detritus | Multidisciplinary Journal for Waste Resources & Residues

CISA

COMPARATIVE STUDY OF CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN CHINA AND THE EUROPEAN UNION

Jianli Hao [1], Francesco Di Maria [2,*], Zhikun Chen [3], Shiwang Yu [1], Wenting Ma [1] and Luigi Di Sarno [1]

[1] *Department of Civil Engineering, Xi'an Jiaotong-Liverpool University, Suzhou, China*
[2] *Department of Engineering, University of Perugia, Perugia, Italy*
[3] *Department of Building, Civil and Environmental Engineering, Concordia University, Montreal, Canada*

Article Info:
Received:
31 October 2019
Revised:
10 July 2020
Accepted:
28 July 2020
Available online:
30 November 2020

Keywords:
Comparative study
China
EU
Construction and demolition waste
Policies and strategies

ABSTRACT

Construction and demolition waste (CDW) accounts for 40% of urban municipal waste in China and around 25% in the European Union (EU). Since the EU is more developed and urbanized than China, its experience with managing CDW may be helpful to China. This study therefore compared China and the EU with respect to the flow of CDW materials and the policies, laws and regulations for CDW management. The results reveal that the CDW management practices and facilities in China are relatively underdeveloped with a large amount of low-value inert material going to landfill compared with the EU. The study also reveals the important role of government involvement in CDW management, including the use of punitive measures and preferential policies; most EU members states achieved their waste recovery rates by 2016 due to mature CDW legalization. To improve the management of CDW in China, a series of suggestions are proposed including waste prevention strategies, establishment of supervision mechanisms, and financial support.

1. INTRODUCTION

Construction and demolition waste (CDW), generated from construction, renovation, and demolition activities, account for 40% of urban municipal waste in China and 25%-30% of all waste generated in the European Union (European Commission, 2020; Jin et al., 2017). The main disposal methods for CDW are incineration, recycling, and landfill, with the latter being the most widely used method in China. Ortiz et al. (2010) assessed the three disposal methods in terms of carbon emissions and found that landfill caused the greatest carbon emission compared to the other two CDW disposal methods. As two of the largest economies in the world, China and the European Union (EU) generate massive amounts of CDW annually at 2.36 billion tonnes and 307 million tonnes respectively (Figure 1), with landfill and dumping having caused serious environmental problems in both jurisdictions (Deloitte, 2017; Zheng et al., 2017).

Although some regulations and laws have mitigated the impacts caused by CDW, a large number of environmental issues are still caused by illegal dumping and landfills (Gao et al., 2015; Liu et al., 2019; Nie et al., 2015). For instance, large areas of land have been contaminated by landfill that contain hazardous waste from CDW. Accordingly, CDW management has attracted worldwide attention as a way to deal with the serious environmental problems caused by increasing amounts of CDW. One of the most important guiding principles of CDW management is the 3R principle, which stands for reduce, reuse, and recycle (Huang et al., 2018). Preventing waste generation at source can be achieved through modular building, advanced design standards, and high labor quality (Esin and Cosgun, 2007). Recycling and reuse of CDW depends on such things as regulations, the market for recycled materials, awareness, and recycling technologies and systems (Begum et al., 2009; Jin et al., 2017).

CDW typically comprises metal, glass, plastics, timber, concrete, mortar, and bricks, all of which have great potential for recovery and reuse. The background of CDW management in China and the EU is very different. Due to insufficient attention to the management of construction waste, the overall recycling rate of CDW in China is less than 10% in China; the country still has a long way to go to achieve a 13% CDW recovery rate before the end of 2020 as proposed by the 'Waste Recycling Development Guidance' (The Ministry of Commerce of the People's Republic of China, 2017). By comparison, the average CDW recovery rate in the EU was about 89% for the year of 2016, even though the recycling rates ranged from about 100% to less than 5%

* Corresponding author:
Francesco Di Maria
email: francesco.dimaria@unipg.it

Detritus / Volume 13 - 2020 / pages 114-121
https://doi.org/10.31025/2611-4135/2020.14029

