse. These conditions call for a more integrated approach of waste management (Tool SWM 1: Integrated Solid Waste Management Plans). One major underlying principle will be the introduction of waste reduction, recycling and reuse (3-R) practices (Tool SWM 2: 3-R Tools). A serious fact of the waste management situation is that there exist only few waste-to-energy projects in the country, and for those that exist there are no modern technologies for their closure known (Tool SWM 3: Management of Closure of Sanitary Landfills). A modernization of the waste sector is urgent, and a better use of the resources through recycling or conversion to energy needs to be developed with the help of private investors (Tool SWM 4: Management of Waste Incinerators).

Traditional labour-intensive neighbourhood waste collection – Zhuhai	*Proper closure of (sanitary) landfills is complicated and a major environmental issue – Zhuhai*
	
	Source: Florian Steinberg

Modern waste compacting station – Zhuhai	*Recycling of waste products - Fly-ash serving as base materials for construction materials – Zhuhai*
	
Waste cardboard recycling – Dongcheng District, Beijing	*Plastics recycling – Wangfujing area, Downtown Beijing*
	
Source of all: F. Steinberg	

Sector Profile

Introduction.

Solid waste management refers to the collection, transfer, and disposal of waste. Eco-cities´ solid waste management should adopt the 3R approach - reduce, recycle, and reuse. As cities develop and increase their waste collection coverage, they graduate from disposal of waste via landfills and composting facilities, to increase recovery of recyclables. On a higher technology level, cities operate waste-to-energy (WTE) plants. The composition of waste from various generators and the availability of conventional or new technologies is critical for the establishment of city level waste management schemes.

State of Demand in China.

Despite the relatively high capital cost of WTE, the central government of China has been very proactive with regard to increasing WTE capacity. One of the measures brought in provided a credit of about $30 per MWh of electricity generated by means of WTE rather than by using fossil fuels. The term ‘harmless treatment’ in China describes conventional solid waste management practices: the disposal of municipal solid waste by recycling, composting, WTE and sanitary landfilling. The ‘harmless treatment’ rate is defined as the percentage of the weight of total municipal solid waste treated with these methods. The generation of

municipal solid waste, and also the 'harmless treatment' have been increasing over the past 30 years in China. Most of the air pollution control systems built in the Chinese WTE plants are based on US technology. A potentially major problem of the incinerators are high dioxin emissions, and abatement techniques are often not well known.

Policy Directions.

The State Council issued a roadmap for city development which mentioned solid waste management as part of ´complete urban services´.[1]

- **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.
- **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.[2]
- **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.[3]

Best Practices in Europe.

Europe currently uses 16 tons of material per person per year, of which 6 tons become waste. Although the management of that waste continues to improve in the EU, the European economy currently still loses a significant amount of potential 'secondary raw materials' such as metals, wood, glass, paper, plastics present waste streams. In 2010, total waste production in the EU amounted to 2.5 billion tons. From this total only a limited (albeit increasing) share (36%) is recycled, with the rest landfilled or burned, of which some 600 million tons could be recycled or reused. Just in terms of household waste alone, each person in Europe is currently producing, on average, half a ton of such waste. Only 40% of it is reused or recycled and in some countries more than 80% still goes to landfill. Turning waste into a resource is one key to a circular economy. The objectives and targets set in European legislation have been key drivers to improve waste management, stimulate innovation in recycling, limit the use of landfilling, and create incentives to change consumer behaviour. If we re-manufacture, reuse and recycle, and if one industry's waste becomes another raw material, we can move to a more circular economy where waste is eliminated and resources are used in an efficient and sustainable way.

State of the art in solid waste management in Europe.

EU Directives must be seen as minimum requirements. Every member-country is obliged to implement the EU Directives in their national law.[4]

Waste Framework Directive.

The EU Directive 2008/98/EC[5] sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery for the EU Members States. It explains when waste is considered to be waste and when it becomes a secondary raw material, and how to distinguish between waste and by-products.

The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or

odours, and without adversely affecting the countryside or places of special interest. Waste legislation and policy of the EU member states shall apply as a priority order the waste management hierarchy.[6]

The European Commission has also published “Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste”. This guidance document is intended to assist both national authorities and economic operators with the aforementioned legislation, which includes some guidelines in implementing the Directive on national level[7]. The European Union's approach to waste management is based on the "waste hierarchy" which sets the following priority order when shaping waste policy and managing waste at the operational level: prevention, (preparing for) reuse, recycling, recovery and, as the least preferred option, disposal. In line with this the 7th Environment Action Programme sets the following priority objectives for waste policy in the EU:

- To reduce the amount of waste generated;
- To maximise recycling and re-use;
- To limit incineration to non-recyclable materials;
- To phase out landfilling to non-recyclable and non-recoverable waste;
- To ensure full implementation of the waste policy targets in all member states.

