EU-CHINA COOPERATION ON
MUNICIPAL SOLID WASTE MANAGEMENT

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1. INTRODUCTION

This article will analyse the relevance of municipal solid waste (MSW) for urban planning and sustainable city management. Sharing best-practices and learning from each other with regard to MSW will be considered a possible building block for cooperation between Europe and China. Hence, this article considers MSW in Germany and China as two examples of how waste management can work and proposes a number of policy recommendations on how to ameliorate the situation.

In section two, the article starts out by providing a definition of municipal solid waste and discusses the relevance of integrated MSW management for sustainable urban planning.

In section three, the article attempts an in-depth comparison of MSW management in China and Germany. Particular attention will be paid to the activities of the relevant actors that influence and handle integrated MSW management. Existing legislation will be reviewed whereby the German case also highlights the importance of European framework legislation.

Section three continues with a more technical perspective on actual waste generation and composition in China and Germany. Subsequently, MSW processing will be reviewed and compared for both cases. Processing includes collection, recycling, disposal, sanitary landfill, incineration and composting.

The section will close by looking into financing strategies and instruments for MSW management in China and Germany.

Drawing on the comparative case study, section four will provide a number of policy recommendations that offer a way forward in MSW management in China and Germany.

Finally, the article will conclude by pointing out possible avenues for further research.

2. MUNICIPAL SOLID WASTE

Municipal solid waste (MSW) management is an important aspect of urban planning and development. Integrated MSW management promotes a sustainable and healthy urban environment for city dwellers around the world. Yet, it has to be defined what the term MSW stands for and what is included in this technical term. The World Bank defines MSW as follows:

**DEFINITION:**

“Municipal solid waste comprises refuse from households, non-hazardous solid waste from industrial, commercial and institutional establishments, market waste, yard waste and street sweepings” (Schübeler, Christen, & Wehrle, 1996, p. 18).

With this definition at hand, it follows that once population density, as well as industrial, commercial and institutional activities in any urban area are increasing, the issue of an integrated MSW management is becoming ever more pertinent. As urban waste includes toxins and other harmful materials, integrated MSW management contributes to sustainable urban centres in the 21st century. What is more, by reusing plastics, composting bio-wastes and by generating heat and energy, recycling, composting and incineration through co-firing can reduce MSW volumes and offset resource demands. Hence, dealing with MSW management can be one of the priorities of the Sino-European cooperation on sustainable urban waste management.

This research contributes to the topic of MSW management – an issue on which
consensus was reached more than 25 years ago. At the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil in 1992, 178 governments agreed upon the need for more sustainable MSW management in both developed and developing nations. Chapter 21 of Agenda 21 of the Rio Declaration on Environment and Development, outlines the environmentally sound management of solid wastes, which includes maximizing environmentally sound waste reuse and recycling (Troschinetz & Mihelcic, 2009, p. 921-922).

This article will focus on urban waste management as a strategy to prevent, reuse, recycle, recover and dispose of waste. Despite all their differences, both Europe and China experience a trend of more and more inhabitants moving to urban areas. Growing cities may lead to increased urban waste. Therefore, the question of integrated MSW management will become ever more pertinent. Sino-European exchange on best-practices of urban waste management will provide possible avenues for cooperation between cities around the world.

The ‘EU-China partnership for sustainable urbanisation’ that was launched on 3 May 2012 specifically addresses urban public services and also waste management as one of the key priorities for potential cooperation between Europe and China (European Commission, 2012.3, European Council, 2012).

3. A SINO-GERMAN COMPARISON

A Sino-German or a Sino-European comparison of MSW management has to address various important aspects including relevant actors, existing legislation, waste generation and composition, waste processing and finally, financing. This section will address one topic at a time.

Deriving from the definition of MSW, waste comes from various sources (Schübeler, Christen, & Wehrle, 1996). This article will focus primarily on MSW from households as it seems to be one aspect of MSW management that has seen substantial development in Europe, but is yet to receive adequate attention in China.

China has experienced a substantial increase in MSW quantity. Based on figures of the World Bank and others, Zhang et. al. argue that “[n]o other country has ever experiences as large and as fast an increase in solid waste quantities” as China (D. Q. Zhang, Tan, & Gersberg, 2010, p. 1623). The annual increase is increasingly becoming an issue with MSW generation equalling GDP growth of 8-10 % per year (China Society of National Resources in Wei et. al. 2012).