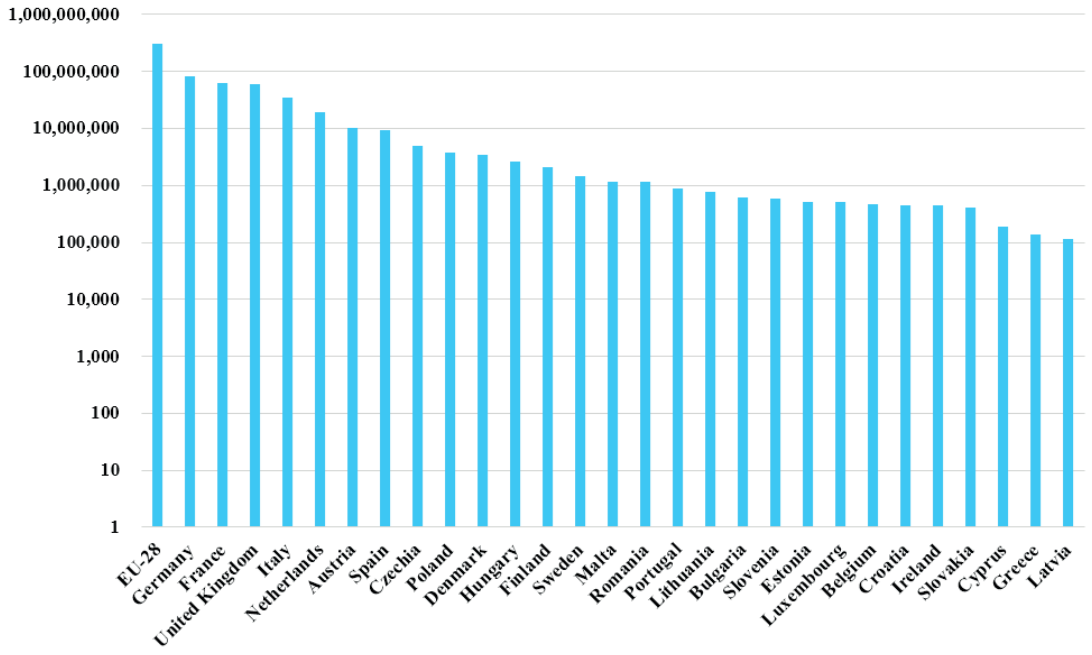

FIGURE 1: CDW generated by the 28 member states of the EU in 2016.

among the 28 different member states due to variations in the level and performance of CDW management practices in those states (Eurostat, 2020); the European Parliament (2008) approved a Directive to require all member states to increase their recovery rate to at least 70% by 2020. Clearly, more effort is required by China and the EU to achieve their respective sustainable goals for CDW. Although the current circumstances and waste management strategies differ in China and the EU, efficient CDW management practices can be further developed to help in both jurisdictions. This paper compares the current situation and CDW management regulations and policies in China and the EU, and discusses the future development direction for CDW management.

2. CDW MANAGEMENT IN CHINA AND THE EU

This section compares CDW management in China and the EU in relation to the flow of CDW materials, policies and strategies.

2.1 Flow of CDW materials

2.1.1 China

The generation and disposal of CDW in China has been extensively studied. Zheng et al. (2017) presented the ideal life cycle of CDW after it has been generated at construction and demolition sites (Figure 2): hazardous wastes are collected separately and sent to special disposal place, while other CDW is then preliminarily sorted to remove materials with a high recycle value, such as metal, plastic, and timber, which are then sold to companies that make recycled products. However, this represents less than 10% of the total CDW generated on site with the vast majority going to landfill or recycled disposal. A typical on-site waste storage facility in China is shown in Figure 3, which shows the storage of (a) hazardous waste (asbestos), (b) plastics, and (c) metal. Lack of on-site and off-site facilities and equipment lead to low recycling rates for the majority of CDW, including concrete, mortar, and bricks. These inert wastes can be crushed by machinery at construction or recycling centers and the resulting aggregate can be used as the raw materials for bricks, concrete, or sub-crust. Some projects have been implemented in China to enhance the development of on-site sorting and off-site CDW treatment (Bao et al., 2019), although most of the generated waste still goes to landfill or is dumped.

