

**COMPARISON OF RECYCLING SYSTEMS AT MICHIGAN STATE UNIVERSITY
AND HUNAN UNIVERSITY**

By

Le Kang

A THESIS

**Submitted to
Michigan State University
In partial fulfillment of the requirements
for the degree of**

Packaging-Master of Science

2015

ABSTRACT

COMPARISON OF RECYCLING SYSTEMS AT MICHIGAN STATE UNIVERSITY AND HUNAN UNIVERSITY

By

Le Kang

Due to the great increase of municipal solid waste in the past decade, China is trying to develop an effective and feasible waste recycling system and keeps on seeking better recycling solutions. The United States, which is one of the developed countries with a relatively complete and advanced recycling system, is considered to be setting a good example for China to improve its own recycling system. This article compares and discusses the differences and similarities in both countries by selecting two universities, Hunan University and Michigan State University, as a starting point to explore the positive suggestions for China's recycling system. It was found that the recycling system in Hunan University is highly dependent on the instructions of its local government due to China's current recycling legislation and management system. Also, the current recycling situation in Hunan University will not change fast due to the lack of technological and financial capability of constructing a complete MRF recycling system that can continue to function as designed. The residents in Hunan University lack the recycling awareness to firmly support the improvement of the current recycling system as well. It is suggested that Hunan University take advantage of the rapid development of the Internet to increase its residents' recycling awareness, and open its recycling market for getting advanced technologies from cooperation with professional recycling companies. Also, it will be a more economical and feasible option for Hunan University to join a regional comprehensive MRF system in Changsha rather than establish its own MRF facility on campus in the near future.

ACKNOWLEDGEMENTS

I would like to thank Dr. Susan Selke, Dr. Diana Twede of the School of Packaging at Michigan State University, along with Dr. Satish Joshi of the Department of Agricultural, Food and Resource Economics at Michigan State University for being members of my academic guidance committee. I would like to thank Dr. Selke for her support in doing the study.

TABLE OF CONTENTS

LIST OF TABLES	vii
LIST OF FIGURES	viii
1. Introduction.....	1
2. Legislation and Organizations of Solid Waste Management.....	6
2.1. China	6
2.1.1. Laws and regulations.....	7
2.1.1.1. Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes	7
2.1.2. Organizations	8
2.1.2.1. Environmental Management of Solid Waste in China.....	8
2.1.2.2. Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD).....	9
2.1.2.3. Local rules.....	11
2.2. U.S.	14
2.2.1. Organizations	15
2.2.1.1. EPA:	15
2.2.1.2. EAC	17
2.2.2. Some recycling related legislation in the United States	17
2.3. Discussion	18
3. Technology	23
3.1. Recycling procedures in two universities.....	23
3.2. Collection	25
3.3. Transportation	34
3.4. Processing	38
3.5. Discussion	38
4. Economy.....	42
4.1. Cost.....	42
4.1.1. Government	42
4.1.1.1. Waste Collector Wage	43
4.1.1.2. Residents costs.....	44
4.2. Markets and Revenue	47

4.3. Discussion	49
5. Culture	53
5.1. Identity	53
5.2. Awareness	55
5.3. Information resources	56
6. Discussion.....	58
REFERENCES.....	66

LIST OF TABLES

Table 1 Value of items collected by "Intellectual Waste recycling platform" in Dao Xiangyuan community (Zhou, 2014).....	29
Table 2 Bins, Bags and Sticker Purchases in East Lansing (City of East Lansing, 2015)	46
Table 3 Improving attempts for recycling system in Changsha	63

LIST OF FIGURES

Figure 1 Trimmed Organization dendrogram of the Environmental Development Center of the Ministry (Organization Structure , 2011).....	10
Figure 2 Lianhecanchu (Xinhua News, 2015)	13
Figure 3 Food waste carts in Saint-Tropez Hotel in Changsha	13
Figure 4 Food waste records	14
Figure 5 Methodology of EPA in calculating net discards	16
Figure 6 Model for recycling system of the U.S. and China	21
Figure 7 Recycling process model of Michigan State University	23
Figure 8 Recycling process model of Hunan University	24
Figure 9 Garbage carts of Hunan University	26
Figure 10 Garbage carts of Juzi Continent	26
Figure 11 Garbage carts of Yuelu Mountain	27
Figure 12 Reverse vending machine (Wikipedia, 2015)	30
Figure 13 Recycling bins in Drop-off Center in Michigan State University. The containers on photo are used to collect cardboard and books	31
Figure 14 Recyclable item details on the garbage bin in Michigan State University.....	32
Figure 15 Blue recycling bin and new recycling cart in East Lansing (City of East Lansing).....	33
Figure 16 Two-color bin garbage container in front of Changsha University.....	34
Figure 17 Typical trash cart in Hunan University	35
Figure 18 A waste transfer station near Hunan University (Baidu Map, 2015)	36
Figure 19 Dumping trash in waste transfer station in Hunan University	37
Figure 20 Trash pool in waste transfer station in Hunan University	37
Figure 21 Garbage collecting container in Michigan State University.....	40

Figure 22 Garbage collecting container in Hunan University	40
Figure 23 Salary comparison of garbage collectors and janitors in China (China Youth Daily, 2014) & the United States (US News Money & World Report, 2015)	44
Figure 24 Exported value of waste from the United States to China from 2000 to 2011 (NetEase, 2012)	49
Figure 25 Cash flow model of the recycling system of Michigan State University	50
Figure 26 Cash flow model of the recycling process in Hunan University	50
Figure 27 Part of recycling hand book for residents in Yokohama (City of Yokohama, 2015)...	57
Figure 28 Recycling related webpage of the website "City of East Lansing" (City of East Lansing, 2015)	57
Figure 29 The "Change recyclables for Green Plants" program in Hunan University (The Green Exchange Family of Hunan University, 2014)	60
Figure 30 Map of the surrounding area of Hunan University (Google, 2015)	61

1. Introduction

With the development of the economy, the recycling system in China has also changed a lot. The early recycling activity in the People's Republic of China was totally run by the central government. The recycling activity also earned public's great passion partially due to encouragement of the country's leader and poverty. The facilities that were run by the government before the 1990s were known as "State-owned waste recycling facilities". These facilities undertook almost all aspects of municipal waste recycling before the 1990s. One interesting example is turtle shells, which can be considered as food waste but are also considered a traditional Chinese medicine. Residents could collect their turtle shells and sell them to local recycling facilities for food stamps, sugar or other groceries. Due to changes in the economic environment, the state-owned recycling facilities gradually disappeared. For example, in 1965 there were more than 2,000 state-owned recycling facilities within the second ring road area in Beijing. But in 1997, there were only 16 such facilities in the same area (Hao Jin, 2010). Meanwhile, formal or informal recycling facilities run by private parties emerged and grew in both number and scale. Beijing, as one of the pioneers of recycling in China, also explored the possibilities of running municipal waste recycling based on community units instead of local government organizations. A community unit, which is the most basic subsidiary of local governments, provides more flexibility and diversity in developing recycling systems. One example is the sorting project for recycling that was launched in the Dacheng Lane community in Beijing in 1996. It was reported in 2010 that 90% of the residents in this community were doing recycling sortation every day (China Waste, 2015). To further promote the recycling concepts, in 2000 eight cities (Beijing, Shanghai, Guangzhou, Shenzhen, Nanjing, Hangzhou, Xiamen and Guilin) were chosen as the test cities for promoting waste sorting for recycling. Due

to the poor performance of those chosen cities in the past decade, more and more debates, complaints and discussions about how to efficiently improve the situation occurred. Following is a summary of opinions and conclusions that appeared (Liu, 2014):

1. Lack of investment. This is one of the most common criticisms. It is widely believed that the government did not invest enough in the recycling sortation programs in those cities in infrastructure, equipment, policy and education.

2. Lack of a complete recycling system. This can be considered as one of the results of insufficient investment. One of the phenomena that reflect this is that most of the time, the sorted waste that is collected in communities will be mixed again during transportation and then be sent to the landfill. This phenomenon has been considered to be very harmful to the people's positive view of doing recycling sorting and renders the previous sorting efforts in vain.

3. Lack of public awareness. Most people express a supportive attitude towards recycling in the community but have no idea how to do recycling (Ma, 2015) (Fu, 2015), which seriously damage the performance of recycling systems, especially the sortation part. In most cities, the designed sorting and recycling plan did not work as well as the government and the public expected.

China still has a long way to go in improving its recycling system to reach higher recycling targets which other developed countries have already achieved. This improvement process takes time and continuous changes to adapt the direction to the current situation. The United States, although it has many differences from China based on economy, geography and demographics, still has possible examples and solutions for China's municipal recycling systems. To set up a complete system of recycling, the United States also experienced decades of development and changes. In the late nineteenth century, after George E. Waring, Jr. first

constructed a comprehensive system of public-sector management in the United States, more and more cities in U.S adopted advanced systematic waste collection systems. Landfill owners began declaring their properties off limits to casual scavenging. This change has been believed to be one of the reasons that caused individual scavengers to gradually lose their position in the recycling system in the U.S. (Rathje & Murphy, 1992). People in the U.S. have kept exploring to create municipal waste management systems that fit local regions the best. The situation in the U.S. changed from time to time during this process as well. Factors like population, social patterns and technology advancement had a big influence on the solid waste management system. According to EPA's 1986 report "Characterization of Municipal Solid Waste in the United States", the increase of population would cause an increase in municipal waste; it is stated in the report that a little over 1% increase in population would make any efforts designed to reduce or stabilize the waste generation in vain (Franklin Associates, Ltd., 1986). Also, the increase of affluence at a personal level in the U.S. after World War II and changes in social traditions (more women entered the work force than before) increased the consumption of packages of frozen dishes (Franklin Associates, Ltd., 1986), which resulted in an increase in waste.

The recycling system in the United States grew up along with the development of a revolution in packaging materials. Recycling has long been a hot topic in packaging history. One example is the commercialization of plastic materials. Back in the 1960s, when plastic packaging materials began to take a large amount of the packaging market, scholars, environmental protection organizations, residents and policy makers started to focus their attention on recycling issues related to this new packaging material and the impact that this new material would bring to the traditional recycling system (mainly dealing with paper, glass and metal). Companies who were eager to use this new material in their packages due to its outstanding properties including

light weight, low cost, accessibility, etc. were forced by the public to work on addressing the recycling problems as well. Government also took a role in increasing the recycling rate of plastics. The “Container Deposit Law” (or “Bottle Bill”) that launched in Oregon is one of the most famous examples. Until today, the United States is still working on increasing its recycling and composting rates for municipal solid waste. The new “Advancing Sustainable Materials Management (SMM): 2013 Fact Sheet” which was previously referred to as “Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures” shows a new trend in the United States’ government concept of recycling and municipal waste management. The efforts in the past two decades of improving the recycling system in the United States seem to be actually and positively affected recycling. A lot of traditional recycling categories have reached high recycling rates. For example, the recycling rate of lead-acid batteries has reached 99.0%, the recycling rate of steel cans reached 70.6% and the recycling rate of newspapers/mechanical papers reached 67% (EPA, 2015).

This thesis is a starting point to compare the two recycling systems both in China and the United States to develop suggestions for making better solutions in doing package recycling. Two universities, Hunan University and Michigan State University, were selected as examples for detailed study on how the recycling system works currently in both countries.

Hunan University is a famous university in China (Hunan University, 2015). There are 38,800 students and staff in this university. Most of them live in the campus area. The area of Hunan University is 1.55 km² with 1.02 km² indoor space (Hunan University , 2014). Michigan State University (or MSU) currently has approximately 55,185 students and staff on campus with a total area of 21 km², of which 8.5 km² is in existing or planned development (Michigan State University, 2015). The university also has 2.13 km² (Michinga State University, 2015) indoor

space. Michigan State University is one of the universities in the U.S. that has its own recycling center (other such universities include Utah State University, Ohio State University and the University of South Carolina). The major difference between Hunan University and Michigan State University from a recycling perspective is that it is located next to the most famous tourist attraction in Changsha city - the Yue Lu Mountain. Thus in addition to the debris created by the people on campus every day, recyclables in trash created by tourists will also be an important factor in the recycling system. There are currently 28 garbage collectors and janitors working for Hunan University doing trash collection and cleaning. The recycling center in Michigan State University has 3 full time staff and 8-10 students on the sorting line. Mr. David Smith, who is the waste coordinator for this facility and has worked there for 2 years, was interviewed for information about the facility. The facility includes the Surplus Store and the recycling center.

Characteristics of the two cities, Changsha (where Hunan University is located) and East Lansing (where Michigan State University is located) were also examined since the policy and properties of the local government on recycling have considerable effects on how the recycling system works in both universities. Comparison of the recycling systems was based on legislation and organizations, technology, economy and culture in order to make suggestions for further development of recycling. These two reasonably similar universities were chosen as a manageable starting point for making comparison of recycling systems in China and the United States.

2. Legislation and Organizations of Solid Waste Management

The historical background for solid waste management legislation and organizations in China is distinct from those in the United States. The recycling legislation or organization system in the United States is a kind of from “Down to Up” mode, which means the recycling concept or activities of the community (like Michigan State University), local government, and state government often run forward and provide great suggestions for recycling improvement on the national scale. This characteristic contributes to the highly complicated and diverse recycling legislation and organization system. Unlike that, the mode in China is more “Top to Down” type, which means most of the legislation and organization system in China is constructed on a general standard set by the central government. The differences in recycling systems are always caused by geographic, demographic or economic reasons that lag some places behind, rather than creating a system suitable for the local environment. The following sections in this chapter list some typical legislation and organizations relating to recycling to make a comparison and discuss how the differences between these two countries affect the recycling systems in Hunan University and Michigan State University.

2.1. China

The current solid waste management system in China was developed in the 1980s. Before that, the central government was in charge of almost every aspect of solid waste management in China. But with rapid economic development and a big increase in the administrative cost of maintaining solid waste management on a national scale, the central government finally decided to give local governments the power and responsibility to deal with their own solid waste

management. But certainly the central government still maintains the capability to regulate the solid waste management system on the national level. For example, the Ministry of Environmental Protection of the People's Republic of China is one of the organizations that are in charge of the monitoring and management of municipal solid waste at the national level. Local governments, which are responsible for selecting appropriate locations for recycling collection facilities, are now playing the major role in China's recycling system. The local Sanitation Bureau takes on more detailed and practical work such as cleaning, collection, storage, transportation and handling of the solid waste. They also undertake responsibilities which include providing data evaluation to assess the results and impacts of dealing with municipal solid waste.