OPPORTUNITY FOR EU-CHINA WASTE MANAGEMENT COOPERATION

The recently established EU-China partnership for sustainable urbanisation could be a useful vehicle to structure cooperation in this matter. Involving city mayors and local bureaucracies in this process of technical cooperation can potentially yield valuable feedback on how to best manage EU-China cooperation. In addition, initiatives of such a local scope can be adapted to fit local needs and circumstances. Ideally, all relevant stakeholders from civil society, politics, and business should be involved to ensure efficient implementation of these initiatives.

After explaining the various aspects of MSW management the article will conclude by pointing out how each of these actors can be included. It will address (1) how the overall framework for cooperation could look like, (2) then it will show how mayors and local bureaucracies play a pivotal role, (3) and finally, it will propose several ways of including all stakeholders in the process of MSW management.
3.1. **Actors**

To explain what can be improved in MSW management, any analysis needs to start out by identifying the relevant actors that possess agenda setting power, can change legislation and are responsible for implementing MSW management in urban centres.

**Chinese actors**

In China, we have a situation where both central government institutions, as well as regional and local actors are involved in the MSW management. Specifically, Chen et.al. (2010, p. 717) identify the following institutions as actors that legislated on MSW management since 2000:

- Ministry of Environmental Protection (MoEP formerly SEPA),
- the Ministry of Construction (MoC),
- the National Development and Reform Commission (NDRC),
- the Ministry of Industry and Information Technology (MIIT formerly MII),
- the Ministry of Commerce (MofCom),
- the State Administration of Industry and Commerce (SAIC),
- the Ministry of Science and Technology (MoST) and
- the General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ).

Next to these institutional actors on central government level, each regional government and local government plays a vital role in supervising implementing national legislation in the respective regions and urban centres.

Equally important are business actors including private entities as well as state-owned enterprises (SOE). However, the focus of this paper are the households and by extension the consumers in Chinese society. The MSW management in urban centres has to focus on the end-user in order to achieve comparable levels of prevention, reuse, recycling, recovery and disposal as in Europe.

One more group of actors that is of particular importance in China, even if not exclusive to China are so-called scavengers, namely people collecting waste that are elementary, yet neither contracted nor institutionalised in the national, regional, or local waste collection schemes (D. Q. Zhang, Tan, & Gersberg, 2010, p. 1662).

**European / German actors**

The European Union (EU) promotes more efficient urban waste management on European, national, regional and local level. When analysing the actors involved, a similar situation as in China can be observed. The European Commission is setting a general framework for action and European member states converge around existing initiatives. However, there are also European champions.

Hence, next to actors on the EU level, Europe also features member states in which national ministries promote MSW management and act beyond the framework of EU legislation. Pires et. al. provide a good overview of national actors and also go into detail with regard to respective legislation (Pires, Martinho, & Chang, 2011, p. 1040). Yet, it is important to note that there can be a nucleus of actors that combine and streamline their initiatives, thereby going well beyond the European standard action. This nucleus may include private as well national, regional or local government.

In this respect, Germany is an interesting case. An example of public private partnership with both governmental as well as private actors is the German ‘green dot system’. This coalition of actors on a national level was introduced in the 1990s but meanwhile spread to the whole of the EU (Pires et al., 2011, pp. 1037–1039). Another example is the case of the orange box of Berlin, a pilot programme on high-value waste collection that will be presented in greater detail in the course of this paper, but that
was initiated by coalition of regional government with private entities in 2010 (Alba, 2013; BSR, 2012).

3.2. LEGISLATION

Having defined MSW and pointed out opportunities for Sino-European cooperation on MSW, the paper has identified the actors with agenda setting power in China and Europe. The next step is to analyse actual legislation on the matter. What are the key provisions for MSW management and are there any similarities that allow closer cooperation and exchange of best-practices?

CHINESE LEGISLATION

The key legislation on MSW management in China is the Law of the People’s Republic of China on the Prevention of Environmental Pollution Caused by Solid Waste. According to Chen et. al., “[t]his law stipulates the principles of waste management, responsibilities for waste supervision and administration, pollution control measures, and associated legal responsibilities” (Chen et al., 2010, p. 717). Reviewed and amended in late 2004, the law now incorporates more provisions on extended producer responsibility just as European legislation does. “The amendment highlights the entire life cycle by extending the producer’s responsibility to include the consumption and disposal of goods, thereby establishing a legal foundation for an integrated solid waste management system” (Chen et al., 2010, p. 717).