2.1.2 European Union

The level of CDW management in the EU varies considerably. For example, the rate of landfill for CDW range from 1% for the Netherlands to 99% for Greece (Deloitte, 2017). Though the recycling strategies are different, the general CDW generation and disposal flows are similar throughout Europe. According to a case study in Spain (Mercante et al., 2012), the generated waste is collected and stored on site

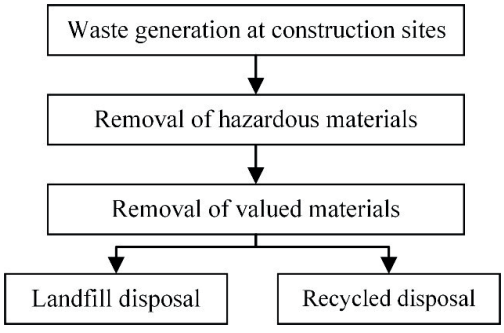

FIGURE 2: Material flow of CDW in China.

FIGURE 3: On-site separate collection: (a) asbestos; (b) plastic; and (c) rebar.

without sorting. The stored CDW is the periodically transported to off-site sorting plants to classify valuable waste (metal, paper, plastics, and timber) and inert waste (concrete and brick). These two types of waste are then sent to companies that produce corresponding products and recycled aggregate. The residues that do not have a recycled value are landfilled or incinerated. As shown in Figure 4, 24 of the 28 countries that made up the EU in 2016 reached their targets in 2020, which is a 70% recovery rate (European Parliament, 2008). Especially for the Netherlands, Luxembourg, and Belgium, the CDW recovery rates are more than 99%. Compared with China, these EU countries have more advanced CDW management facilities and technologies, and use inert waste to produce secondary aggregate for road construction (Deloitte, 2017).

2.2 Laws and regulations for CDW management

Laws and regulations can have a positive impact on the management of CDW through fair reward and punishment mechanisms. This section presents the current policies and regulations for stimulating the development of CDW recycling in China and the EU.

2.2.1 China

A plethora of laws and regulations have been published by China's Central Government in the past thirty years to promote CDW management (Table 1). These policies provide guidance to regional governments and offer tax breaks for companies involved in the CDW recycling industry. Although China's Central People's Government publish detailed regulations at provincial and city level to encourage recycling and reuse of CDW, there are still some limitations to the government's policies and strategies.

- Lack of regulations or practices on the reduction and prevention of CDW generation. Even though the many laws and regulations emphasize the importance of recycling and reuse of CDW, there are no government measures in place to prevent and reduce the generation of CDW at source.
- Lack of preferential policy for recycled products. There are very few policies that encourage and support the development of CDW recycling industries through tax exemptions and the like.
- Lack of supervisory mechanisms. Even though some regulation state that construction companies should

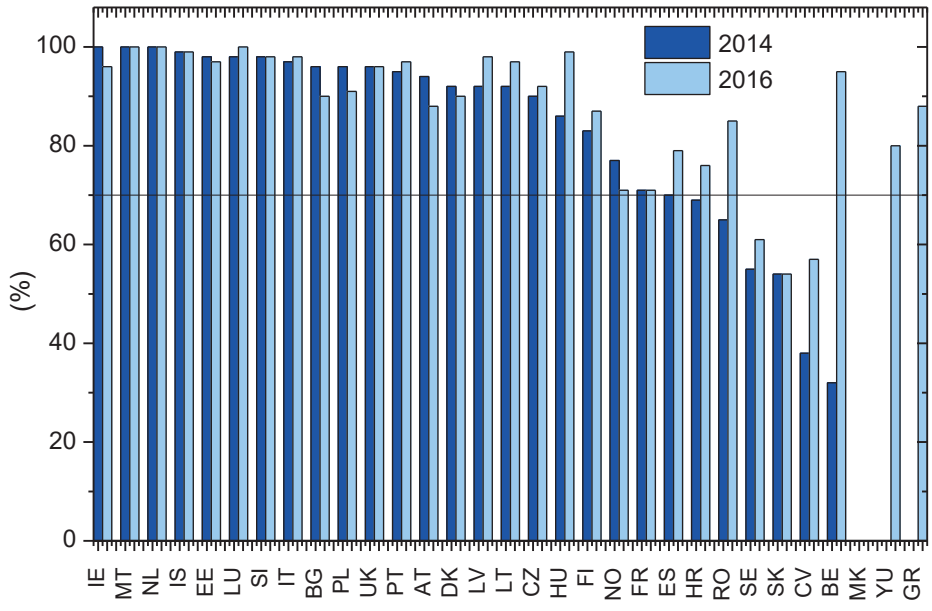

FIGURE 4: Recovery rate of construction and demolition waste in EU-27 (Eurostat, 2020).

TABLE 1: Laws and regulations for CDW management in China.