2.1.1. Laws and regulations

2.1.1.1. Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes

The first version of this law was established on 10/30/1995. The most recent revision was in 2014. This law is the main legislation for pollution control and solid waste management in China (Chen et al., 2009). It established the fundamental requirements for MSW. There are several points directly related to municipal waste management and recycling.

1. This law established requirements for local governments to collect, transport, and handle the municipal waste and to increase the percentage of "innocent treatment of municipal waste". Innocent treatment of municipal waste means collecting all the garbage created by the city residents and transporting the garbage in confined vehicles. The garbage should be treated under safe conditions and the facilities

that deal with the garbage should discharge only pollutants that obey the environmental protection requirements.

2. The process for improving garbage sorting and transportation will be gradual. Innocent treatment and appropriate usage will be encouraged.
3. The local government should manage and set up recycling facilities.

2.1.2. Organizations

2.1.2.1. Environmental Management of Solid Waste in China

Some of the laws and regulations about solid waste were established by the department named “Environmental Management of Solid Waste in China” which was set up in February 2006. This organization is under the control of the Ministry of Environmental Protection of the People’s Republic of China (Environmental Management of Solid Waste in China, 2015). The major responsibilities of the organization include:

1. Compose the laws and regulations and management rules for solid waste
2. Inspect and manage imported waste
3. Provide technical support for hazardous waste management
4. Monitor and manage the operation and process of the national hazardous waste center
5. Construct and manage the national solid waste information management system
6. Construct national solid waste management records and data base
7. Assist with hazardous waste pollution accidents
8. Instruct solid waste centers on the provincial scale
9. Conduct activities of education, technical communication and consultation.

10. Other work assigned by the Ministry of Environmental Protection of the People's Republic of China.

This organization is a relative new organization in the official environmental protection system in China. Thus information that is related to this organization has not yet been updated in the system. For example, although the Environmental Management of Solid Waste in China states that it is a subsidiary of the Sino-Japan Friendship Center for Environmental Protection (Environmental Management of Solid Waste in China, 2011). However, the organization dendrogram of “Sino-Japan Friendship Center for Environmental Protection” does not show the Environmental Management of Solid Waste (see Figure 1).

2.1.2.2. Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD)

MOHURD is in charge of the cleaning, collection, storage, transportation and final disposal of municipal solid waste in China (Chen et al, 2009). The range of responsibilities of MOHURD (Ministry of Housing and Urban-Rural Development of People's Republic of China, 2015) is quite wide, and involves almost all the aspects regarding to construction work in urban and rural areas in China. Among the 13 major missions, there is one point that connects to the municipal waste management the most closely, which describes the mission as promoting the energy saving of construction and cities and setting and monitoring the application of policies and regulations. In addition to that, MOHURD also undertakes large projects that aim at reducing waste and saving energy.

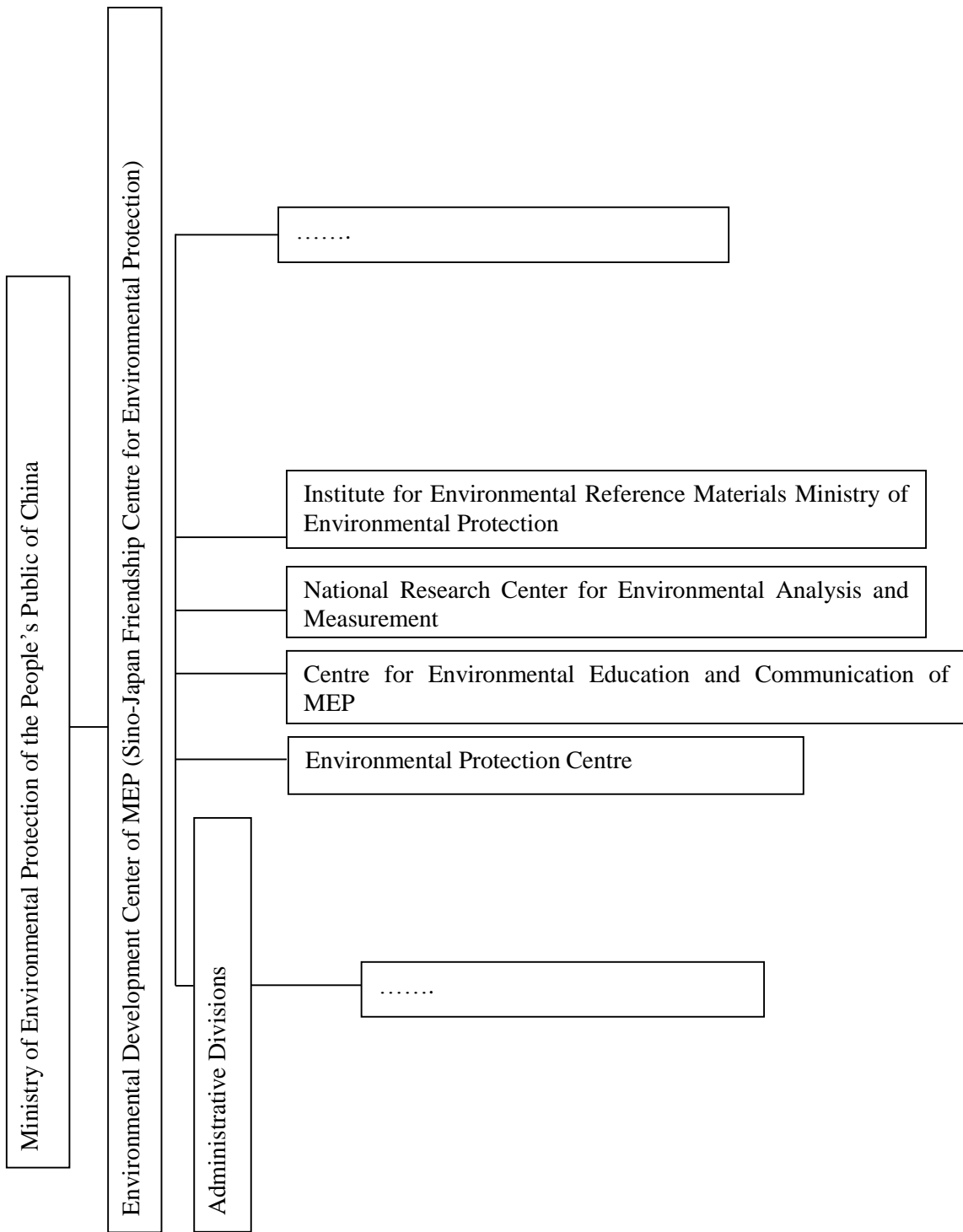


Figure 1 Trimmed Organization dendrogram of the Environmental Development Center of the Ministry (Organization Structure , 2011)

2.1.2.3. Local rules

Changsha is not the most advanced city in China in recycling. But in recent decades, due to the rapid urbanization and industrialization process, improving the MSW management system has been one of the priority considerations of the local government. According to the “2014 Changsha Solid Waste Management Report”, the municipal solid waste increased by 11.6% from just under 1.7 million metric tons in 2013 to nearly 1.9 million metric tons in 2014 (Changsha Environment Protection Agency, 2015). The high speed of increasing municipal solid waste forced the local government to take action to deal with it. Setting up new solid waste management rules is one of the primary actions that the local government took in the past five years to improve its solid waste management system. The two rules that stand out are the “Changsha Government Rule” and the “Changsha Food Waste Management Rule”.

The “Changsha Government Rule” was released in 2000 to replace the previous municipal solid waste management rule of 2/19/1998. Two chapters of the total nine chapters are relevant to solid waste management, which also includes content related to construction waste, medical waste, punishment and so on. The rules regarding municipal solid waste management can be described as several violation situations followed by a corresponding fine range. Moreover, the violation situations are written in a very vague and general manner, like one of the rules that says “do not dump waste as instructed, will be charged a fee of 50 yuan (\$8) to 500 yuan (\$80)”, where no detailed information is provided on what is the instruction and who will charge the fee, etc. It is obvious that most of the rules in this document will not be smoothly applied to residents’ daily lives.

The “Changsha Food Waste Management Rules” were established on 12/08/2010, and went into effect on 06/01/2011 (City of Changsha, 2011). Although most of the food waste is

used for composting or energy recovery, it is still worthwhile to discuss this food waste management rule since it set up an example for a possible mode to improve recycling in Changsha. In Changsha, selling food waste is an important source of income for most of the restaurants. Thus before this food waste management rule, most of the restaurants sold their food waste to a middle man or directly to people from an illegal refinery. The appearance of this rule was primarily aiming at ending this food waste trade which threatened public food safety and health by refining the used oil and selling it as edible oil. Lianhecanchu (Figure 2) is a contract company which is responsible for collecting food waste from over 3,000 large or medium restaurants in Changsha and refining food waste to biodiesel and methane (Xinhua News, 2015). A representative of a restaurant, Saint Tropez Hotel, (see Figure 3) in Changsha that has signed an agreement with the contract company (Lianhecanchu) for collecting their food waste was interviewed to see how the system currently works. Based on the interview, the sample restaurant is actually obeying the rule to some extent. Figure 4 is the food waste record in Saint Tropez Hotel. There are 7 requirements for filling out this record: 1. The records must be taken every day; 2. The time of collection should be detailed from month, days, hours to minutes; 3. Records should not be changed; 4. The inspector should inspect the restaurant at least twice a week; 5. The records will randomly be checked and recorded; 6. The records should be authentically taken and obey the “Food waste management regulations of Changsha”; 7. Restaurant is responsible for properly keeping the records. Punishment will result to a restaurant which has lost this record. Currently it is hard to get actual information about whether the restaurant submits all their food waste to the contract company. But, new waste management rules actually influence and shape the way people are treating and dealing with food waste. Within two years, the company that is

responsible for collecting food waste has already signed contracts with over 93.3% of the major restaurants in Changsha (Hunan Daily, 2014).



Figure 2 Lianhechanchu (Xinhua News, 2015)



Figure 3 Food waste carts in Saint-Tropez Hotel in Changsha

注意事项：

- 1、餐饮单位和收运单位必须做到一日一登记；
- 2、收运时间填写具体（如：__月__日__时__分）；
- 3、填写内容不得涂改；
- 4、辖区执法干部对管辖的餐饮单位每周检查两次以上；
- 5、餐厨大队定期和不定期对收运台账进行检查，并就检查情况进行登记；
- 6、餐饮单位和收运单位必须如实记录台账，否则按《长沙市餐厨垃圾管理办法》处理。
- 7、餐饮单位应妥善保管台账，台账遗失的，餐厨执法部门将依据《长沙市餐厨垃圾管理办法》的相关规定予以处罚。

日期	时间	检查人	记录
10	10	王	
11	11	王	
12	12	王	
13	13	王	
14	14	王	
15	15	王	
16	16	王	
17	17	王	
18	18	王	
19	19	王	
20	20	王	
21	21	王	
22	22	王	
23	23	王	
24	24	王	
25	25	王	
26	26	王	
27	27	王	
28	28	王	
29	29	王	
30	30	王	
31	31	王	

Figure 4 Food waste records

2.2. U.S.

Before the birth of plastic, the U.S. already had a well-secured recycling system for traditional packaging materials like glass, paper and metal, etc. (Feldman & Wolf, 1984). There is no national legislation forcing people to do recycling in the United States. However, some states have their own legislation to help promote recycling. For example, California, Michigan and Oregon (among others) have “Bottle Bills” to increase the recycling percentage for beverage bottles. The following section will discuss some organizations and legislation that are related to recycling in the United States.

2.2.1. Organizations

2.2.1.1. EPA:

The United States Environmental Protection Agency or EPA was established on 2/12/1970. This organization is not specially designed for the waste management function in the United States. One of the accomplishments of this governmental organization is releasing general reports about the municipal waste management situation in the United States. Those reports provide an overview of the municipal waste management process from the government side. For example, the most recent version was published in 2015, named “Advancing Sustainable Materials Management: 2013 Fact Sheet”. It changed the previous name “Municipal Solid Waste Generation, Recycling and Disposal in the United States: Facts and Figures”, which includes municipal solid waste categories, data and facts. This organization uses a “materials flow method” to estimate the net discards of the United States on a national level, which takes the rate of the tons of recycled materials divided the tons of total domestic materials production (and imported materials) as the national recycling rate. Figure 5 provides a general idea about how the methodology works. EPA’s first report “Characterization of Municipal Solid Waste in the United States 1960 to 2000” was released on July 11, 1986. The “materials flow approach” (see Figure 5) was adopted as the methodology used in this report. The data in the report included quantity and composition of MSW in two categories - materials and products (Franklin Associates, Ltd., 1986). This report laid the framework for the subsequent MSW reports released by EPA.