The authors identify an extensive number of Chinese pieces of legislation that regulated MSW management since 2000, which is useful for a detailed overview. However they point out that the “11th Five-Year Plan on Urban Environment and Sanitation” (Ibid., p. 717) of the Ministry of Commerce is a key document with regard to MSW management. Introducing a target rate of 60% safe MSW disposal, the plan set ambitious targets that were then further specified.

Wei et. al. also highlight that the national 11th Five Year Plan (FYP) already had a focus on sustainable urbanisation (Friends of Europe, 2012, p. 21). Meanwhile, the 12th FYP has advanced MSW management even further without actually referring to the issue of MSW management, but instead focusing on resource conservation, environmental protection and, most importantly for MSW management, the plan focuses on the circular economy.

In particular, the 12th FYP highlights MSW management in two chapters. Chapter 20 seeks to promote urbanisation including overall planning and “comprehensively increasing the levels of... waste water and garbage disposal infrastructures” (China’s 12th Five-Year Plan, 2011, p. 41). In addition, chapter 23 of the plan calls on both people and the government to "vigorously develop the circular economy” (Ibid, p. 45). Specific activities require the government to “encourage the recycling of industrial waste, upgrade recycling systems and waste separation and recovery of renewable resources, and advance the industrialization of renewable resource recycling” (Ibid, p. 45). Beyond that, the plan also focuses on consumption patterns by encouraging “low carbon consumption models and lifestyles among the people and government” (Ibid, p. 45).

The priorities are really close to what European legislation calls for as well. The Chinese propose a development model focusing on:

- Resource conservation
- Recycling
- Remanufacturing
- Zero emissions and
- Industry links
Thus, while legislation has considerably developed in China over the last decade, regional practice is still lagging behind because of lack of implementation. However, comparing Chinese legislation with the centrepiece of European legislation on MSW management, namely the European Waste Framework Direction, one realises that priorities are converging.

**EUROPEAN / GERMAN LEGISLATION**

The EU promotes more efficient urban waste management in various communications related to the Europe 2020 strategy. The flagship initiatives on ‘A resource-efficient Europe’ and ‘An industrial policy for the globalisation era’ are of particular importance to the topic of urban waste management. They provide overall guidance for respective initiatives by national, regional and local actors.

The legal basis for the EU’s waste management initiatives are provided by the Waste Framework Directive (European Commission, 2008). The directive proposes a ‘waste hierarchy’ to address waste management:

1. prevention;
2. preparing for reuse;
3. recycling;
4. other recovery, notably energy recovery;
5. disposal.

This hierarchy stipulates that each element of MSW has to be considered for the highest category of the hierarchy. Only if a category cannot be applied, the next category may be tested for managing MSW. Jofra Sora also points out that there is an additional qualification for incineration stipulating that it “must be considered a disposal operation and will only be considered as recovery where the energy efficiency of the process is higher than the one detailed in Annex II of the Directive” (Sora Jofra, 2013, p. 3; European Commission, 2008). The annex specifies an energy efficiency equation calculating energy produced in form of heat and electricity versus energy lost due to additional energy input, energy content and energy in residues.\(^1\)

The EU aims to work simultaneously on supranational, national, regional and local level to achieve the goal of more efficient waste management (European Commission, 2010). The strategies are implemented by public and private actors throughout the EU with national or regional schemes sometimes outperforming European regulatory requirements.

Policy innovation on the European level has been motivated by resource scarcity and “new strategies at European level to promote life cycle thinking in waste management policies, and consequently, the problems of MSW management, are tied with how to integrate economically feasible and environmentally sustainable practices holistically” (Pires et al., 2011, p. 1036).

The European Waste Framework Directive is such an approach to an integrated MSW management process. The goals are ambitious with articles 10 and 11 providing the guideline of a separate collection of paper, metal, plastic and glass by 2015 in the whole of Europe. At the same time, re-use and recycling from household waste is set to go beyond 50% by the year 2020 (Hall, 2013, p. 3).

Mühle et. al. summarises European objectives for integrated MSW management as follows (Mühle, Balsam, & Cheeseman, 2010, p. 749):

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\(^1\) The energy efficiency equation specifies a minimum efficiency of 0,60 for installations constructed before 2009 and 0,65 for installations constructed after 2009 with the formula: 
Energy efficiency = \((E_p - (E_f + E_i))/(0,97 \times (E_w + E_f))\) (Sora Jofra, 2013, p. 3; European Commission, 2008).
- 20% reduction in waste disposal by 2010 and 50% reduction by 2050 compared to 2000;
- 20% reduction in hazardous waste generation by 2020 and 50% by 2050 compared to 2000;
- 75% of biodegradable MSW going to landfill by 2006, 50% by 2009 and 35% by 2016 compared to a 1995 baseline.