Type	Name	Year Issued	Content
Laws	Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution*	1987	Construction earthwork, muck and waste should be timely cleaned. Construction muck and waste should be utilized as a resource.
	Environmental Protection Act	1989	Authorities should take proper actions to organize the classification, recycling, and disposal.
	Law on the Prevention and Control of Environmental Pollution by Solid Waste**	1995	Construction companies should clean, transport, and dispose of CDW generated during the construction process and avoid contamination.
	Law on Promoting Clean Production	2003	Companies that use waste as raw materials to manufacture products shall have a tax preference in accordance with state regulations.
	Circular Economy Promotion Law	2008	Construction companies should be responsible for the recycling and reuse of CDW. For waste that cannot be recycled, qualified organizations shall be entrusted with the disposal of non-hazardous waste.
Regulations	Regulations on the management of urban construction waste	2005	This regulation formalized the construction waste disposal activities in urban areas, including dumping, transferring, landfilling and reusing.
	Implementation Plan for Comprehensive Utilization of Bulk Solid Waste	2011	Achieving 30% CDW recycling rate in cities.
	12th Five-Year Plan Guidance on Comprehensive Utilization of Resources	2011	Promoting the use of recycled materials on road construction and backfill and building complete recycling system for CDW.
	Catalogue of Value-Added Tax Preferences for Products and Labor Involving Utilization of Resources	2015	Production and sales of recycled aggregates should be exempted from value-added tax when the waste account for at least 90% of the raw materials for production.
Standards	Recycled fine aggregate for concrete and mortar	2010	Technical standard for recycled fine aggregate for concrete and mortar.
	Recycled coarse aggregate for concrete	2010	Technical standard for coarse aggregate for concrete.

*Note: *-amended in 2015; **-amended in 2016*

be responsible for the recycling, reuse, and disposal of CDW, the laxed supervisory mechanism makes it very difficult to implement.

- Lack of a standardization system. Apart from some technical standards for recycled products, no norms and standards for the demolition, sorting, transportation, and disposal have been developed to build a standardized system of CDW management.

2.2.2 European Union

The EU's Waste Framework Directive (2008/98/EC - European Parliament, 2008) imposes relevant recycling goals for waste to be achieved by 2020. The directive states that at least of 50% of waste such as plastics, metal, paper, and glass have to be prepared for reuse and recycled. Furthermore, not less than 70% of non-hazardous construction and demolition waste has to be prepared for reuse, recycled or recovered, including for back filling operations. The European Commission (2015) launched an EU action plan for the implementation of a circular economy by "closing the loop". The plan highlights CDW as one of the five priority areas, together with plastics, a bio-based economy, critical raw materials, and secondary raw materials, for implementation of a circular economy in the EU.

Most member states of the EU have introduced the target directive of a 70% CDW recovery rate by 2020 into their national legislation for CDW management. Germany, Estonia, Flanders of Belgium, and the Netherlands have higher targets, which are 75%, 80%, 85%, and 90% CDW recovery rates respectively. In addition, some countries of the EU have built their own legal framework to promote CDW management and the recycling of waste. Deloitte (2017) assessed the level of CDW management legalization in member states of the EU and concluded that Austria, Belgium, Denmark, Finland, France, Germany, Luxembourg, the Netherlands, and Sweden have relatively mature legal frameworks for sustainable and resource efficient CDW management. Table 2 summarizes the current laws and regulations that comprise the framework and the obligations for specific activities related to CDW in these countries. The whole disposal process of CDW can be defined from waste generation to the end of the life cycle, including the obligation of selective demolition, on-site or off-site sorting, separate collection, green public procurement, and landfill taxes or bans. Among these policies, landfill taxes and bans could be two of the most efficient practices to enhance CDW recovery rates (Deloitte, 2017). However, although 28 member states in the EU in 2019 had implemented landfill taxes, Sáez and Osmani (2019) demon-

TABLE 2: Legal framework for EU countries with mature CDW management legislation.