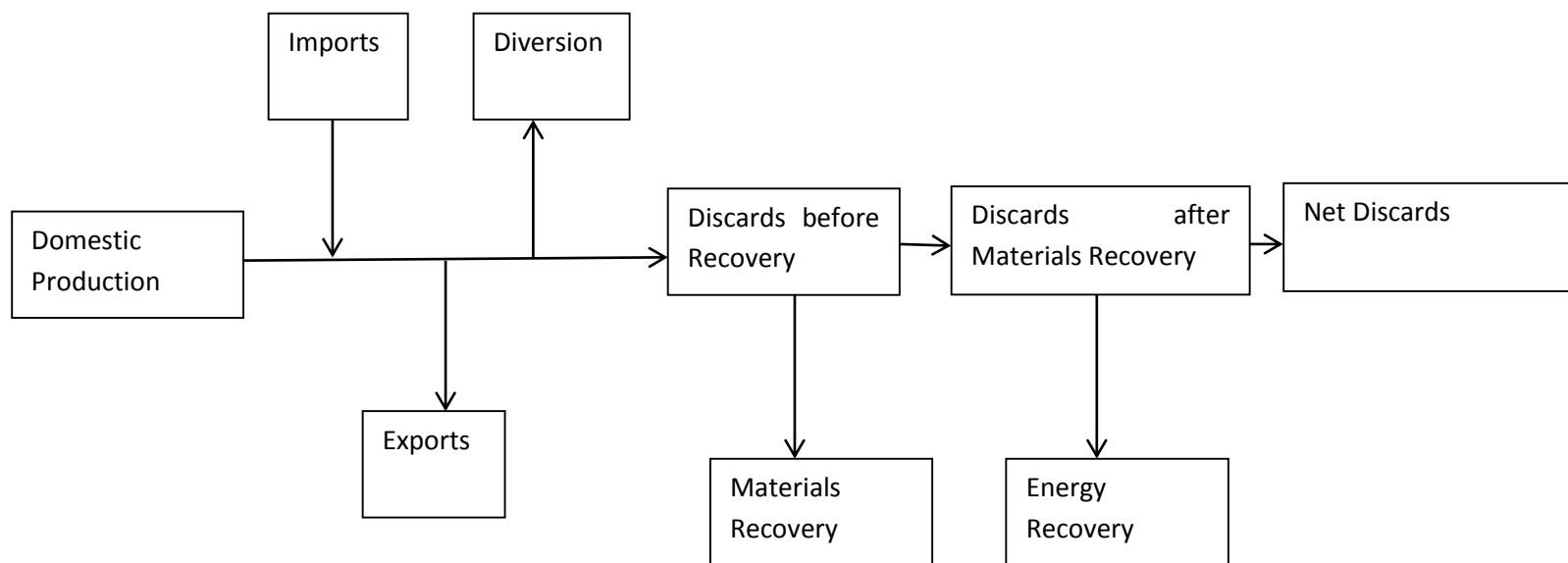


Figure 5 Methodology of EPA in calculating net discards

2.2.1.2. EAC

The EAC (Environmental Action Coalition) was a non-governmental pioneer in research on plastic recycling issues. The plastic research project that started in 1984 led by EAC provided a new view of applying data in assessing the recyclability of the waste stream (Feldman & Wolf, 1984). This organization does not exist today.

2.2.2. Some recycling related legislation in the United States

Although the United States does not have federal laws directly regulating recycling, there are still lots of laws and regulations related to recycling activities in the United States. For example, “Bottle Bills” have been passed by 11 states - New York, Michigan, Massachusetts, Vermont, Oregon, Maine, Iowa, Connecticut, California, Hawaii and Guam. The city of Columbia, Missouri repealed this law in April of 2002 and the state of Delaware repealed this law in 2010 (Bottle Bill Resource Guide, 2015). Even though the primary intention for the “Bottle Bills” is to reduce litter rather than collecting bottles for recycling, the bills helped a lot with plastic recycling in the United States.

Also, there have been some attempts to set up recycling laws directly related to the packaging industry in the United States. Packaging taxes is another concept that was raised around 1980-1990s. For example, the H.R.5197 Recycling Promotion Tax Incentive Act of 1990 was introduced but did not make it out of committee (Eckart, 1990). Another concept that had the same fate was the Recyclable Materials Science and Technology Development Act (H.R. 500), which was first introduced in 1988 by Representative George J. Hochbrueckner. This Act was the first comprehensive recycling legislation in the U.S. Congress (The Library of Congress Thomas, 2015). In addition to that, a county in New York and some communities in California

(and some elsewhere) established another type of legislation – the material ban. For example, in 1988, Suffolk County, New York, passed a law banning the use of polystyrene foam cups, plates, packing peanuts, coolers and clamshells, etc. because they were considered not recyclable. However, this rule was overturned on 9/22/2015 since the local judge considered those products can be recycled (Dokoupil, 2015).

2.3. Discussion

It is clear that organizations and legislations for recycling have experienced plenty of changes in the past decades in both countries. The way for developing a better recycling system is not always smooth and easy. And the birth of new materials and packaging also brings challenges and changes to recycling legislation systems. For example, in the 1980s, the United States experienced a “confusion” time dealing with recycling issues when the “new” packaging material – plastic - came into the spotlight. One of the examples that provided for confusion in recycling of plastics is “degradability” versus “non-degradability.” Lots of companies took advantage of the unclear definition of the concept and released new plastic materials claiming that the great “degradability” of the materials could help the recycling process and reduce harm to the environment. In “Plastic-America’s Packaging Dilemma”, the author emphasized the need for national level recycling activity several times (Feldman & Wolf, 1984). Not all of the environmental protection agencies immediately took action. The EPA faded from the public debate at that time. Only FDA established some health regulations directly related to recycling. Due to EPA’s absence, debate at the local and state levels about issues pertaining to packaging, waste reduction, recycling, and safe disposal created an ever-escalating political controversy (Feldman & Wolf, 1984).

In its early stage of setting up recycling legislation, the United States tried to put some legislation in the upstream of the recycling chain, which means to regulate the producers' behaviors to help recycle better. But from a packaging prospective, all of the efforts in that direction failed. Currently there are no laws that manage producers' packaging recycling. However, the public's recycling awareness and actions to protect the environment helped more in forcing producers to improve their products and packages for better recycling results. For example, back in the 1980s and 1990s, the major agencies in the United States dealing with recycling worked hard to raise the public awareness of recycling new packaging materials such as plastics. That public awareness turned back to pressure on packaging material suppliers and product producers or even retailers to figure out ways to improve the "recyclability" of their products. In the 1980s, the awareness of the public had great impact on improving recycling systems even before laws were issued in the United States. But, without legislative efforts, the recycling just does not seem to move forward at the expected speed with the desired results. One example is New York State's mandatory deposit law. After the first year of the establishment of this law, the recycling rate for all cans increased from 5 percent to 59 percent. Also glass and plastic experienced a great increase in their recycling rates (Feldman & Wolf, 1984). The recycling system in both the United States and China involves governmental legislation and organizations and efforts from the public. However, the public in the United States affects the recycling system on a greater level. The public can let producers know they need to improve either the design or production process of their products and packaging to increase their sales. The public's proactive role in recycling also contributes to more effective and systematic legislation that can help improve recycling quality.

Unlike the situation where communities have a big influence on recycling in the United States, current organizations and legislation are still the main forces that move China's recycling system forward, since the public awareness of recycling is not high enough, which does not only indicate the proportion of people who know they need to recycle material but also how, where, why and when to do recycling. This is kind of like the legislation situation that the United States had in its early stages. However, China has a much more complicated system. Hundreds of domestic recycling companies and international companies also want to join the recycling market in China. Interestingly, when checking online recycling information for recycling in cities, most of the information that pops out for the US is government regulations, guides or posts. For most parts of China, the "recycling companies" seem to have a much more influence on shaping the concepts of recycling system than the public at the current stage. Perhaps in the future when the public realizes the importance of comprehensive recycling systems, those companies will work with the government to change the current recycling system. This phenomenon reflects the fact that, unlike in the United States, China is focusing more on its recycling downstream, which is consumers and companies that try to solve recycling problems. There are some basic situations that make the mode in China work so differently.

First, informal waste collectors hide the fact that there are lags in construction of recycling systems from the public in China. Currently, government still needs the informal waste collectors for creating jobs. It is estimated that roughly 3.3 to 5.6 million people in China are doing informal garbage collection to make money. Most of them are poorly educated and low income. For example, in the combination of the urban and rural areas of Beijing, around 170,000 people depend on garbage collection to make a living (Xinhua News, 2014).

Second, the lack of the government's "ability" to restrict the upper stream of the recycling process causes the development of recycling processing to be slow. Recycling is giving way for economic development. Economic development still plays the major role in China's society. Although the basic law of "Law of the People's Republic of China on the Prevention and Control pollution of Environmental Pollution by solid waste" said that the producers have the responsibility to take back their packages or products to prevent pollution, those producers are only limited to certain categories and most of the producers are not required to do detailed actions to recycle their products. For example, there is general information in the "Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by solid waste" and the local rule in Changsha that says that producers have the responsibility to properly recycle and deposit their waste. However, the details of punishments for violations and instructions for producers to follow are still not available. Figure 6 is a brief model indication for how legislation is positioned in both countries.

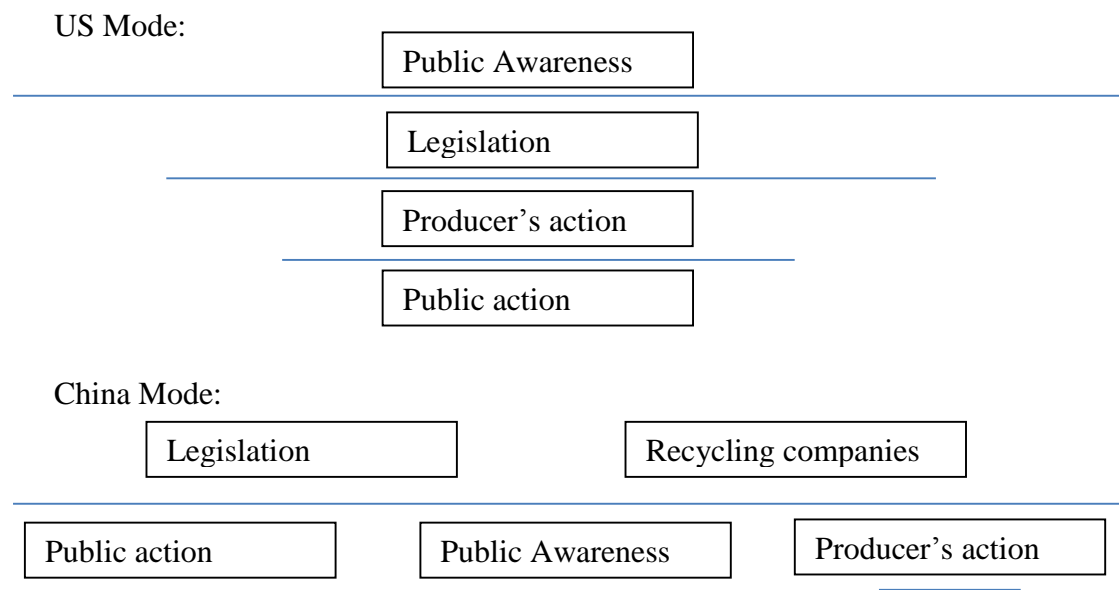


Figure 6 Model for recycling system of the U.S. and China

The model shows that the public's force plays a primary role in improving the recycling system in the United States and the legislation system as well. But the legislation system is also needed to secure the consequent required performance of the recycling system. For China, the recycling improvement system is still loose. Legislation has kind of an equal role with recycling companies to manage and upgrade the recycling system in China.

3. Technology

There are four major steps in a complete recycling system, which are collecting, sorting, transporting and disposal. On the campuses of the two universities, collecting, sorting and transporting processes can be observed. So those three steps are selected for further discussion in this chapter.

3.1. Recycling procedures in two universities

There are not many differences between the recycling system structure in Hunan University and Michigan State University. In Figure 7 and Figure 8, the major steps of recycling are listed. Both universities have three stages of recycling: 1. Collection, 2. Processing, 3. Transporting.

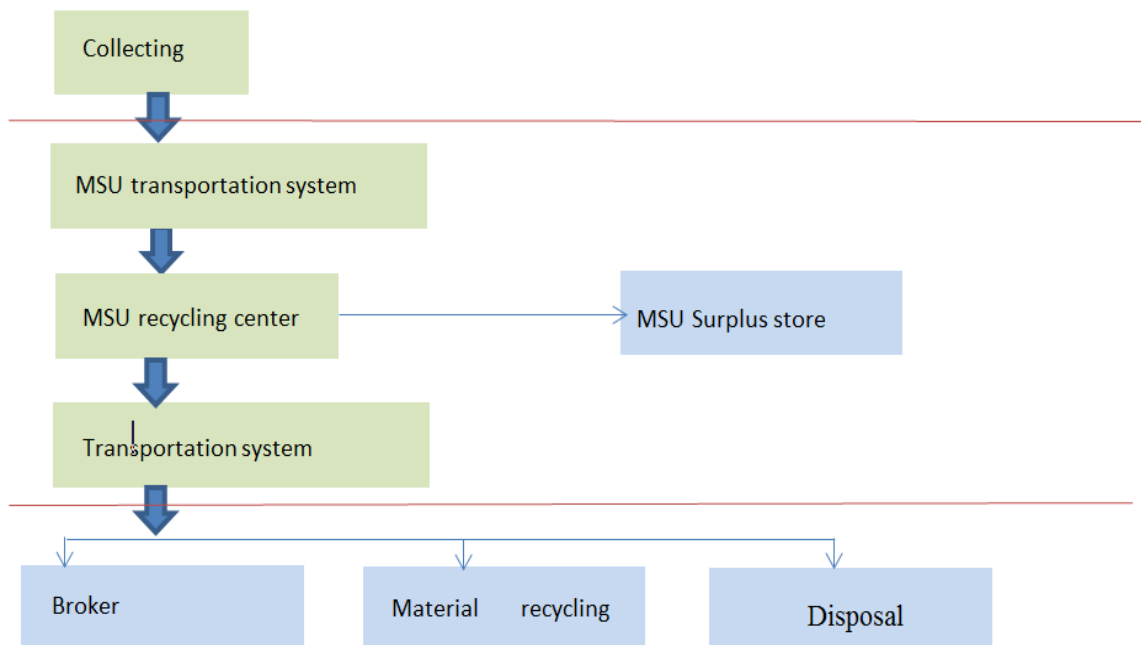


Figure 7 Recycling process model of Michigan State University

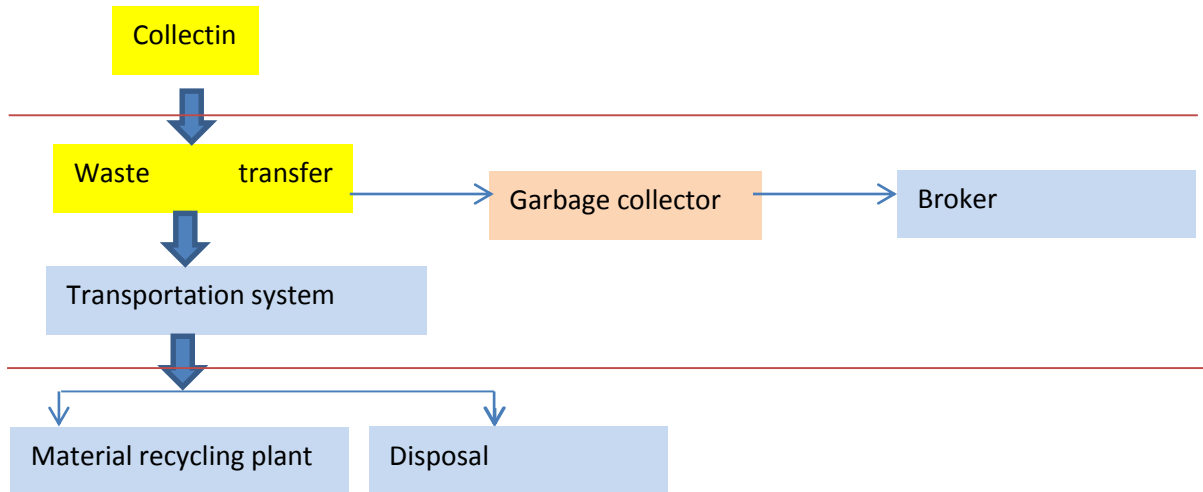


Figure 8 Recycling process model of Hunan University

The recycling center in Michigan State University plays a critical role in handling the recycling procedure. The old facility was established in 1988 after students petitioned the Board of Trustees for a focus on recycling (Michigan State University, 2015). The new facility, which includes a recycling center, a 24/7 drop off center, and a Surplus Store, was opened in 2009. The facility could handle 10 million tons of solid waste in 2013. The recycling center has its own transportation team and can provide a comprehensive waste management solution for the entire campus. In Figure 7, the steps in the green squares mean that the process happens on campus and Michigan State University is in charge of it. It is obvious that this recycling center provides technologies that can cover collecting, sorting and transporting.