In terms of recycling, the EU is advancing quickly. In 2010, 63.3% of all packaging materials in the EU were recycled. However, this high quota was only achieved by very high rates in paper, metal and glass recycling and was negatively affected by comparatively low rates of recycling for wood and plastics (DNR, 2013). This will be discussed in greater detail in section 3.4.1. focusing on recycling.

German legislation is a good example of how national or regional schemes can outperform the European regulatory framework. Mühle et. al. argue that Germany has three MSW management strategies that need to be considered (Mühle et al., 2010, p. 794).
- The deposit refund system
- Separated household collection
- Landfill restrictions

Even though the authors name their categories slightly different, these three strategies exemplify how a national MSW management schemes can act as a showcase for other European member states and by extension China. Each strategy will be considered at a time in section 3.4. on waste processing. Next, however, it is important to understand MSW generation and analyse composition. This will help explain what methods of MSW management are used locally and much more importantly, waste generation and composition will also highlight what MSW management solutions work best in each specific context.

### 3.3. WASTE GENERATION AND COMPOSITION

Waste generation and avoidance thereof is an important aspect of sustainable urban planning. MSW has to be managed which requires infrastructure, creates emissions and requires financing. Therefore, reduction of waste is the most important priority of both China and Europe (12th Five Year Plan, 2012; European Commission, 2008).

However, as waste is increasingly generated, the composition might be an important aspect defining how cities can deal with increasing volumes of MSW.

Reliable data on waste generation and composition help cities make the right decisions and choose the appropriate MSW management solutions.

#### CHINESE WASTE GENERATION AND COMPOSITION

China’s per capita generation of MSW and its composition is considered first. China has surpassed the United States as the number one generator of MSW in 2004. China is now generating 29% of global MSW output. In general, urban centres are the main source of MSW. However, there are regional differences that can be explained by cultural as well as economic differences (D. Q. Zhang, Tan, & Gersberg, 2010, p. 1624). While China’s waste generation has increased rapidly over the past decade, the per capita waste generation is still relatively low (Wei et. al., 2012; Zhang et al., 2010).

According to the OECD, per capita generation of MSW in China is at 0.98 kg/day together on one level with Mexico (0.93), but in stark comparison with many European countries that feature in medium range like Germany (1.64), France (1.48), or Portugal (1.29). Larger per capita MSW generation can be found in the United States (2.05), but
also Denmark (2.03), or Switzerland (1.78) (D. Q. Zhang, Tan, & Gersberg, 2010, p. 1625). While this indicates a correlation between affluence and generation of MSW this link is not undisputed because of flaws in data collection. Household waste might decrease for example due to increasing times spent elsewhere and decreasing amounts of meals consumed at home. Hence, the general positive correlation between increasing affluence and increasing MSW generation is true, but more research is needed (D. Q. Zhang, Tan, & Gersberg, 2010).

In terms of composition, China features a very high degree of biodegradable waste and moisture. Zhang et. al. argue that this is due to cultural specificity of diet characterised by fresh vegetables and fruit. Their prediction is that increasing affluence will not lead to a decrease in the amount of biodegradable MSW generated. As the percentage of biodegradable MSW is as high as 60%, this composition promises plenty of room to improve source separation and subsequent composting (D. Q. Zhang, Tan, & Gersberg, 2010).

At the same time Chinese households also feature a substantial amount of ash – a situation that is quickly changing with increasing affluence and a more integrated gas distribution network (Chen et al., 2010, p. 718).

Lastly, so-called scavenging also influences Chinese MSW composition, which is waste collection by private individuals. Scavengers collect anything valuable from households, including plastics, household appliances and other valuable materials that can be sold (Chen et al., 2010, p. 718).

EUROPEAN / GERMAN WASTE GENERATION AND COMPOSITION

European per capita generation of MSW has already been highlighted. Thus while the aggregate amount of waste are below those of China, the per capita MSW generation is much higher than in China. Affluence has been mentioned as a possible explanatory indicator for waster generation and MSW generation per capita in the EU 12 is considerably lower with an exceptionally low rate of 0.68 kg/day in Poland (D. Q. Zhang, Tan, & Gersberg, 2010, p. 1625).