Centuries	Laws and regulations	Obligations in legalisation
Austria	Waste Management Act 2002 Remediation of Contaminated Sites Austrian Ordinance for Tracking Waste List of waste ordinance Separation of Construction Waste Ordinance Landfill Ordinance Hazardous Waste Ordinance End-of-Waste Act Recycled Construction Materials Regulation	☑ Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax
Belgium	Three different legislation in Flemish, Brussels Capital, and Walloon regions respectively	☑Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax
Denmark	Environmental Protection Act No. 879 26/06/2010 Statutory Order No. 1309/2012 Statutory Order No. 1662/2010 Circular of 15 July 1985	☑ Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax
Finland	Waste Act 646/2011 Land use and building Act 132/1999 Environmental protection Act 527/2014	☑ Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax
France	Law 2009-967 Decree n°2011-610 Law 2010-788 Decree n°2014-1501	☑ Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax
Germany	Waste Disposal Act The Circular Economy Act The Circular Economy Act Waste Classification Ordinance Federal Soil Protection Ordinance Federal Soil Protection Act Ordinance on the Management of Municipal Wastes Landfill Directive	☑ Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax
Luxembourg	Law of 21 March 2012 on management of waste Grand-Ducal Regulation of 24 February 2003 on landfilling of waste	☑ Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax
Netherlands	Environmental Protection Act The National Waste Plan The Decree on landfills and waste bans The Decree on notification of industrial and hazardous waste From Waste to Resource	☑ Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax
Sweden	Ordinance on Environmental assessment SFS 2013:251 Waste Ordinance SFS 2011:927 Building Code (SFS 2010:900) Swedish Ordinance on PCB (SFS 2007:19) The Regulation NFS 2004:4	☑ Selective demolition ☑ CDW sorting ☑ Separate collection ☑ Hazardous waste management ☑ Green public procurement ☑ Landfill tax

strated that the CDW recovery rate was not correlated with the level of landfill tax due to the complicated situation in each country.

3. RESULTS AND DISCUSSION

The literature review summarized the materials flow of CDW and related policies for CDW management in China and the EU. This section compares CDW management in these two respects and identifies the differences as shown in Table 3.

3.1 Comparison of CDW management in China and the EU

3.1.1 Materials flow of CDW

In China, CDW management practices and facilities are still developing. Only waste that has a high recycled value

TABLE 3: Comparison of CDW management in China and the EU.

Terms	China	European Union
CDW recovery rate	<10%	89%
Distribution of CDW recycling facilities	Some facilities have been in operation in some developed cities.	Relevant waste recycling facilities were distributed in most member states.
Preferential policies	Tax exemption for recycled products.	Tax exemption and loans for use of recycled materials in some nations.
Landfill taxes/bans	No.	24 of 28 member states have implemented landfill taxes or bans.
Regulatory mechanisms	Lack of punitive regulations and corresponding organizations.	17 of 28 member states have implemented pre-demolition audits.

or hazardous waste can be sorted and collated separately on site or from plants off-site. Other low-value inert materials, such as concrete, brick, mortar, and masonry, accounting for 90% of total generated CDW, are typically transferred to landfills as mixture (Villoria Sáez et al., 2019). This type of waste can be of disposed by specific machinery or plants to produce recycled aggregates, which can then be used for backfilling and raw material for concrete and road construction. Although this technology is not yet widely applied in China, it is being used in some regions of the country. For example, in the city of Suzhou a public-private partnership (PPP) project initiated by the government established a CDW recycling company that is capable of disposing of more than one million tons of CDW annually over a six-year operational period (Bao et al., 2019); the recycled products include recycled bricks and aggregates used for buildings and road construction. However, since low profitability and massive initial investments can be barriers to the wider adoption of such CDW recycling facilities in China, the success of this type of project depends heavily on strong government support.

By comparison to the situation in China, most member states in the EU have relatively developed CDW recycling technologies and facilities. In addition, the recovery amount and rate of CDW is highly related to the density of the recycling network in the member countries (Sáez and Osmani, 2019). Deloitte (2017) determined that insufficient CDW recycling facilities and systems are the main reason for Cyprus' and Slovakia's relatively low recovery rate at 58% and 55% respectively in 2016 (see Figure 5). Early planning before construction and demolition activities begin could also be a practice for enhancing CDW management in the EU. Selective demolition is an obligation under national or regional legalization in the EU countries with mature CDW management legislation as shown in Table 2, and 17 of the 28 EU member states have implemented pre-demolition audits to evaluate the types and amount of CDW generated in deconstruction activities (Deloitte, 2017). The advantage of waste recycling of selective demolition is that most of the materials with high recycled value are manually demol-