Figure 8 shows the recycling system structure in Hunan University; the yellow steps mean that Hunan University is in charge of the process. The blue steps mean other individuals or organizations (especially local governments) are in charge of the process. The garbage collector part is kind of a mix of both of them so is marked with an orange color. It can be seen from the recycling structure that Hunan University actually has limited capability in managing its recycling system.

This limitation can be interpreted as due to high dependence on government, limited capital for on campus recycling and unwillingness to update the recycling system on campus. Nevertheless, lack of appropriate recycling technology is one of the reasons for the situation. The following section will compare the recycling technology that each university uses, to spotlight the differences

3.2. Collection

Collection is the starting point of a complete recycling process. Compared to transportation and processing, this stage involves less technology.

There are three waste collection systems working together in and around Hunan University: Hunan University system (the garbage cart used in this system can be found in Figure 9), Juzi Continent (the garbage cart used in this system can be found in Figure 10) and Yue Lu Mountain (the garbage cart used in this system can be found in Figure 11).



Figure 9 Garbage carts of Hunan University



Figure 10 Garbage carts of Juzi Continent



Figure 11 Garbage carts of Yuelu Mountain

These three systems share the same waste transfer station in the area. The garbage collectors in all three systems dump the waste that they collect every day at the waste transfer stations. During this process, the garbage sorting totally depends on the garbage collectors. There is no formal procedure or available machinery to help to separate the recyclables from the non-recyclables among the collected waste at this stage. Another feature of the recycling system in Hunan University is that the districts of the three systems are separated clearly. Actually, conflict of interest may exist to some extent. The staff in the system usually do not have professional knowledge of recycling. They collect the bottles, papers or metals based on their personal experience to judge if this kind of material is recyclable. The collection mode in Hunan University described above is currently used by most of the communities in Changsha.

1. Individual recyclable collectors or individual recyclable collecting companies.

Residents will accumulate the recyclables that they collect every day until it is enough to sell them to the recyclable collectors. Although there are some formal

companies collecting recyclables for profit, most of the individual collectors and private companies are “informal”, which means that they do not formally register with the government and are not controlled by laws and regulations.

2. Collected by garbage bins.

Two-color divided garbage bins are the most commonly used garbage bins designed to collect recyclables in public areas. The other bin is for garbage that contains no recyclable items. On the street in Hunan University, a lot of two-color garbage bins can be found (see Figure 22).

3. Open dumping.

It is also common for residents to dump their waste in places that are not a regular landfill. Most of the recyclables dumped this way are construction debris.

4. Recycled by reverse vending machine.

This is a new trend in China. However, this mode is still in the testing stage. Different waste vending machines (or “robots”) are entering people’s view. For example, in the Dao Xiangyuan community of Hangzhou, a machine called “Intellectual waste recycling platform”, which can recycle certain items in residents’ daily life, has been introduced to the community. However, currently the recyclable items that are collected by this machine do not include paper and paper board (see Table 1).

Table 1 Value of items collected by "Intellectual Waste recycling platform" in Dao Xiangyuan community (Zhou, 2014)

Item	Value
Cola bottle	10 credits (\$0.0016)
Colored glassware	15 credits(\$0.0024)
Cell phone charger	350 credits (\$0.056)
Mouse and Keyboard	350 credits (\$0.056)
Cell phone	1650 credits (\$0.27)
Other plastic products	300 credits (\$0.048)
Non-rechargeable alkaline battery	10 credits (\$0.0016)
Mobile phone battery	50 credits (\$0.0081)
CPU, Hard drive, CD driver, Main board	1350 credits(\$0.22)

5. Other methods

Guangzhou adopted a pneumatic waste collection system from Sweden in 2004. Three communities were chosen as tests for this new system. One of the communities, Jinshazhou Community, reported that the system stopped working just a few days after set up (An, 2009). The system did not work properly in any of the three communities. Residents who live in the community said that they never had the chance to actually use the system by themselves. Currently the garbage collectors collect waste from the residents, and drop preselected wastes into the waste pipe system (Lai et al., 2009).

The mode for recyclables collection in Michigan State University is different from that in Hunan University. But the Michigan State University mode also has a lot of similarities to the recycling mode in the local area - East Lansing.

There are two major modes for individuals to recycle their waste in East Lansing:

1. Drop Off

- 1) “Container Deposit Law” mode. This mode developed from the previous glass bottle recycling mode. When consumers buy certain drinks from certain producers from retailers, they will pay a refundable deposit for the bottles of the products when they check out. Once consumers return the bottles to the retailers, they will get the deposit back (Bottle Bill Resource Guide, 2015). This method is designed mainly for collecting plastic bottles and metal beverage containers. There is a unique type of machine that is commonly used at this stage, which is known as a reverse vending machine (see Figure 12).



Figure 12 Reverse vending machine (Wikipedia, 2015)

- 2) Drop-off centers. There is a drop-off center on the Michigan State University campus available for both on campus and off campus residents. The recycling center of Michigan State University has several big containers for residents to dump the plastic, paper and paperboard, glass, metal and even books that they collected in their daily life (see Figure 13).



Figure 13 Recycling bins in Drop-off Center in Michigan State University. The containers on photo are used to collect cardboard and books

- 3) Collected by garbage bins. Most garbage bins in the city are one-bin systems, which means recyclables are not separated from non-recyclable garbage. Those garbage bins are located mostly in outside public areas, like bus stations, on the roadside and at the door of shopping malls, etc. However, at Michigan State University, bins for collecting different recyclables have been set up. There are several types of recyclable materials that those bins collect: mixed paper (newspaper and inserts, boxboard, beverage boxes, catalogs,

directories, magazines, junk mail, envelopes, post-it notes, ream wrappers, cards), glass, metal and plastic (water bottles, jugs, grocery bags, frozen food trays, steel/tin cans, aluminum foil, bottle caps, jar lids) and office paper (computer paper, letterhead, notebook paper, tablet white paper, copy paper, index card, ink and staples). That information is printed on notices above the containers (see Figure 14).

2. Curbside pickup mode. In areas like East Lansing, this approach is the most commonly used method to collect recyclables that are generated in daily life by households. People who use this method will buy a certain type of container from the local government or a private company for separately collecting recyclables. For example, a blue recycling bin (see Figure 15) can often be found outside of residents' houses for collecting recyclables.



Figure 14 Recyclable item details on the garbage bin in Michigan State University



Figure 15 Blue recycling bin and new recycling cart in East Lansing
(City of East Lansing, 2015)

The recyclables collection system is complicated both in China and the United States due to their diversity and broad territory. For example, due to the poor performance of the two-bin garbage collection system (since few people actually follow the instructions and put waste in the right bin) and high investment, Guangzhou stopped using the two-color garbage bin system in 2007 (Yangcheng Evening News, 2015). However, some other cities like Changsha still use the two-color bins to collect and sort garbage. In 2014 new two-color bins were set up on the new streets near Changsha University (see Figure 16).



Figure 16 Two-color bin garbage container in front of Changsha University

3.3. Transportation

In Hunan University, the first step of transportation for recycling is a cart. Usually the cart is accompanied with a crate or a plastic bag, which is used by garbage collectors to collect possible recyclables from waste before dumping it. This is the common way that most of garbage collectors use to gain extra income. Figure 17 shows the typical garbage carts used in Hunan University.



Figure 17 Typical trash cart in Hunan University

The next step is sending collected garbage to a waste transfer station. The garbage collected in all three garbage-collecting systems (Hunan University, Juzi Continent and YueLu Mountain) will be gathered in the waste transfer stations. So, basically, those waste transfer stations will be the final point of garbage flow in this university area. After this, the garbage will be taken over by the garbage truck operated by the local sanitation bureau.



Figure 18 A waste transfer station near Hunan University (Baidu Map, 2015)

There are two things to be noticed in this situation. First, the waste transfer station does not have any equipment or regulations to strictly separate recyclable and non-recyclable materials. But before dumping the trash, most of the recyclable materials have been taken out of the flow by the garbage collectors. The black plastic bag on the cart that is shown in Figure 19 is used for this purpose. Second, a few recyclables that have relatively high value (bottles, metal, books and so on) can be found in the sunken garbage tank, which is a hole in the ground that temporarily stores waste that was collected by garbage collectors (see Figure 20). According to the definition of “Transfer Stations” from EPA, the waste transfer station only works as an assembly point for trash collection. There are no requirements for waste transfer stations to sort or collect recyclables (U.S. Environmental Protection Agency, 2015). Based on this information, both in China and the United States, the functionalities of the waste transfer station do not include sorting for recycling. In China, during or after dumping in the waste transfer station, the staff will sometimes sort the recyclables.



Figure 19 Dumping trash in waste transfer station in Hunan University



Figure 20 Trash pool in waste transfer station in Hunan University

3.4. Processing

Two types of waste processing facilities - MRFs (materials recovery facilities) and MWPFs (mixed waste processing facilities) - can be found in Changsha. East Lansing currently only has one MRF facility. The MWPF for Changsha is located in Hongshanqiao. The facility constructed the first sorting line in Hunan Province in 2010. However, the sorting line stopped working after 18 months of operation, which caused the municipal waste to be transferred directly to the landfill without any recycling in the facility (Pu, 2013). Concentrated complaints from the residents about the bad smell released from the facility were reported by the local media (Hunan Daily, 2014). It was also reported that the company that was responsible for running this line complained that the unexpectedly low profits generated by this sorting line forced them to shut it down. The company had nearly a hundred and sixty thousand dollars loss per month for running this line (Pu, 2013).

Most of the MRFs in Changsha are run by private and informal parties. Although the number of such facilities was reduced in urban areas in recent years due to the price drop of recyclables and local governments efforts to shut down such facilities to prevent pollution and protect public safety (some facilities blocked the street and stored tons of flammable or toxic materials), it is believed that those informal privately owned MRFs chose to relocate in fringe areas (Meihekou yangshengzixunwang, 2015).

3.5. Discussion

“The 12th Five-Year Plan Outline” was released by China’s Ministry of Science and Technology, National Development and Reform Commission, and five other ministries and commissions jointly (China Briefing, 2012) in 2010 as a short term national plan for next five

years (2011-2015). Section two of the twenty third chapter of this document listed some general ideas about how to construct the recycling system in China. According to the document, “reduce” is the most important consideration among “reduce”, “reuse” and “recycle”. The plan also aimed at constructing a resource recycling system that will cover the whole society. The plan calls for the development of recyclables collection centers, transfer centers and sorting centers, and markets. Those four things will be the key points in the recycling system (National People's Congress, 2010).

China has been adopting new technologies for waste management in recent years. In 2001, facing huge municipal waste management demands, a lot of companies with more advanced technology and capital, used the BOT (Build-operate-transfer) mode to import new recycling technologies. Private companies often sign a contract with local governments for constructing new recycling facilities, maintaining the facilities and handling the operation for a certain period. After that, the local government will take over the facilities that were constructed by the private company (Wikipedia, 2015). This mode makes advanced technologies and facilities, especially incineration, become an economic choice available for local governments.

Most of the time, the garbage bin is the most common way for collecting trash. Figure 21 and Figure 22 show the typical trash containers in both Michigan State University and Hunan University.



Figure 21 Garbage collecting container in Michigan State University



Figure 22 Garbage collecting container in Hunan University

Hunan University still uses the two-color garbage containers (see Figure 22). The green bins are for collecting recyclable materials and the yellow bins are used to collect non-recyclable materials. At Michigan State University, the trash bin used to collect recyclables is often

separated into 4 categories: 1. Plastic and metal; 2. Mixed Paper and box board; 3. Office paper; 4. Landfill trash. The garbage container system in Michigan State University is much more complicated and contains much more detailed information and instructions to guide people how to separate the trash in their hand that will go into the recycling system. Every container (except ones for landfill trash collection) that is designed to collect recyclables has a label for instructions with items that can be thrown into the container (see Figure 14).

Like many other countries in the world, China has tried many different technologies to raise the efficacy and effectiveness of collecting recyclables.

In the 1980's, people in the United States started to carefully look at their plastic recycling system. This situation happened partly because a relatively mature recycling system for "old" packaging materials - paper, glass and metal (aluminum) was already established (Curlee, 1986).

4. Economy

Although both China and the United States emphasize the importance of recycling, economic factors still play one of the decisive roles in the development of recycling. It is almost certain that the countries with better economies will have more advanced recycling systems. Currently, developed countries in Europe, Japan, the United States and Canada, etc. are in the first class on recycling on a global scope. Those countries have more advanced recycling technologies, relatively mature recycling systems and long recycling experiences to learn from for developing countries like China. Also, cost effectiveness can be considered as one of the most important factors for promoting new and more advanced recycling systems. It is often the case that the high cost of introducing new recycling technologies and systems drives local governments away from improving the current system in China. Also, on an individual level, gaining income from recycling (residents and garbage collectors from China) and reducing cost from recycling (residents and business from the United States) are always big incentives for promoting waste recycling and raising the recycling rate. The following section will analyze how economic factors affect the recycling system functioning in both Hunan University and Michigan State University.