In terms of MSW composition, Europe is very different from China. The amount of plastic, paper and organic waste is relatively high. For the example of Germany, plastic used to be the most important component with 23%, paper with 20%, organic waste at 15% (D. Zhang, Keat, & Gersberg, 2010, p. 924). However, the composition also changes with Mühle et. al. identifying organic waste at 30%, paper at 24% and plastics at 13% of the MSW mix (Mühle et al., 2010).

Either way, it is important to appreciate the difference on the amount of plastic and other valuable components such as glass (7% / 10%) or metals (2% / 1%). Hence in comparison to China, European MSW is less organic and contains less moisture, and it includes more plastic, and other valuable components with a high recycling or caloric value.

3.4. WASTE COLLECTION AND PROCESSING

In section 3.2. on Chinese and European / German legislation it was already highlighted that Germany is a good example of how national or regional schemes can outperform the European regulatory framework (Mühle et al., 2010, p. 794). A major reason for this good performance is combination of strict legislation paired with sophisticated separating schemes allowing for relatively homogenous MSW.

In China the implementation of central government legislation can still be optimised and waste separation schemes need to be incorporated in architectural and urban planning.
What is more, scavenging and other alternative modes of recycling and waste collection need to be formalised and integrated into the MSW management strategy (Chen et al., 2010, p. 720).

3.4.1. Recycling & Disposal

Chinese waste recycling & disposal

Chinese MSW collection is organised differently across the country and there are also considerable differences within urban areas. Traditionally, there were two dominant modes of waste collection. On the one hand, there is a system called 'ring bell and collection' and on the other hand there are ‘refuse chutes’. The former system provides for each household to store waste inside until ringing bells indicate that waste is being collected and residents take out the trash to the curb-side. Waste is normally not separated in this process. The latter system, is particularly common in densely populated areas characterised by high-rise apartments. The high-rise apartments feature refuse chutes on each level and residents dispose of garbage by the means of the chutes on each storey. Household waste is being stored per apartment block until it is collected. As most apartments only have a single refuse chute, household waste is not separated either (D. Q. Zhang, Tan, & Gersberg, 2010, p. 1625).

Generally, these waste collection systems have been deemed insufficient and in the 1990s and 2000s many Chinese municipalities introduced source separation schemes with designated bags that are then deposited by residents into specific bins just as it is done in Europe. However, implementation of the new schemes is not systematic and there is considerable room for improvement (Chen et al., 2010, p. 720; D. Q. Zhang, Tan, & Gersberg, 2010, p. 1626).

While source separation of MSW is thus taking place to a limited extend in many municipalities, there was also a considerable rise the phenomenon of scavenging. Scavenging refers to people collecting recyclable goods and selling them to collection sites at a negotiated rate. Scavenging considerably increases the recycling rate in many Chinese municipalities. However, the process is not formalised at municipal level, but organised privately.

Scavenging leads to all valuable parts of waste being separated at source, while non-valuable parts of waste are left behind. Municipalities have thus no economic incentive in enhancing recycling through further source separation. Chen et. al. estimate the number of private scavengers at approximately 2mn people. It is thus a considerably large informal sector. Latest developments point to various Chinese municipalities aiming to formalise the sector by either offering voluntary registration of scavengers with municipal authorities or expulsion. Neither approach has yielded substantial success so far (Chen et al., 2010, p. 720; D. Q. Zhang, Tan, & Gersberg, 2010, p. 1626).

Figure 1. from Zhang et. al. offers an overview of MSW management in China. Section 3.4.3. will show however, that, given investments in bio gas fired power plants, composting potentially yields a strong economic incentive for further source separation in China.
EUROPEAN / GERMAN WASTE COLLECTION

With regard to MSW collection, articles 10 and 11 of the European waste framework direction will require all European member states and their municipalities to separate the collection of paper, metal, plastic and glass by 2015 (Hall, 2013, p. 3).

In order to see how this directive can be fulfilled by member states or even outperformed, this article will focus on MSW management as implemented by the city of Berlin, Germany. Berlin’s urban household waste management system will be briefly analysed in the framework of existing strategies and legislation i.e. the EU’s ‘waste hierarchy’. The ultimate aim will be to evaluate the initiative and discuss whether it should be introduced in other cities throughout Europe and China.