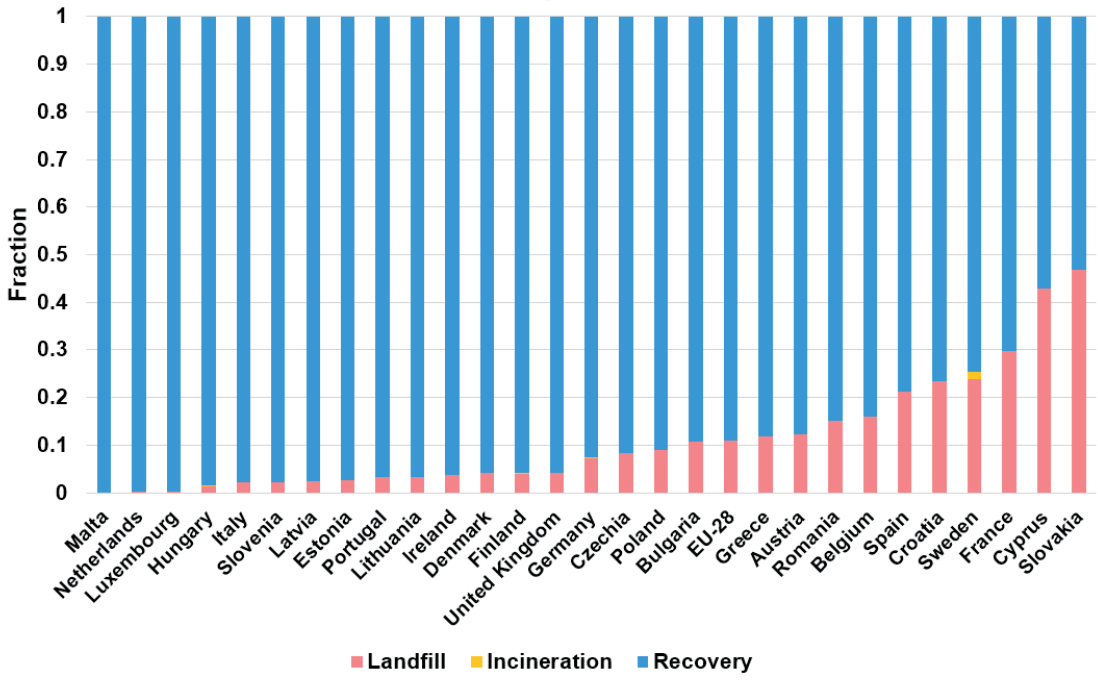

FIGURE 5: Management of CDW in the 28 member states of the EU in 2016.

ished by tools or light machinery; thus, a higher recovery rate can be achieved than by unsorted waste generated by conventional demolition (Kourmpanis et al., 2008).

3.1.2 Laws and regulations

Government involvement plays an important role in CDW management. The maturity level of the legal framework and preferential policies can significantly affect the development of CDW management. Although many laws and regulations govern the responsibility of CDW recycling, reuse, and disposal at the national and provincial level of China's government structure, implementation depends heavily on the punitive measures in place at the municipal authority level to encourage compliance. In terms of preferential policies, China's Ministry of Finance introduced a value-added tax preference and exemptions on the production and sale of recycled materials (State Administration of Taxation, 2011). In addition, relevant departments in some areas invested in and assisted the establishment of companies that focus on CDW recycling and reuse. Related CDW recycling facilities and plants are operating in some big cities in China, such as Suzhou, Chongqing, Dongguan, and Beijing (Bao et al., 2019).

An early start in many countries of the EU has led to relatively developed and mature legalization for CDW management. In 2008, the Waste Framework Directive was published by the European Parliament (2008) setting the goal of a 70% CDW recovery rate in all member states by 2020. By 2016, almost all 28 member states, with the exception of Slovakia and Cyprus, had achieved that goal (Eurostat, 2020). Different countries have developed various legal frameworks for CDW management as shown in Table 2, but CDW recovery can be affected by many other factors apart from policies and regulations. For instance, although no laws or regulations were specifically made for the promotion of CDW management in Poland, the CDW recovery rate was 92% in that EU member state (Sáez and Osmani, 2019). Deloitte (2017) claimed that the introduction of landfill taxes in most EU member states has been an effective practice for enhancing CDW recovery rates in the EU, even though previous studies had shown that CDW recovery rates did not have a correlation with the rate of landfill taxes (Sáez and Osmani, 2019).