4.1. Cost

4.1.1. Government

The total cost of MSW services can be separated into two parts: disposal and recycling (Bohm et al., 2010). Most of the communities in Changsha have their own garbage collectors to collect and send the garbage to a nearby waste transfer center. Staff from the local government will then transport the waste to the general waste transfer center and the waste will be processed for recycling or disposed later.

4.1.1.1. Waste Collector Wage

In 2013, the average annual salary of a garbage collector was \$ 32,730 in the United States (US News Money & World Report, 2015) and the annual average salary of a janitor was \$25,140 in the United States (U.S. News & World Report Money, 2015). Compared to that, the annual salary for garbage collectors in Changsha is from \$2,288 to \$3,428 (China Youth Daily, 2014). The salary of a garbage collector in the United States is over 10 times that in China. Garbage collectors in the United States also receive formal training before they take the positions. The average salary in the United States is \$44,888.16 (Social Security, 2015). The average salary of garbage collectors in the United States is almost 73% of the overall salary level. In China, the average salary in 2013 was \$8,302 (ChinaIRN.com, 2014). The average salary of garbage collectors in China is 43.4% of the average level. The comparison shows that the garbage collectors in China do not have as strong financial support from their salary as their colleagues in the United States. 18% or even more of their annual income comes from selling the recyclable materials that they collected from the municipal waste stream (CNTV News Network, 2013). It is really hard for these people to give up the benefits gaining from collecting recyclables by themselves. Figure 23 shows the salary comparison of garbage collectors in both countries based on the above information.

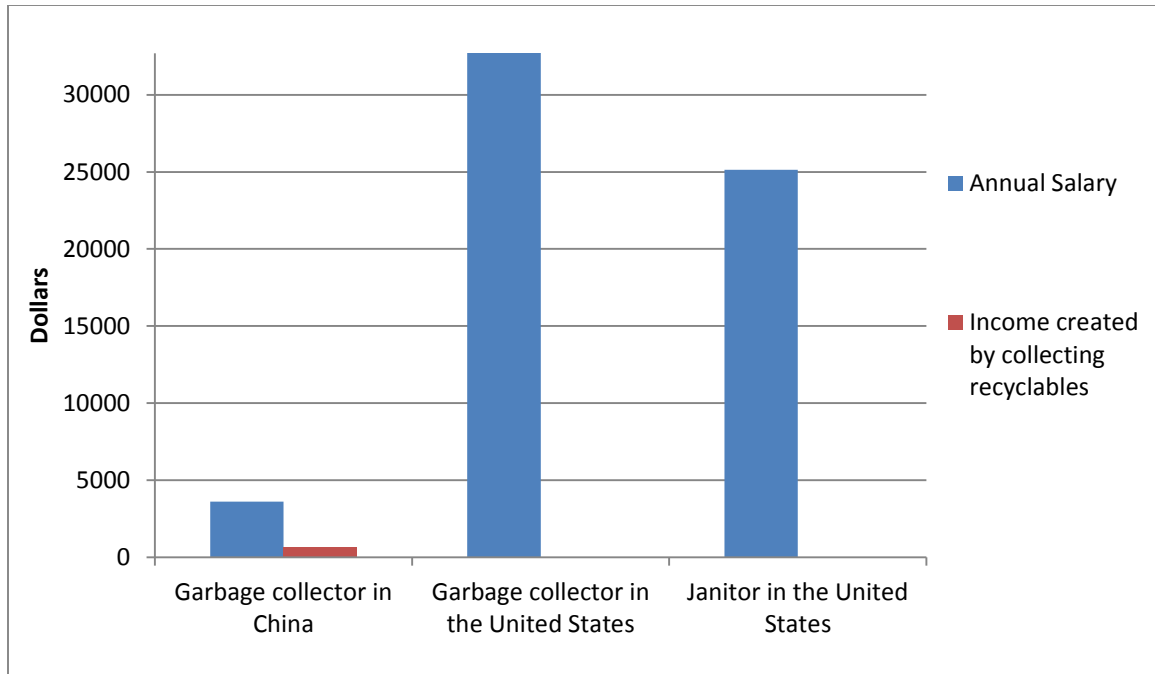


Figure 23 Salary comparison of garbage collectors and janitors in China (China Youth Daily, 2014) & the United States (US News Money & World Report, 2015)

4.1.1.2. Residents costs

Due to the high level of diversity in demographics and geography, China has a lot of different waste fee charging systems in cities. One of the waste fee charging models is there are certain staff in every community to collect a fixed waste fee from each household and residents can go to the local sanitary department to pay the fee. For example, in 2012, Guangzhou raised its previous waste fee from 5 yuan, which is \$0.79 per household per month, to 15 yuan, which is \$2.38 per household per month. But it is reported that only 20% of the waste fee can be collected by the government using this method (Liang & Cheng, 2015). Currently, lots of cities in China have adopted a new garbage disposal fee charging system. Although those systems have different rules, all of them tie the submission of the waste fee with the submission of payment for water. In general, the waste fee is either charged based on the amount of water that residents use or

collected by the water supplier as a fixed amount (for example, Nanping charges every individual household 15 yuan per month, which is \$2.38 per month as a waste fee regardless of how much water the household uses) (China Huanwei Technology, 2012). Changsha also began to implement this system in 2010. Residents in the city were charged the waste fee by the amount of water they used. For every ton of water use, the residents will be charged 0.3 yuan, which is \$0.048 (Liu, 2011). Since the water fee collection system is relative stable and mature in China, the waste fee now becomes an obligatory charge for the local residents. The rate of submission of the waste fee before using this new system in China was between 30%-70%, and the administrative cost for collecting the waste fee is 20%-50% of the total fee collected (Guo & Chen, 2005). After adopting this water consumption coefficient method, local governments saw a big increase in the waste fee collection and decrease in the administrative cost of managing and collecting it. In Shenzhen, for example, the rate of waste fee submission has reached 97% with administration cost amounting to only 1% of the total fee collected (China Huanwei Technology, 2012). The waste fee is used for collecting, transport, recycling and disposal.

The average consumption of water per household in Changsha is around 15 m³ per month (News 938, 2014). Based on that, the trash management fee on average is 0.3 yuan/m³*15 m³=4.5 yuan. Thus the annual trash management fee will be 4.5 yuan/month*12 months=54 yuan, which is \$8.70. This policy went into effect in Changsha in 2012.

In the United States, the residents in East Lansing also pay the local government for dealing with their garbage. Usually, for a typical household, a recycling bin will be purchased to contain recyclables and a 64-gallon easy cart will be used to contain garbage that will end up in the landfill. The bins are used for curbside recycling while carts are used for garbage collection.

Following is the list of costs for “Bins, Bags and Sticker Purchases” (City of East Lansing, 2015) of East Lansing recycling.

Table 2 Bins, Bags and Sticker Purchases in East Lansing (City of East Lansing, 2015)

What	Cost
Recycling Bin	\$7
Easy Carts	\$55(+0 annual fee) for 32-gallon cart \$70(+0 annual fee) for 64-gallon cart \$79(+75 annual fee) for 96 gallon cart
Yellow Bags imprinted with City logo (refuse)	\$7.50 for a roll of 5 bags
City-issued Paper Yard Waste Bag imprinted with City logo (collection cost included)	\$1.50
Yard Waste Sticker for Non-City Paper Bags and Rigid Plastic Containers	\$1.50
Bulk Item Special Pickup Sticker	\$15
Hazardous Waste Sticker	\$40 (for items containing Freon)
Generic Bags	\$10.50 per roll of 50 bags

So for a typical household in East Lansing, the average cost of garbage disposal can be calculated as the sum of \$7 for 1 recycling bin and \$70 for 1 64 gallon cart. These two fees are not renewed until the old trash containers are replaced with new ones. The average life time for both containers can be estimated as 10 years. Yard waste can be disposed for free on the first two Mondays in spring and fall (e.g. May 4 and May 18, 2015) (City of East Lansing, 2015). Most of the residents tend to dispose of their yard waste on those “No-Fee Curbside Yard Waste Collection” days. So the estimated average cost per household in East Lansing is

$(\$7+\$70)/10=\$7.70$. In addition to that, some payment for waste management is included in the taxes paid to the city government.

In the fall of 2015, East Lansing will start a new recycling plan. The current recycling bins (cost \$7) will be replaced by new 96-gallon carts for free. The new containers will be able to recycle corrugated board, which previously needed to be dropped off by residents for recycling. Moreover, the routine pick up will be scheduled twice a month instead of once per week (Parker, 2015).

From the comparison we can estimate that the “visible” cost of garbage collection for residents in Changsha is a dollar higher than that of the residents in East Lansing. There is no big difference between the two cities. However, the “invisible” part, for example the taxes, is really hard to estimate. Moreover, only a certain percentage of the total amount of the trash fee will be paid for recycling, which also adds difficulty in accurately reporting how much a household paid for their recycling activity.

4.2. Markets and Revenue

As mentioned before, Michigan State University has a special step which Hunan University does not have - the Surplus Store, which actually affects a lot how the recycling system will function. According to the interview with Mr. David Smith from the Michigan State University Recycling Center, the recycling center of Michigan State University created gross sales of \$3 million in 2013 with \$2 million of the sales returned to the departments on campus. The Surplus Store operated by Michigan State University had net annual revenue of \$1.2 million in 2013 with gross revenue of \$3 million dollars. The business that the Surplus Store is doing is reuse rather than recycle, which means it sells items that have already been used or are unused

but no longer needed by the previous owner. Michigan State University has combined this surplus store with their recycling business, which actually benefits each part.

Also, one big attribute of the United States recycling system is its international waste trade of recyclables, which is also one of the most important differences in the recycling process between China and the United States. China as a developing country that depends more on the power of exports to drag its economy forward, consumes a huge amount of waste from the United States and other countries to reproduce them into new products. China is the biggest market in this trade. From 2000 to 2011, the export of waste from the United States to China increased from \$740 million to \$11.5 billion. 11.1% of the imports in 2001 from the United States to China were waste. The trend is shown in Figure 24 (NetEase, 2012). The “Green Fence” is one of the triggers in recent years that caused a large amount of discussion in the recycling industry in the United States. This activity started from 2/1/2013 and lasted 10 months to 11/31/2013. The “Green Fence” was designed to restrict the contraband of forbidden and dangerous garbage from foreign countries and enforce the management of imported solid waste (General Administration of Customs of the P.R.C, 2013). Based on the fact that this trade existed for the past several decades, and the economic situation remains the same currently, the trend seems to not easily be reversed or changed in direction. Although international waste trade does not directly affect recycling systems at either Michigan State University or Hunan University, it affects the larger recycling environment that the two universities function within.

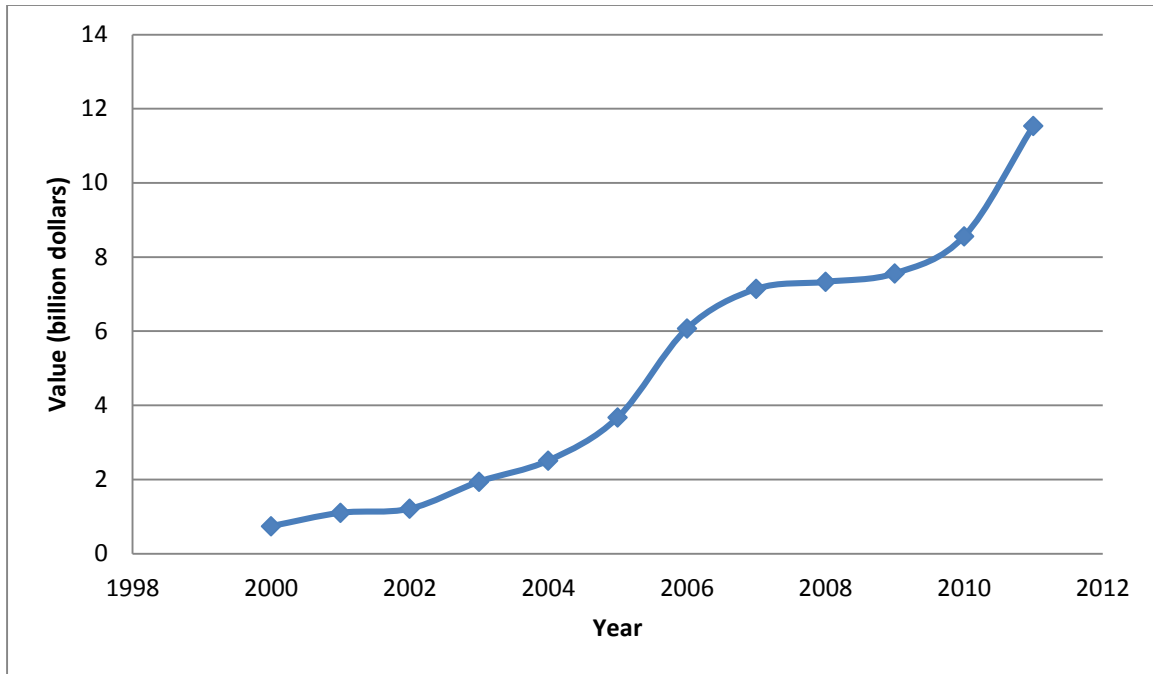


Figure 24 Exported value of waste from the United States to China from 2000 to 2011 (NetEase, 2012)

4.3. Discussion

The recycling center of Michigan State University is a MRF, which also creates benefits for the university. The economic system of the recycling process in Michigan State University and Hunan University can be shown in Figure 25 and Figure 26.

In the model of Michigan State University, the products that can be reused (for recycling from the university's departments, a good proportion is used products or equipment that can be sold again) are collected primarily from two sources: the university's departments and "residents" (university students, staff, and even some local residents). Departments provide more ready for resale products and equipment than residents. Based on the information provided by the recycling center, 80% of every sale over \$100 will be returned to the department which provides

the products or equipment. This part of selling reusable products is a very important source of income in supporting the operation of the recycling center.

In addition to that, the recycling center also collects recyclable materials that can be sold to brokers or some local recycling facilities.