The European Commission defines ‘recycling’ as including all operations, through which waste is processed into products, materials or substances for the original use or other purposes. Energetic recovery is excluded (DNR, 2013) and will therefore be addressed in section 3.4.3. on incineration. Mühle et. al. identified three strategies that are of particular importance for Germany. As highlighted above, they were the deposit refund system, separated household collection and sanitary landfill restriction.

The deposit refund system has two components. On the one hand glass and plastic bottles and on the other hand cans. First direct reuse and recycling of glass and plastic bottles or second, recycling of plastic bottles and cans. Both components foresee a refund option on all packaging. "Only juice, nectar, wine, milk and dietary refreshments are not affected by the refund obligation" (Mühle et al., 2010, p. 794). The amount of money demanded per packaging is regulated by the ‘Ordinance on the avoidance and recovery of packaging wastes’ introduced in 1998. Going beyond what the European Waste Framework directive demands, this law aimed at 80% usage of reusable and recyclable packaging, but underperformed by roughly 20% and only achieved a target of almost 60% for the drink packaging in 2010.

Berlin’s MSW from households is organised partly by public, partly by private entities and source separation works according coloured bags and bins. Resident’s separate waste in their respective household and then dispose of waste in bins in the courtyard. The respective bins are then collected either by a public or private MSW collection scheme (BSR, 2012, p. 64).

The public agency BSR is collecting the following household wastes:
- Grey box for all other residues:
- Brown box for all biodegradable waste;
- Bulky waste that is collected on the curb-side upon request.

The private agency ALBA is collecting the following household wastes on behalf of the German dual system (the green dot scheme):
- Yellow box for light plastics;
- Blue box for paper and cardboard;
- Two separate boxes for white-glass and coloured-glass.

Through this scheme, Berlin realises a seven-fold source separation of MSW by the residents. Hence the MSW treated is of very high homogeneity. Therefore, recycling rates are relatively high and relatively cost effective.

Separated household collection of MSW is organised according to the European Waste Framework Directive. Thus Germany already fulfils the target of separated household collection as foreseen by the European waste framework directive. What is reality in Germany today, will have to be implemented throughout Europe in by 2015 (Mühle et al., 2010; Sora Jofra, 2013).

Next to these two strategies, Berlin offers a couple of additional services that display the opportunities that can be achieved through MSW recycling.

### 3.4.2. INCINERATION

**Chinese MSW Incineration**

Incineration will be considered next. In 2009, approximately 4,5% of all MSW generated in China was incinerated. However, incineration is a rapidly developing sector as the government favours incineration over landfills for three reasons.

First, by incinerating waste, Chinese municipalities can create both energy and heat. For local circumstances, this might be particularly useful. Especially in cold areas, both electricity and heat can be used. In warmer regions, electricity is still enough of an incentive for incineration. The catch phrase for incineration has become energy from waste (EfW) and many local governments want to use the technology (Chen et al., 2010; Klöckner, 2013).

Second, by incinerating MSW can be reduced in both mass and volume. Numbers differ, but volume is argued to be decreased by up to 90% while mass is decreased by up 70%. However, the remainder is highly toxic and especially in China, the large amount of coal ashes from household heating leads to a very high amount of coal sludge after incineration. As the remainder is not further processed, but directly landfilled, the at times highly toxic sludge is disposed of including all its metals. Thus, the technology allows for significant reduction in mass and volume of waste, but some issues remain unaddressed (Sora Jofra, 2013; D. Zhang, Keat, & Gersberg, 2010; D. Q. Zhang, Tan, & Gersberg, 2010).

Third, incineration is considered to be a mature industry. It is not a pilot project technology, but has been tested successfully, despite various drawbacks, for a considerable amount of time. The alternative being landfills, Chinese authorities prefer incineration (Chen et al., 2010, p. 721).

It follows, that the Chinese government wants to instil the construction of MSW incineration plants. Therefore, the government offers substantial subsidies in the form of direct feed-in tariff of an extra 0,25RMB per kilowatt/hour. In addition, there are build, operate, transfer (BOT) schemes that help lift the burden of investment off municipalities by involving the private sector (Chen et al., 2010).
Next to the problem of toxic residues from incineration, there is an argument made against incineration on the grounds of air pollution. Greenhouse gas emissions from energy from waste may be much higher than from conventional fossil fuels. What is more, the caloric value of waste is decreased by the disproportionately high percentages of biodegradable waste of overall MSW in China (Chen et al., 2010; Sora Jofra, 2013). However, the issue of air pollution has been recognised as a matter of urgency and newer generation incineration plants employ additional filter technology (D. Q. Zhang, Tan, & Gersberg, 2010).