3.2 Suggestions for future improvement of CDW management

To further enhance the recovery and management of CDW, the following suggestions are made:

- *Waste prevention strategy*
  Reducing waste at source is the most effective method for mitigating the environmental impacts caused by CDW generation. However, currently only a very few strategies have been implemented to prevent the generation of CDW, even though goals might be set in some countries or regions (Deloitte, 2017). Using waste prevention strategies in the design phase has been proven to be a possible solution. For instance, from a case study in South Korea it was found that using a building information model or flexible design can avoid 4.3% to 15.2% waste produced from design changes due to clashes of building elements (Won et al., 2016). Other practices, such as prefabrication and accurate quantity take-off, can also be effective techniques for waste prevention (Gálvez-Martos et al., 2018). Proper guidance by relevant governments or departments are required to promote and implement waste prevention.
- *Establishment of mature supervision mechanism*
  The aim of punitive regulations, such as landfill taxes, is to promote development of the recycling industry by imposing additional cost on unwanted activities. However, without mature supervision mechanisms, implementation of punitive regulations can give rise to an increasing number of illegal activities. For instance, owners might tend to send the waste to illegal landfills instead of approved recycling facilities if government imposed landfill taxes and are high and there is a lack of supervision (Deloitte, 2017). Huang et al. (2018) proposed a CDW supervision system for China, which includes: (1) a department for practice standardization; (2) a monitoring system for the whole CDW life cycle; (3) strict punitive regulations; (4) guidelines and norms for CDW prevention and recycled products; and (5) encouragement to use CDW recycled products.
- *Financial support*
  High investment risk is regarded as the main barrier to operating a CDW recycling facility (Zhao et al., 2010). Although CDW recycling centers have been operating in some areas of China and the EU, which show that it is economically feasible, several case studies have found that profitability is highly correlated with support policies and market maturity (Bao et al., 2019; Nunes et al., 2007). The financial aid (loans) and related policy support (public procurements) offered by governments can assist companies with their initial investment in CDW recycling plants. Attracting social capital is therefore very much involved in the development of CDW management.

4. CONCLUSIONS

If not dealt with appropriately, the massive amounts of CDW generated in China and the EU could lead to very serious environmental problems. Governments and related industries have made a great effort to minimize the potential risks through CDW management. However, differences in urban development, technologies, policies have led to variations in the level of CDW management and formulation of relevant regulations between China and the EU. This study compared CDW management in China and the EU in respect of waste flows and legal frameworks and arrived at the following conclusions:

- The EU has much more advanced CDW management systems compared to China. The CDW recovery rate in 2016 for the EU was 89%, whereas it was less than 10% in China.
- Landfill is the main CDW disposal method in China but new CDW recycling facilities are being developed.

Dense CDW recycling networks and tools such as selective demolition could be the reasons for the high CDW recovery rate in the EU. However, factors such as lack of supervision mechanisms, inadequate practices, and limited standardization systems, give rise to the low efficiency of some CDW management systems.

- The EU member states have relatively mature legal frameworks and management systems for CDW. Although the specific regulations differ from state to state, most member states have laws or regulations specifically governing CDW management, such as landfill taxes or bans, and green public procurement.
- Suggestions for future development include improved waste prevention strategies, establishment of supervision mechanisms for illegal CDW disposal, and economic support for recycling facilities.

ACKNOWLEDGMENTS

The authors wish to acknowledge the support from the Research Development Fund (2016-01-32), Xi'an Jiaotong-Liverpool University, and Key Special Fund Exploring Program, Suzhou Industrial Park (2018-E-29).

REFERENCES

Bao, Z., Lu, W., Chi, B., Yuan, H., Hao, J., 2019. Procurement innovation for a circular economy of construction and demolition waste: lessons learnt from Suzhou, China. Waste Management 99, 12-21.

Begum, R.A., Siwar, C., Pereira, J.J., Jaafar, A.H., 2009. Attitude and behavioral factors in waste management in the construction industry of Malaysia. Resources, Conservation and Recycling 53, 321-328.

Deloitte, 2017. Resource Efficient Use of Mixed Wastes – Improving management of construction and demolition waste – Final report, Brussels, Belgium.

Esin, T., Cosgun, N., 2007. A study conducted to reduce construction waste generation in Turkey. Building and Environment 42, 1667-1674.

European Commission, 2015. Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions closing the loop - An EU action plan for the circular economy, Brussels.