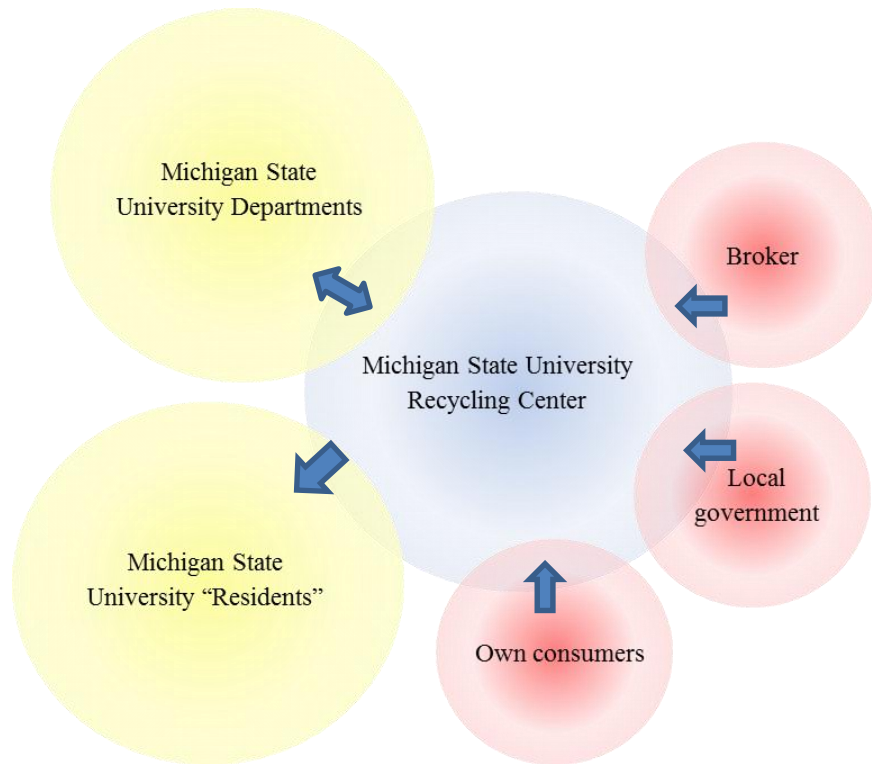


Figure 25 Cash flow model of the recycling system of Michigan State University

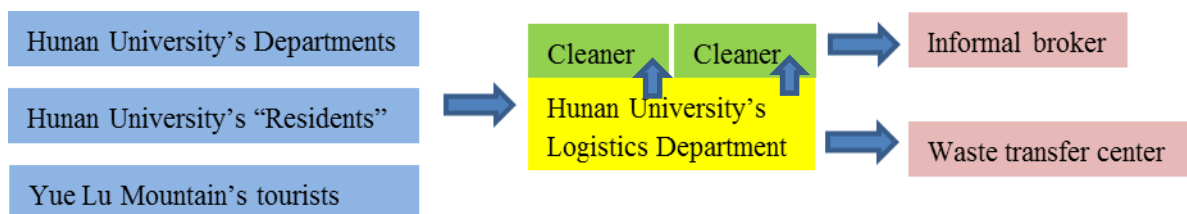


Figure 26 Cash flow model of the recycling process in Hunan University

In Hunan University, due to its specific location, the huge numbers of visiting tourists create an important source of recyclables. According to the interview with cleaners (Garbage

collector of Hunan University, 2015) in the university area, on holidays or weekends, their work load doubles from 4 carts a day to 8 carts a day. Their routine schedule is 2 hours/shift, 4 times a day for cleaning up approximately a 100 m² area.

Compared to Michigan State University, the profits created by recyclables in Hunan University are in a one way model. The recyclable materials are of low value (e.g. waste paper, bottles, some small furniture) and are turned into private income for the garbage collectors on campus. The profits never re-enter the recycling system on the Hunan University campus. The profits are shared by the garbage collectors on campus, the informal garbage collectors at this stage. For Michigan State University, part of the income from the recycling process goes back to the recycling system on campus. Both the departments and recycling facilities benefit from the recycling process. This circle in profits creates a relatively stable relationship between the university, which is the service provider, and the departments, which are the recyclables providers.

The profits flow model determines that the formal sorting facilities will be the major ones in the United States. But China, in contrast, will face great challenges from the informal garbage collectors. The formal facilities are not able to make profits from the recycling process. The informal garbage collectors or even the formal garbage collectors have already separated the profits from recyclables before they enter the formal recycling facility.

Creating a relative closed-circle structure will help strengthen the formal recycling process, which means keeping the profits created in waste processing flowing to the people or organizations who actually undertake the formal recycling process. In Hunan University's case, the organization that formally does recycling of the waste that is created in the university is designed to be the MWPF in Changsha. However, since most of the recyclable materials are

taken out of the waste flow by informal garbage collectors, the sorting line in the MWPF is not able to create enough social benefits and economic profits to function normally.

5. Culture

The curbside recycling programs in the U.S. grew rapidly from 1973 when it first started. In the past decade, the residents in the United States have gotten used to this recycling method. Especially for small cities with relative lower population density, this method is one of the major methods that people are using for recycling. The Chinese government, no matter whether central or local, emphasized 10 years ago that one of the major tasks in improving the recycling situation is to increase the awareness of residents to separate recyclables from non-recyclables when dumping their waste. However, it seems it has not quite been a successful process. In addition to the factors like legislation, technology and economy, recycling culture construction, which seems to be a lagging part in the whole process, will provide part of the explanation of the current situation.

5.1. Identity

Like other developing countries, informal waste workers play a very important role in recycling in China. However, actual data about this group is hard to get since the unclarified identity between the formal and informal recycling system is not well interpreted (Salhofer, 2014).

Scavengers have played an important role in the recycling process both in China and the United States. However, the number of individual scavengers in the United States dropped drastically in the 1970s. The big concern that scavengers would get hurt in their landfills drove the landfill owners to keep individual scavengers out of their landfills (Rathje & Murphy, 1992). In the United States, there are two types of people that usually collect wastes: janitors and garbage collectors. One of the janitor's jobs is to clean, dispose of trash, vacuum floors, and clean spills (Payscale, 2015). Garbage collector is another occupation. Garbage collectors in the

United States collect waste from residential and commercial locations that will then be transported to a landfill or incinerator. The garbage collectors usually need more professional training than janitors. They need to know how to operate a garbage truck and sometimes need to manually dump trash cans into the truck (Payscale, 2015). The people in China who directly deal with garbage and join the primary recycling process can be separated into three groups: scavengers, garbage collectors and janitors. Individual scavengers who significantly depend on collecting recyclables from landfill for their living almost disappeared in the 1980s in the United States. However, in China, the scavengers seem to be pushed out of the landfills mostly by the improvement of technologies and fierce competition between private companies that try to take ownership of landfills.

In China, however, it is often the case that those three identities may belong to one person. The interview (Garbage collector of Hunan University, 2015) on Hunan University campus can reveal part of the reason. Formal waste collectors working on the Hunan University campus will also help cleaning the campus, empty trash bins and sending waste to the waste transfer station. Moreover, most of them also act as informal individual scavengers who collecting recyclables to increase their income. Currently it is impossible to set a clear separation line between the “formal sector” and “informal sector” of recycling in China. The janitors and garbage collectors hired by the university and the local government can be considered as “formal” workers in the recycling system. However, at the same time, they also collect recyclables and sell them by themselves to increase their income. In most situations, this behavior is considered as an “informal” way of recycling. It is estimated that 0.56%-0.93% of the total population in China is involved in informal waste collection activities (Salhofer, 2014).

5.2. Awareness

One of the major factors that affects the efficiency of recycling in one country is the awareness of the importance of recycling by the public. But the recycling backgrounds for both countries are different. Plastic recycling is a good example to show this cultural difference. In 1975, 65% of interviewees, most of them professionals in the recycling area expressed that they were concerned that plastic materials would do the most harm to the environment of any other daily used materials (Curlee, 1986). That was about the time when plastic materials were starting to replace traditional packaging and construction materials (wood, metal, glass and paper) in people's daily lives. So the awareness and understanding of the recycling of this new material has developed from nothing to a relatively mature stage. Compared to that, the plastic industry in China started in 1921, which is almost 30 years later than that of the United States. The time for people to catch up with the rapidly developed plastic material trend is relatively limited, which may partially provide answers to the relatively simplified and incomplete control and awareness of the plastic recycling system. The situation in the plastic recycling industry is not the only case. Due to rapid economic growth, more and more new package materials appear in people's daily lives in China. While the parents' and grandparents' generations still remember they can trade turtle shells to state owned recycling facilities for money, the new generation has already been taught how to sort and recycle new packages and materials. It seems overwhelming for most of the older generations in China, who also did not have enough education when they were young. China is in a stage where most of the educated people are aware of the importance of recycling, but few have any idea of what to do to actively participate in the systematic recycling process. This phenomenon can be observed in the results of several surveys investigating the awareness of classified collection of garbage in China (Liu J. , 2014).

5.3. Information resources

Another question is how the current information resources help people in China to obtain further understanding of recycling. If the recycling education system in countries like Japan that have more detailed and strict requirements can be ranked as the top level, and the United States is in the middle, perhaps China can only be counted as an entry level country. One of the obvious clues is the information that a resident can get as their recycling instructions. Figure 27 shows a part of the recycling hand book for residents in Yokohama, Japan, which shows when, where, and how to dispose bottles or cans with very detailed instructions and images for explanation. For residents in East Lansing, the website of the “City of East Lansing” (see Figure 28) has detailed instructions and suggestions about how to do recycling in the area that are accessible to the public. For example, for the new curbside recycling program, the curbside recycling guide on the very first page lists 11 categories of recyclables. However, on the official website of Changsha (China Changsha, 2015), there is no information about how to do recycling for citizens to read.

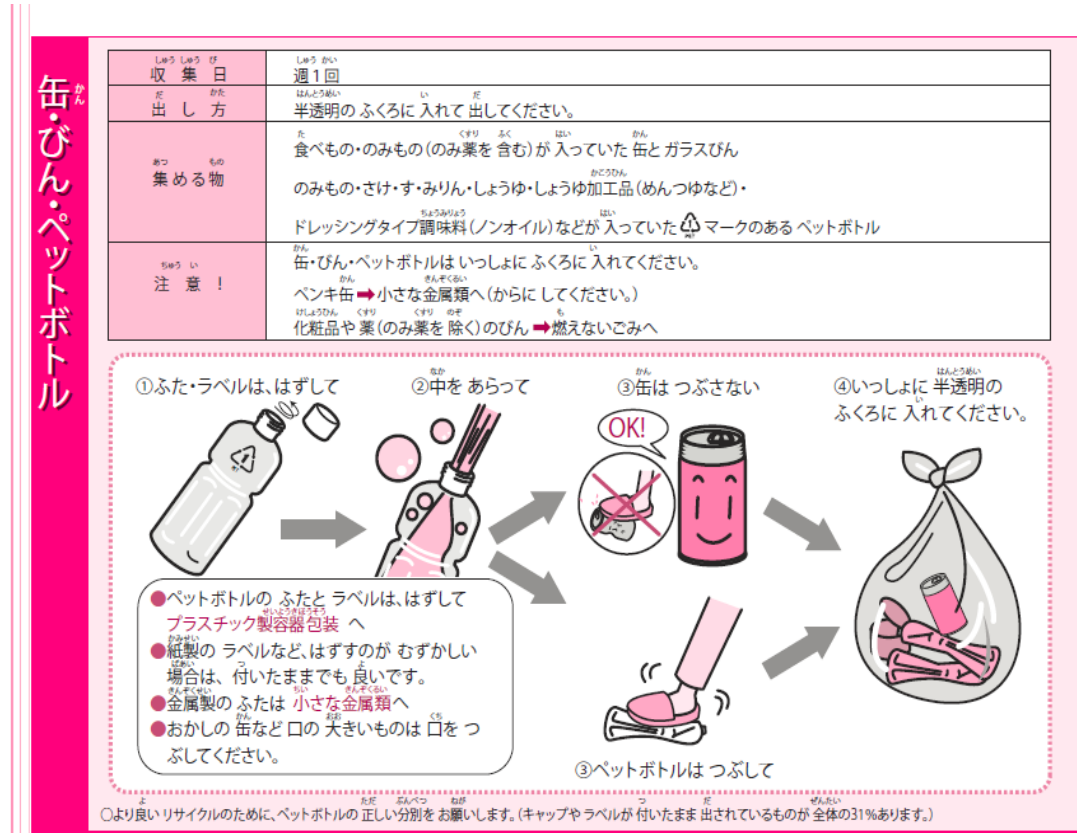


Figure 27 Part of recycling hand book for residents in Yokohama (City of Yokohama, 2015)



Figure 28 Recycling related webpage of the website "City of East Lansing" (City of East Lansing, 2015)

6. Discussion

On an overall view, the recycling system in China has a 20-30 year gap compared to that of the United States. And because there are so many differences between these two countries, simply copying the U.S. recycling mode will not actually help improve the recycling situation in China.