**EUROPEAN MSW INCINERATION**

In Europe, incineration capacity is increasing continually. Incineration is employed for a similar set of reasons as in China. First, incineration provides for energy from waste. Second, incineration can considerably reduce volume and mass of waste. Even though the regulatory requirements for incineration plants built after 2009 are more rigorous, many European member states opt for this technology. Thus according to the waste framework directive, energy efficiency of incineration plants needs to be higher than the value 0.65 in the equation calculating energy produced in form of heat and electricity versus energy lost due to additional energy input, energy content and energy in residues (Sora Jofra, 2013, p. 3; European Commission, 2008).

As has been shown, Berlin achieved high recycling rates and also reduced waste substantially over time. In 2007 the amount of waste disposed of was 0.97mn tonnes down from 2.32mn tonnes in 1990. This is a remarkable reduction in MSW. From the disposed 0.97mn tonnes, more than 50% has been incinerated. Once incinerated, the remaining sludge is further processed to allow recycling of metal and other toxic wastes that can still be recovered (D. Zhang, Keat, & Gersberg, 2010, p. 926).

Thus, despite important recycling efforts, incineration remains a dominant mode of dealing with disposal waste. This seems to be even more evident in other European member states.

![Graph of Modes of Municipal Solid Waste Management in Europe](image)

**Table 1:** Modes of Municipal Solid Waste management in Europe (Sora Jofra, 2013, p. 6).
It is argued that overcapacity in certain western European countries also leads to waste being shipped around Europe to be incinerated in countries that have installed overcapacities (Sora Jofra, 2013). Thus, it remains to be seen whether the technology will persist to exist, or not.

3.4.3. Composting

Chinese composting
While incineration is widespread and rapidly growing sector in China, biodegradable composting potential is yet to be fully utilised. Incineration capacity increased substantially in China, while biodegradable composting capacity actually decreased.

![Figure 2: MSW facilities by number and their treatment capacity (Chen et al., 2010, p. 721).](image)

There are two fundamental problems preventing increased use of composting in China. First, there is a lack of source separation of biodegradable waste from other forms of household MSW. For the time being, organic waste is binned together with all other disposables. The introduction of a separate bio box could alleviate this problem and make biodegradable much more economically feasible. As costs for separation are born by households, this sub-sector of urban waste could become much more profitable.

Second, there is some hesitance on the part of farmers using transformed biodegradable fertilisers for their field. This should also be addressed by informing and convincing farmers of the value of introducing natural fertilisers for this.

European composting
On the other hand, European biodegradable waste recycling capacity is increasing. There is bio fermentation and anaerobic digestion. Most biodegradable is collected via household collection systems. It has been noted that bio waste volumes differ greatly according to season as household gardening waste cannot be collected constantly. Therefore, it is difficult to have optimal use of all installed bio fermentation and anaerobic digestion capacity at any time in the year (D. Zhang, Keat, & Gersberg, 2010, p. 927).

The waste is then fermented to gas and can be either fed into the gas network or it can be used to fuel engines. The example of Berlin shows how biogas can be integrated into the MSW management system. Berlin has constructed a fermentation plant that transforms approximately sixty thousand tonnes per annum into bio-methane to fuel the collection vehicles and thereby visibly improved energy availability and reduced their operating costs (BSR, 2011, p. 8).
Overall, composting offers further opportunities for both China and Europe.

3.4.4. **SANITARY LANDFILL**

Finally, sanitary landfill will be considered. For China, landfill is still the number one mode of MSW disposal. As of 2006, 324 MSW landfill sites existed in China and received 64.1mn tonnes of MSW, accounting for 81.4% of the total amount of safe disposal” (Chen et al., 2010, p. 721). However, many Chinese authorities became aware of possible difficulties related to landfill sites, including toxic waste water, climate gas emissions, land requirement. Therefore, the new strategy is to reduce the number of sites while maintaining or even increasing landfill capacity and regulating the sector more stringently.

Chinese authorities are also increasingly interested in modern technology enhancing landfill sites. Good examples include biogas recovery from landfills – mainly methane. Bearing in mind their very devastating effect on the climate. What is more, water pollution due to leachate produced problems in the past. Hence, the focus is on better infrastructure, better siting of landfills, and addressing undercapacity.