The development and implementation of EU waste policy and legislation takes place within the context of a number of wider EU policies and programmes including 7th Environment Action Programme[8], the Resource Efficiency Roadmap[9] and the Raw Materials Initiative[10]. The 7th Environment Action Programme (EAP) will be guiding European environment policy until 2020. In order to give more long-term direction it sets out a vision beyond that, of where it wants the Union to be by 2050. The European Union does not quantify its strategy. It is the task of the member states to establish country targets.

The present Directive, which replaces EU Directive 2006/12/EC on waste and Directives 75/439/EEC and 91/689/EEC regarding waste oils and hazardous waste, respectively, introduces the "polluter pays principle" and the "extended producer responsibility and includes two new recycling and recovery targets to be achieved by 2020: 50% preparing for re-use and recycling of certain waste materials from households and other origins similar to households, and 70% preparing for re-use, recycling and other recovery of construction and demolition waste. The Directive is, as it is stated, a Framework Directive that compile all activities and other Directives., below lists some of the most important Directives under the Waste Framework.

Municipal Waste Collection.

When looking at the management of waste generated by households, the picture is more simple and clear although, even this system may vary across Europe. A municipality in EU is responsible for the handling of the waste generated by the households. The municipality can issue local directives, which defines the level of service, how the household shall sort and store waste before collection, and how the household shall pay for the service. According to EU is a municipality allowed to collect the household waste using their own vehicles and workers, if the vehicles and workers are organised as a department in the municipality, but if the work is organised in a municipal enterprise, the work shall be open for competition. Almost every municipality have today contracted their waste collection activities to private operators. The reason for doing so is, that the municipalities cannot afford to have municipal funds tied up in waste collection vehicles and containers, when the local investment budget also have to provide for schools, elderly care taking, etc. On the bottom line is the annual

operation costs the same whether the task is organised by the municipality or tendered to a private operator when including financial costs like interests and depreciation.

Best Practices.

The practice of green and smart solid waste management in Europe is evolving rapidly. Some of the most well-known European green waste management experiences can be found in the following cities and countries:

- **Denmark: Focusing on Resources in Danish Waste Management.** Cities in Denmark are preparing Municipal Solid Waste Management Plans as a part of the national strategy "Denmark without waste". These plans want to ensure that valuable materials are not lost.[11]
- **Finland: Waste Collection Using Smart City Management Tools.** Based upon the data send from the individual waste container, the system can automatically generate collection schedules and optimise routes based several parameters (future fill-level projections, truck availability, traffic information, road restrictions etc.). Collection based this type of smart planning tools can significantly reduce costs, emissions, road wear, vehicle wear, noise pollution and work hours.[12]
- **Lund, Sweden: Collecting four different Waste Fractions at once.** Domestic waste which has been separated at source is being collected using specially designed vehicles.
- **Denmark and Sweden: Vacuum Systems.** Both countries are pioneering vacuum collection piping systems, and vacuum collection vehicles.[13]
- Braunschweig, Germany: Material Recovery Facility. This facility receives 120,000 tons of waste, annually. Its income is mostly from the sale of materials, a subsidy from the national recycling campaign ("Green Point")[14]
- **Denmark: Aiken Technology.** This technology is Denmark's largest supplier of compost, growth media and turf care products. The system separates hydrolysis ("leaching out") and methane generation, the two main processes that constitute what is generally known as dry anaerobic digestion.[15]
- **Copenhagen, Denmark: REnescience – a pilot project to decompose waste with enzymes.** This technology converts unsorted household waste to a bio-fluid that can be used to produce everything from biogas to bio-ethanol, electricity and heat. [16]
- **Denmark: I/S Reno Nord – Incinerators.** I/S Reno Nord is treating MSW from 225.000 inhabitants from 7 municipalities in the northern part of Denmark. I/S Reno Nord is a partnership owned by the 7 municipalities.[17]
- **Guldborgsund, Denmark: Sorting of Construction Waste.** Construction waste must always be sorted at the source - irrespective of volume - either directly on site or at a reception facility approved for the separation of construction and demolition waste.[18]
- **Germany: Gasification – Waste to Energy.** The thermolytic cracking process ensures a very high energy utilisation of substantially not further treatable organic waste. The patent-secured INTEC Technology involves a closed and thus completely emission-free thermal waste treatment primarily consisting of the procedural steps degassing/smouldering (thermolysis) and gasification. The procedure achieves utilisation by more than 99 % of the energy content of the waste material applied. [19]

State of the art in solid waste management in China.