Thus, it is believed that the MRF mode in Michigan State University cannot be directly applied to Hunan University. On one hand, Hunan University does not have enough recycling support, which means that most of the Hunan University residents do not take recycling as seriously as students at Michigan State University. This is partially because of the lack of recycling education for the Hunan University residents, especially students. Although there are some small scale recycling promotion activities or programs in Hunan University, for example, a program named “Exchange Recyclables for Green Plants (see Figure 29)” in which students can trade the recyclables they have collected for green plants, the influence that those activities created is limited. On the other hand, the financial support from both local government and from Hunan University is not enough for establishing a complete MRF recycling system. For internal financial support, first, informal or some formal workers in the recycling system are sharing the profits created by collecting recyclables on campus. Also, the residents of Hunan University still have the tendency to sell items that are reusable or recyclable to private recyclable dealers. This part of the income is not enough to provide significant financial support to establish a complete MRF system on campus. Especially the recyclables sold by formal waste collectors, which is roughly \$16,000 per year ($\$48 \times 12 \times 28 = \$16,000$), only amounts to a very limited part of the total cost of construction of a new recycling system. However, giving up this part makes Hunan University lack the continuing financial support to maintain the system operation. The interview

with Mr. David Smith of the Michigan State University Recycling Center shows that it is still expected to use the accumulating profits created over a certain period of time to pay off the new recycling center facilities and buildings. So to make the MRF on campus a “sustainable” system that can live on its own, it still needs the university to appropriately take advantage and make profits from its own recyclable and reusable resources. For the government part, the general direction, like the 12th “Five-year Plan”, which is a general plan established by the Chinese government indicating the direction of development aims for next five years, shows that China is willing to construct more official MRFs for improving the recycling environment. But at the current stage in Changsha, the local government is more interested in new incineration facilities rather than a comprehensive MRF facility (An, 2009). This is likely partially because the shutdown of Changsha’s first automatic sorting line due to insufficient profits set up a “bad example” for choosing this method. The contracted companies that constructed the sorting line were also not willing to sacrifice their profits to operate and improve their current equipment. Furthermore, this “bad example” proves that the general recycling situation in Changsha is not suitable for constructing a relatively big and comprehensive MRF facility. Also, unlike the status of Michigan State University in East Lansing, which has over 50% of the city’s population, Hunan University accounts for only 5% of the total population in Changsha and 10% of the total population in the Yuelu District, where Yuelu Mountain is located. And it is located next to two other big university campuses in Changsha - Central South University and Hunan Normal University. Figure 30 provides a rough indication of the area of each university; the blue region is Hunan University, the red region is Central South University and the orange region is Hunan Normal University. It can be seen from the map that those three university’ locations are quite close. The other two universities have over 80,000 students and staff on campus, which occupies

nearly 20% of the population in Yuelu District. Considering the demographic and geographic influences, it will be better for the local government to choose a spot to build a comprehensive MRF system to serve the whole area, rather than merely supporting Hunan University for a regional on campus MRF facility.



Figure 29 The "Change recyclables for Green Plants" program in Hunan University (The Green Exchange Family of Hunan University, 2014)

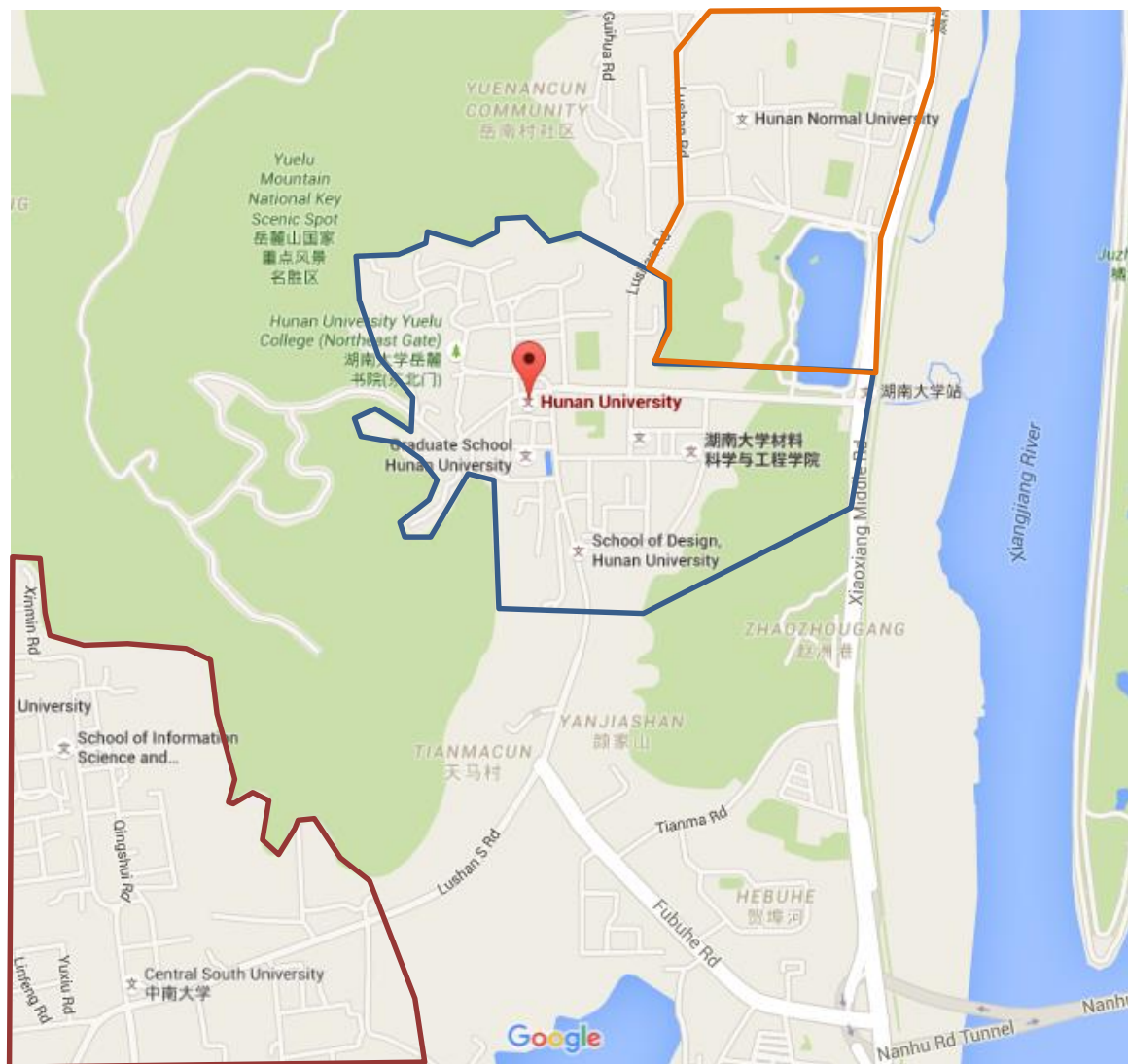


Figure 30 Map of the surrounding area of Hunan University (Google, 2015)

From a technology view, without a MRF facility, Hunan University plays a relatively passive role in the entire recycling chain (collecting, pre-sorting, transporting, sorting, disposal or processing). Unlike Michigan States University, which has a MRF facility on campus which can do collecting, presorting and transportation, Hunan University currently can only do very basic collecting and does not have an effective way to collect its recyclables. But will Hunan University have the possibility to construct its own comprehensive MRF facility in the future?

The answer will probably be “no” as well. On one hand, Hunan University does not have enough financial support or a systematic financial strategy to sustain a MRF facility and does not have demands for a better formal recycling system from its staff and students due to low recycling awareness at the current stage. Rather, local government will still keep its leadership role in dealing with recycling. Hunan University perhaps does not have the willingness to construct a MRF system on campus based on the current situation. Also, Hunan University does not have the same strong influence on the local government as Michigan State University has in East Lansing. The local government perhaps will more intend to establish a regional big MRF or run several small MRFs on its own rather than letting Hunan University establish a MRF by itself.

It is certain that both China and the United States are still working on improving their recycling systems. For China, since the needs for increasing recycling are growing so fast, improvements and new ideas can be found in different directions simultaneously. For example, the government of Changsha is updating its recycling infrastructure by introducing a new sorting line and new garbage bins in communities and on streets. Also it is trying to set up “model communities” by educating the residents of the selected communities how to classify their waste. Regulations about collecting food waste are also established, etc. Table 3 is a list of some of the actions that Changsha took in recent years to improve its recycling system.

Table 3 Improving attempts for recycling system in Changsha

Actions	Result
Introducing new sorting line	Failed to function normally
Setting up modeling communities and introducing new four-color garbage bins in the community while educating residents how to use the garbage bins to classify daily waste	Failed, four-color garbage bins have been replaced by previous two-color garbage bins again
Food waste collection	Signed contract with large and medium restaurants and is able to deal with 50% of the commercial food waste

It can be told that the actions that local governments take have different effects on residents. For residents in Changsha, the changes that were made in the recycling system by local governments exert little effect in motivating them to understand and perform well in the recycling process, which does not necessarily mean that the actions taken by the government are restricted to only the macro scale, like constructing new MRFs for the city or introducing new sorting lines. Some “micro scale” actions, like setting up garbage bins with recycling functions and promoting recycling education in certain communities also did not reach the desired results. However, the food waste recycling project seems to be the most successful one among all the actions that Changsha took in the past years to improve the recycling process. Actually, this project is the only one among the above listed actions that has positive supports in all four categories: legislation, economy, technology and cultural. On the legislation part, local government announced the food waste recycling regulations. And then, the local governments

obtained technology support from Re He to provide the needed equipment and technologies. From the economy point, Re He (although it said that the margin is thin, the company actually grew with this project based on scale and experiences), the local government and residents are all benefitting from this project. On the cultural side, the increasing concerns of the local residents about fake oil that was informally refined from the food waste also helped the project to move forward smoothly.

Although China can learn from the United State on all four aspects, it is still not appropriate to simply copy the recycling mode in the United States, neither on the national level nor the state level, and apply that to China. In summary, China's recycling system has four characteristics in the above four areas. The recycling legislation system is immature and unstable, which means both the federal government and local governments are working on enriching legislation, regulations, rules and standards to better manage the previous relatively simple recycling system. But due to the change of the broader environment and involvement of recycling companies, the current recycling legislation system in China will still experience some major changes in the next decades. On the technology part, China is more active on this part than other parts. Although Hunan University does not have the most advanced recycling technologies and systems, new waste transportation trucks (although they cannot separate recyclables from non-recyclables) and construction of a new waste transfer station that replaced the previous normal truck and open dumping station, shows that China has and will continue to take actions to improve its recycling system from the basic level. The financial mode in the recycling area still keeps the previous mode of sharing little of the benefits to informal garbage collectors for certain levels of recycling performance, but will change to a more organized and sustainable mode also because of the joining of formal recycling companies. Constructing a higher level of recycling

culture is what the Chinese government advertises to the public, but definitely the performance of the activities in the past decade is not satisfactory. Although China has to face a swiftly changing world of new materials and packaging components for recycling, it is still good to learn from the United States on constructing a positive and much more detailed recycling education system to increase the public's awareness and actions in participating in recycling.

It is recommended that Hunan University can first learn from Michigan State University to construct a more informed recycling knowledge platform, both online and offline for its residents to actually learn about what, when, how and where to help recycling on campus. Also, with the possible opening of the recycling market in the future, Hunan University also can connect with its neighbor universities and communities for forming a larger regional force to negotiate improving its recycling system and services with recycling companies.

REFERENCES

REFERENCES

- An, Z. 安. (2009, 12 15). The pneumatic waste collection system stopped working. The 100 million investment on the system is in vain(广州真空垃圾收集系统停用, 1 亿元造价成摆设). Retrieved 6 7, 2015, from NetEase: <http://news.163.com/09/1215/11/5QIQ4HEO000125LI.html>
- Baidu Map. (2015). *Baidu Map*. Retrieved 11 9, 2015, from Baidu Map: http://map.baidu.com/#panoid=0503180000140906035442853SL&panotype=street&heading=150.95&pitch=-20&l=17&tn=B_NORMAL_MAP&sc=0&newmap=1&shareurl=1&pid=0503180000140906035442853SL&psp=%7B%22PanoModule%22%3A%7B%22markerUid%22%3A%22600241c5a9a16bf845e274e7%22%7D%7D
- Berenyi, E. B. (2001, January). State of MRFs:2001. *Resource Recycling*, pp. 16-18.
- Bottle Bill Resource Guide. (2015). *Bottle Bills in the United States*. Retrieved 11 8, 2015, from Bottle Bill Resource Guide: <http://www.bottlebill.org/legislation/usa.htm>
- Bottle Bill Resource Guide. (2015). *What is a bottle bill?* Retrieved 6 1, 2015, from Bottle Bill Resource Guide: <http://www.bottlebill.org/about/whatis.htm>
- Changsha Environment Protection Agency. (2015, 6 9). *2014 Changsha Solid Waste Management Report* 长沙市 2014 固体废物污染环境防治信息公告. Retrieved 11 6, 2015, from Changsha Environment Protection Agency 长沙市环境保护局: http://hbj.changsha.gov.cn/wjgl/wrhz/201506/t20150609_761484.htm
- Chen, X., Geng, Y., & Fujita, T. (2009, 11 20). An overview of municipal solid waste management in China. *Waste Management*, pp. 716-724.
- China Briefing. (2012, 6 25). *China Releases 12th Five-Year Plan for Waste Recycling Technology - See more at:* <http://www.china-briefing.com/news/2012/06/25/china-releases-12th-five-year-plan-for-waste-recycling-technology.html#sthash.DmDxMIG5.dpuf>. Retrieved 6 8, 2015, from China Briefing: <http://www.china-briefing.com/news/2012/06/25/china-releases-12th-five-year-plan-for-waste-recycling-technology.html>
- China Changsha. (2015). *The important information for public of City of Changsha* 长沙市政府重点信息公开专栏. Retrieved 6 12, 2015, from China Changsha 中国长沙: http://www.changsha.gov.cn/xxgk/zdxxgkml/hjbh_24272/shjzl/