European Commission (2020, 31/12/2019). "Construction and Demolition Waste (CDW)." Waste Streams. Retrieved 07/06, 2020, from https://ec.europa.eu/environment/waste/construction_demolition.htm.

European Parliament, 2008. Directive 2008/98/CE of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Cerain Directives. Official Journal of the European Union, 3-30.

Eurostat, 2020. Generation of waste by waste category, hazardousness and NACE Rev. 2 activity.

Gálvez-Martos, J.-L., Styles, D., Schoenberger, H., Zeschmar-Lahl, B., 2018. Construction and demolition waste best management practice in Europe. Resources, Conservation and Recycling 136, 166-178.

Gao, X., Gu, Y., Xie, T., Zhen, G., Huang, S., Zhao, Y., 2015. Characterization and environmental risk assessment of heavy metals in construction and demolition wastes from five sources (chemical, metallurgical and light industries, and residential and recycled aggregates). Environmental Science and Pollution Research 22, 9332-9344.

Huang, B., Wang, X., Kua, H., Geng, Y., Bleischwitz, R., Ren, J., 2018. Construction and demolition waste management in China through the 3R principle. Resources, Conservation and Recycling 129, 36-44.

Jin, R., Li, B., Zhou, T., Wanatowski, D., Piroozfar, P., 2017. An empirical study of perceptions towards construction and demolition waste recycling and reuse in China. Resources, Conservation and Recycling 126, 86-98.

Kourmpanis, B., Papadopoulos, A., Moustakas, K., Stylianou, M., Haralambous, K., Loizidou, M., 2008. Preliminary study for the management of construction and demolition waste. Waste Management & Research 26, 267-275.

Liu, J., Gong, E., Wang, D., Lai, X., Zhu, J., 2019. Attitudes and behaviour towards construction waste minimisation: a comparative analysis between China and the USA. Environmental Science and Pollution Research 26, 13681-13690.

Mercante, I.T., Bovea, M.D., Ibáñez-Forés, V., Arena, A.P., 2012. Life cycle assessment of construction and demolition waste management systems: a Spanish case study. The International Journal of Life Cycle Assessment 17, 232-241.

Nie, Z., Yang, Z., Fang, Y., Yang, Y., Tang, Z., Wang, X., Die, Q., Gao, X., Zhang, F., Wang, Q., 2015. Environmental risks of HBCDD from construction and demolition waste: a contemporary and future issue. Environmental Science and Pollution Research 22, 17249-17252.

Nunes, K., Mahler, C., Valle, R., Neves, C., 2007. Evaluation of investments in recycling centres for construction and demolition wastes in Brazilian municipalities. Waste Management 27, 1531-1540.

Ortiz, O., Pasqualino, J., Castells, F., 2010. Environmental performance of construction waste: comparing three scenarios from a case study in Catalonia, Spain. Waste Management 30, 646-654.

Sáez, P.V., Osmani, M., 2019. A diagnosis of construction and demolition waste generation and recovery practice in the European Union. Journal of Cleaner Production 241, 118400.

State Administration of Taxation (2011). "Notice on Adjusting and improving the Policy of Value-added Tax on Products and Labor Services for comprehensive Utilization of Resources." Retrieved 08/06, 2020, from http://www.chinatax.gov.cn/n810341/n810765/n812156/n812459/c1185761/content.html.

The Ministry of Commerce of the People's Republic of China, 2017. Waste recycling development guidance.

Villoria Sáez, P., Del Río Merino, M., Porras-Amores, C., Santa Cruz Astorqui, J., González Pericot, N., 2019. Analysis of Best Practices to Prevent and Manage the Waste Generated in Building Rehabilitation Works. Sustainability 11, 2796.

Won, J., Cheng, J.C., Lee, G., 2016. Quantification of construction waste prevented by BIM-based design validation: Case studies in South Korea. Waste Management 49, 170-180.

Zhao, W., Leeftink, R., Rotter, V., 2010. Evaluation of the economic feasibility for the recycling of construction and demolition waste in China—The case of Chongqing. Resources, Conservation and Recycling 54, 377-389.

Zheng, L., Wu, H., Zhang, H., Duan, H., Wang, J., Jiang, W., Dong, B., Liu, G., Zuo, J., Song, Q., 2017. Characterizing the generation and flows of construction and demolition waste in China. Construction and Building Materials 136, 405-413.