Germany has very strict landfill restrictions and since the introduction of the so-called “technical instructions on municipal solid waste” (Mühle et al., 2010, p. 795), landfill is only a secondary option for disposal. Any MSW has to be pre-treated, i.e. bio-degraded or incinerated before it may be landfilled. The amount of landfilled MSW in Germany or The Netherlands is reduced to virtually 0% while other EU member states still heavily rely on this mode of MSW disposal. It should also be noted that there is a difference between the EU 15 (EU member states that joined before 2004) and the EU 12 (EU member states that joined after 2004). The difference is in the order of on average 30% direct landfill disposal of MSW for the EU 15 (in 2006) and almost 80% for the EU 12 (in 2010) (Mühle et al., 2010, p. 795; Sora Jofra, 2013, p. 6).

Hence, despite very positive indications and relatively strict legislation, there is a lot of room for improvement. What is also worth noting is the potential economic incentives of being a regional or national champion in the EU or for that matter globally. The case of Berlin, Germany shows that other urban centres in Germany, Europe and beyond want learn more about best-practices and lessons learned. This allows the export of technology and know-how and the private companies as well as local authorities welcome Chinese delegations and export recycling solution to China through their representative offices (Klöckner, 2013; Pei, 2013).

In conclusion to waste processing, it can be established that more stringent regulation on recycling, landfill, incineration and composting is a major reason for reduced CO2 emissions. In their study comparing the United Kingdom and Germany, Mühle et. al. point out that CO2 emissions are five times lower in Germany than in the United Kingdom. “The tightened waste acceptance criteria for landfills, an increased use of EfW, and recycling policy enabled by a proven source separation system in Germany were identified as the major reasons for this difference” (Mühle et al., 2010, p. 800). The memorable analogy that these authors: Germany’s CO2 savings are equivalent to the emissions of 1.2mn cars.

3.5. **FINANCING**

This last section will shortly highlight possible enhancement in the realm of financing. In China, there are only rudimentary fee levying systems in place for the time being. The systems that are in place are flat-rates. Flat rates disregard the polluter pays principle.
however, and are therefore not very conducive. If this issue is addressed, and a pay as you throw (PAYT) system is introduced, it could lead to a doubly positive outcome. First, there would be more financing available for MSW management and secondly, the consumers would also decrease waste by trying to reduce, reuse and recycle (D. Q. Zhang, Tan, & Gersberg, 2010, p. 1631).

Many European countries have already introduced the pay as you throw system and the city of Berlin is one example. While fees are paid according to volume of waste collected per household, the city of Berlin has introduced various other means of decreasing prices and making MSW management in the city more efficient. The paper pointed out the value of recycling schemes and biogas power plants.

4. **Policy Recommendations & Conclusion**

When introducing Sino-German and Sino-European cooperation on MSW management, the article stressed the importance of involving all relevant stakeholders from civil society, politics, and business to ensure efficient implementation of sustainable and more efficient MSW management. The comparative case study on MSW management in China and Germany has highlighted the various aspects of MSW management that need particular attention.

Now, this article sought to reiterate how each of the relevant stakeholders can be included.

It has addressed how EU-China overall framework for cooperation could look like, and it shows how mayors and local bureaucracies play a pivotal role.

While we have seen a relatively sophisticated MSW management schemes already introduced in China, large-scale nation wide standards and their implementation is still lacking. Therefore, further research is necessary to devise and explain large-scale systems solutions. Possibly this literature could refocus on system engineering models.

Countries like Germany and other European states have already introduced and implemented a number of MSW management schemes. Yet there is still a lot of potential to be realised by making the sector more efficient. Possibly tools include system assessment tools (Pires et al., 2011, p. 1044).

However, the largest potential can be discovered by introducing more biogas power plants that can divert biodegradable waste from regular disposal to biological composting.

In China, where household waste is made up to approximately 50% the potential is very good. What is more, by separating regular disposal of waste from biological waste, the moisture of the regular MSW will decrease. This in turn will increase the caloric value of regularly disposed waste and increases the efficiency of incineration while decreasing the amount of residues.

The same is of course true for Europe and Germany. Increased use of biogas power plants for the treatment of biodegradable waste will reduce the amount of waste, lead to increased energy from waste, while making incineration much more efficient because of less moisture and more caloric value.

Hence, EU-China cooperation on municipal solid waste management should focus on transfer of best-practices and particular focus should be paid to making more use of the large amounts of biodegradable wastes from households.
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