China is one of the largest nations in the world, encompassing a vast area, with diversified nationalities and cultures, and a very large population. It is also the largest developing country and which has relatively poor infrastructures and an underdeveloped industry. China has been undergoing a rapid urbanization, resulting in the enormous generation of municipal sol-

id 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.[20]

With rapid urbanization and urban residents accounting for more than half of the total population, China is experiencing rapid increase in solid waste generation and growing pressure for solid waste management in cities. The quantity of municipal solid waste collected and transported surged from about 31 million tons in 1980 to 157 million tons in 2009, and is projected to reach 585 million tons in 2030. As it is increasingly difficult to build more landfills and incineration facilities due to land scarcity and public concern, China has been exploring alternative approaches for solid waste management, including waste separation and recycling. However, the challenges to waste separation in Chinese cities include a lack of:

- adequate facilities for distinct transport, sorting and recycling;
- effective regulatory and policy instruments including financial incentive tools for waste minimization and recycling, and
- public awareness and participation in waste separation at source. [21]

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 mu-

nicipal 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.

i)

Proposed Solid Waste Management KPIs [22]

	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

Outlook and future sector agenda. Along with this rapidly growing waste stream, municipal solid waste treatment technology has been improved, environmental legal frameworks have been established and developed, and public environmental awareness has also been promoted in the past three decades. Nevertheless, municipal solid waste management in China still facing many challenges. For cities to progress in the field of waste management, the national government level will need to develop comprehensive solid waste management policies. Such policies should encourage cross-agency jurisdiction and coordination, and facilitate use of economic instruments like collection of revenues for improving waste management. An integrated waste management approach with consistent and holistic concept; waste minimization, collection, transfer, treatment, recycling, resource recovery and final disposal. Cities need to be encouraged to 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, and waste practices.

Cities need to decide about using the integrated approach to waste, developing Integrated Solid Waste Management Plans, and using the 3-R concept. Among the more technical concepts of relevance are the proper ecological closure of old saturated (sanitary) landfills. The treatment of massive amounts household waste require the full socialization of the 3-R concept (Reduce-Recycle-Reuse), and management of waste incineration without harmful side-effects. The management of construction waste, a growing environmental nuisance in a nation with such rapid urbanization, requires additional attention.

With regard to the SWM sector China we can paraphrase UNEP's statements:

- 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.[23]

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. 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. 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 CO2 emissions, and augment the number of jobs in the sector.

Notes

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

[2] 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

[3] 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

[4] http://www.eurometrec.org/html/waste-laws.php

[5] European commission Directive 2008/98/EC on waste
http://ec.europa.eu/environment/waste/framework/

[6] http://ec.europa.eu/environment/waste/framework/

[7] http://ec.europa.eu/environment/waste/framework/pdf/guidance_doc.pdf

[8] 7th Environment Action Programme, http://ec.europa.eu/environment/action-programme/

[9] Resource Efficiency Roadmap, http://ec.europa.eu/environment/resource_efficiency/

[10] Raw Materials Initiative, http://ec.europa.eu/enterprise/policies/raw-materials/index_en.htm

[11] http://eng.mst.dk/media/mst/Attachments/Ressourcestrategi_UK_web.pdf

[12] http://www.enevo.com/

[13] http://www.envacgroup.com/; http://molok.com/; http://www.geesinknorba.com/; https://www.faun.com

[14] http://ing.dk/artikel/laer-af-nabolande-her-sorteres-affald-med-trykluft-og-optisk-teknologi-127646

[15] http://aikantechnology.com/

[16] http://www.renescience.com/en

[17] http://www.renonord.dk/; http://www.volund.dk/Waste_to_Energy/References/Reno_Nordhttp://www.volund.dk/Waste_to_Energy/References/Reno_Nord

[18] www.guldborgsund.dk; http://www.guldborgsund.dk/

[19] http://www.intec-micro-powder.de/syngas_en.html; www.intec-micro-powder.com; http://intec-micro-powder.com/sg_pages/sg_technology_en.html

[20] 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, Retrieved: 8. July 2015), 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, Retrieved 8. July 2015)

[21] China: 3 Million to Benefit from Improved Solid Waste Management in City of Ningbo. May 31, 2013 http://www.worldbank.org/en/news/press-release/2013/05/31/china-3-million-to-benefit-from-improved-solid-waste-management-in-city-of-ningbo

[22] 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)

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