- China Huanwei Technology. (2012, 3 31). *各大城市成功案例 生活垃圾处理费换算系数法 The successful example of applying the water consumption method*. Retrieved 11 1, 2015, from 环卫科技网 China Huanwei Technology: <http://www.cn-hw.net/html/baike/201203/32800.html>
- China Waste. (2015). *90% of the residents in Dacheng Lane community sort recycles conscientiously for 14 years*. Retrieved 5 31, 2015, from China Waste: <http://www.zgfp.com/news/View/23/53301.htm>
- China Youth Daily, 中. (2014, 3 28). *环卫临时工现状: 每天清扫十多个小时 月薪千元 The current situation of garbage collectors:work more than ten hours with salary less than a thousand yuan*. Retrieved 11 2, 2015, from 新华网 Xinhuan News: http://news.xinhuanet.com/local/2014-03/28/c_126327582.html
- ChinaIRN.com. (2014, 5 28). *National Bureau of Statistics of China: the average salary of China in 2013*. Retrieved 6 8, 2015, from ChinaIRN.com: <http://www.chinairn.com/news/20140528/092426898.shtml>
- City of Changsha. (2011, 1 11). *Changsha Food Waste Management Regulations*. Retrieved 6 4, 2015, from China, Changsha: http://www.changsha.gov.cn/xxgk/szfxgkml/zfwj/zfl/201103/t20110317_5249.html?yundunkey=1da9d23511d215e1c0864a10e712355c61433463799_7871030
- City of East Lansing. (2015). Retrieved 5 13, 2015, from Recycling Guide: <https://www.cityofeastlansing.com/284/Recycling-Guide>
- City of East Lansing. (2015). *Bins, Bags and Sticker Purchases*. Retrieved 5 7, 2015, from City of East Lansing: <https://www.cityofeastlansing.com/279/Bins-Bags-Sticker-Purchases>
- City of East Lansing. (2015). *Yard waste, Recycling & Refuse*. Retrieved 11 22, 2015, from City of East Lansing: <https://www.cityofeastlansing.com/278/Yard-Waste-Recycling-Refuse>
- City of Yokohama. (2015, 4). *Method of sortation and disposal of waste*. Retrieved 12 13, 2015, from City of Yokohama: <http://www.cit y.yokohama.jp/me/pcbc>
- CNTV News Network. (2013, 1 25). *Garbage collectors work inside and outside of the system, 体制内外的环卫工*. Retrieved 11 22, 2015, from CNTV News Network: <http://news.cntv.cn/dujia/coverstory/tizhineijiu ye/index.shtml>
- Curlee, T. R. (1986). *The economic Feasibility of Recycling-a case study of plastic wastes*.
- Dokoupil, T. (2015, 9 22). *New York City foam ban overturned*. Retrieved 11 8, 2015, from MSNBC: <http://www.msnbc.com/new-york-city-foam-ban-overturned>

- Eckart, D. E. (1990, 6 28). *H.R.5197 - Recycling Promotion Tax Incentive Act of 1990*. Retrieved 6 5, 2015, from Congress.Gov: <https://www.congress.gov/bill/101st-congress/house-bill/5197/all-actions>
- Environmental Management of Solid Waste in China. (2011, 5 18). *Environmental Management Center of Solid Waste*. Retrieved 12 12, 2015, from Environmental Management of Solid Waste in China: <http://ncswm.mep.gov.cn/wwwroot/gfmh/jgj/hjbhbgf/wglzx/249394.shtml>
- Environmental Management of Solid Waste in China. (2015). *Environmental Management of Solid Waste in China*. Retrieved 6 4, 2015, from Environmental Management of Solid Waste in China: <http://ncswm.mep.gov.cn/wwwroot/gfmh/index.shtml>
- EPA. (2015, 6). *Advancing Sustainable Materials Management:2013 Fact Sheet*. Retrieved 10 25, 2015, from EPA: http://www2.epa.gov/sites/production/files/2015-09/documents/2013_advncng_smm_fs.pdf
- Feldman, E., & Wolf, N. (1984). *Plastic-American's Pacakging Dilemma*. Washington, D.C.: Island Press.
- Franklin Associates, Ltd. (1986). *Characterization of Municipal Solid Waste in The United States 1960 to 2000*. Prairie Village, Kansas.
- Fu, Y. (2015). *Garbage sorting problems cannot be solved by just setting sorting garbage bin*. Retrieved 5 31, 2015, from China teenager: http://zqb.cyol.com/content/2009-06/03/content_2692331.htm
- Garbage collector of Hunan University. (2015, 1 8). Interview about how the recycling system works in Hunan University. (L. Kang, Interviewer)
- General Administration of Customs of the P.R.C. (2013, 5 24). *What is "Green Fence"?* 海关总署解读“绿篱”专项行动. Retrieved 6 11, 2015, from General Administration of Customs of the People's Republic of China: <http://www3.customs.gov.cn/tabid/50104/Default.aspx>
- Google. (2015). *Google Map*. Retrieved 11 3, 2015, from Google: <https://www.google.com/maps/place/Hunan+University/@28.175828,112.935828,15z/data=!4m2!3m1!1s0x0000000000000000:0x28cc5b7f70a8f9aa>
- Guo, P., & Chen, H. 陈. (2005, 10). Study on Levy Domestic Waste fee Adopting Water Consumption Coefficient Method 采用水消费系数法收缴生活垃圾处理费的研究. *Environmental Sanitation Engineering 环境卫生工程*, pp. 28-30.
- Hao Jin. (2010, 8 25). *News Center-The history and current situation of the recycling market in Beijing* 新闻中心-北京再生资源回收市场历史与现状. Retrieved 10 24, 2015, from Hao Jin 濠锦: <http://www.lunnex.com/news.asp?id=888>

- Hunan Daily. (2014, 6 24). *Changsha's method of dealing with food waste worth promoting* 餐厨垃圾处理“长沙模式”值得推广. Retrieved 5 12, 2015, from Development and reform commission of Hunan Province: <http://www.hnfgw.gov.cn/gmjj/zyhj/51934.html>
- Hunan Daily. (2014, 8 5). *The bad smell still haunt around the First Waste Transfer Station of Changsha* 长沙第一垃圾中转处理厂臭气依旧. Retrieved 6 7, 2015, from Hunan Daily: http://hnrbc.voc.com.cn/hnrbc_epaper/html/2014-08/05/content_863302.htm?div=-1
- Hunan Daily, 湖. (2014, 8 5). *The bad smell still haunt around the First Waste Transfer Station of Changsha* 长沙第一垃圾中转处理厂臭气依旧. Retrieved 6 7, 2015, from Hunan Daily 湖南日报 : http://hnrbc.voc.com.cn/hnrbc_epaper/html/2014-08/05/content_863302.htm?div=-1
- Hunan University . (2014, 12). *Introduction*. Retrieved 6 12, 2015, from Hunan University 湖南大学: <http://www.hnu.edu.cn/html/hudagaikuang/xuexiaojianjie/>
- Hunan University. (2015). *Hunan University*. Retrieved 5 11, 2015, from Hunan University: <http://www.hnu.edu.cn/>
- Lai, W., Li, J., Qiu, W., Lu, Y., Chen, S., & Su, W. (2009, 12 02). *The garbage collecting system is not functioning due to not decide charging* 广东投入过亿垃圾系统难运行被指因收费未定. Retrieved 11 1, 2015, from Sina, Guangdong: <http://gd.news.sina.com.cn/news/2009/12/02/741505.html>
- Liang, Y., & Cheng, G. 梁. (2015, 4 14). *垃圾费随水费征收, 你同意?* *Do you agree to tie the garbage fee with water fee?* Retrieved 11 1, 2015, from 羊城晚报 Yangchen Evening News: <http://news.163.com/15/0414/14/AN5VVQC600014AED.html>
- Liu, J. (2014, 9 3). *China's struggle in promoting recycling for fourteen years* 中国垃圾分类坎坷之路 ——十四年垃圾分类: 风雨中前行. Retrieved 11 23, 2015, from China Environmental Sanitation Network 中国环卫网 : <http://www.cnues.com/zixun/33101.html>
- Liu, L. (2011, 11 24). *The garbage fee collection based on water consumption was approved* 长沙垃圾处理费捆绑水费征收获得批准. Retrieved 6 10, 2015, from Chian Environmental Sanitation Technology: <http://www.cn-hw.net/html/china/201111/30870.html>
- Ma, X. (2015). *History of sorting garbage*. Retrieved 5 31, 2015, from China Police: <http://news.cpd.com.cn/n19016/n47141/c21158953/content.html>
- Meihekou yangshengzixunwang. (2015, 10 20). *Why the recycling of electronics not goes smoothly?* 电子垃圾回收之路堵在哪儿? . Retrieved 11 1, 2015, from Yang Sheng Wang 养生网: <http://www.ysphr.com/etysz/2330.html>

- Michigan State University. (2015). *Mision and History*. Retrieved 10 26, 2015, from Michigan State University-Recycling: <http://www.recycle.msu.edu/index.php/about/history-mission/>
- Michigan State University. (2015). *MSU Facts*. Retrieved 6 12, 2015, from Michigan State University: <https://msu.edu/about/thisismsu/facts.html>
- Michinga State University. (2015). *Building Data Summary*. Retrieved 5 21, 2015, from MICHIGAN STATE UNIVERSITY-PHYSICAL PLANT DIVISION: <http://www.eas.msu.edu/fit/reports/buildingdatasummary.cfr>
- Ministry of Housing and Urban-Rural Development of People's Republic of China. (2015). *Ministry of Housing and Urban-Rural Development of People's Republic of China*. Retrieved 5 8, 2015, from Ministry of Housing and Urban-Rural Development of People's Republic of China: <http://www.mohurd.gov.cn/>
- National People's Congress. (2010). *National "12th Five-Year Plan" Outline*.
- NetEase. (2012, 12 18). *The waste imported in China is four times of the amount ten years ago* . Retrieved 6 11, 2015, from NetEase: <http://data.163.com/12/1218/17/8J1BIEUS00014MTN.html>
- News 938. (2014, 1 8). *The resident's consumption of waste reduced by 20% in Changsha* . Retrieved 12 14, 2015, from Hunan Radio: <http://news.hnradio.com/f/2014/20141/20141894358293.html>
- Organization Structure* . (2011, 6 27). Retrieved 5 23, 2015, from Environmental Development Centre of Ministry of Environmental Protection: <http://www.china-epc.cn/jgsz/20.html>
- Pan, E. (2012, 8). Solution for Shenzhen Garbage Sorting. *Journal of Green Science and Technology*, pp. 173-174.
- Parker, D. (2015, 5 28). *Bins out, carts in for East Lansing recycling program*. Retrieved 6 4, 2015, from Lansing State Journal : <http://www.lansingstatejournal.com/story/news/local/2015/05/28/twice-monthly-recycling-east-lansing/28068297/>
- Payscale. (2015). *Janitor Salary (United States)*. Retrieved 6 11, 2015, from Payscale: http://www.payscale.com/research/US/Job=Janitor/Hourly_Rate
- Payscale. (2015). *Garbage man salary (United States)*. Retrieved 6 11, 2015, from Payscale: http://www.payscale.com/research/US/Job=Garbage_Man/Hourly_Rate

- Pu, J. (2013, 8 14). *Citizens do not have passion for sorting garbage and the sorting line stopped working for a long time*. Retrieved 6 6, 2015, from China News: http://www.cn-hw.net/html/china/201308/41666_2.html
- Pu, J. (2013, 8 14). *Why the first sorting line stopped working? 首条垃圾分拣线为何长期停工 ?*. Retrieved 6 7, 2015, from CHANGSHA WANBAO 长沙晚报 : http://cswb.changsha.cn/html/2013-08/14/content_5_1.html
- Rathje, W., & Murphy, C. (1992). *Rubbish!:the archaeology of garbage*. New York: HarperCollinsPublibers.
- Robert A.Bohm, D. H. (2010, 1 12). The costs of municipal waste and recycling programs. pp. 864-871.
- Salhofer, R. L. (2014). Municipal solid waste recycling and the significance of informal sector in urban China. *Waste Management & Research*, 896-906.
- Social Scurity. (2015). *National average wage index*. Retrieved 6 8, 2015, from Social Scurity: <http://www.ssa.gov/oact/cola/AWI.html>
- The Green Exchange Family of Hunan University, 湖. (2014, 3 24). *The Green Exchange Family of Hunan University 湖南大学绿色兑换之家*. Retrieved 11 1, 2015, from The Green Exchange Family of Hunan University 湖南大学绿色兑换之家 : <http://zhan.renren.com/wangshangduihuan?tagId=19717&from=template&checked=true>
- The Library of Congress Thomas. (2015). *Bill Summary & Status Search Results*. Retrieved 6 2, 2015, from The Library of Congress Thomas: <http://thomas.loc.gov/cgi-bin/bdquery/?&Db=d101&querybd=@FIELD%28FLD001+@4%28Recycling+of+waste+products%29%29>
- The library of the Congress*. (2015). Retrieved 5 13, 2015, from Bill summary and Status Search Results: <http://thomas.loc.gov/cgi-bin/bdquery/?&Db=d101&querybd=@FIELD%28FLD001+@4%28Recycling+of+waste+products%29%29>
- U.S. Environmental Protection Agency. (2015). *Transfer Stations*. Retrieved 6 7, 2015, from U.S. Environmental Protection Agency: <http://www.epa.gov/solidwaste/nonhaz/municipal/transfer.html>
- U.S.News & World Report Money. (2015). *Janitor: Salary*. Retrieved 6 8, 2015, from U.S.News & World Report Money: <http://money.usnews.com/careers/best-jobs/janitor/salary>
- US News Money & World Report. (2015). *Garbage Collector*. Retrieved 6 8, 2015, from US News Money & World Report: <http://money.usnews.com/careers/best-jobs/garbage-collector>

- Wang, H. 王. (2013, 11 26). *Garbage collection increase our income* 捡垃圾增加了我们的收入. Retrieved 6 10, 2015, from Panyu Daily 番禺日报 : http://www.pyrb.cn/node_15/node_42/2013/11/26/138542429223838.shtml
- Wikipedia. (2015, 10 24). *Wikipedia, the free encyclopedia*. Retrieved 11 22, 2015, from Reverse vending machine: https://en.wikipedia.org/wiki/Reverse_vending_machine
- Wikipedia. (2015, 5 20). *Build-operate-transfer*. Retrieved 6 8, 2015, from Wikipedia: <http://en.wikipedia.org/wiki/Build%E2%80%93operate%E2%80%93transfer>
- Xinhua News. (2014, 9 13). *170,000 Garbage Collectors in Beijing Collect 4 Million Tons of Waste Each Year*. Retrieved 12 14, 2015, from CNR News: http://finance.cnr.cn/gundong/201409/t20140913_516430236.shtml
- Xinhua News, 新. (2015, 6 18). *Turns food waste to "treasure"* 餐厨垃圾变废为宝. Retrieved 11 7, 2015, from Xinhua News 新华网 : http://news.xinhuanet.com/photo/2015-06/18/c_127929242_2.htm
- Xudong Chen, Y. G. (2009, 11 20). An overview of municipal solid waste management in China. *Waste Management*, pp. 716-724.
- Yangcheng Evening News. (2015). *The sorting bins with misleading labels cause confusion in public*. Retrieved 6 3, 2015, from Yangcheng Evening News: http://www.ycwb.com/ePaper/ycwb/html/2012-11/07/content_1530643.htm
- Zhou, D. (2014, 6 3). *A master student who lives in Dao Xiangyuan community exchange the credits of garbage collecting for a 5 year usage of a new car* 家住稻香园社区的美院研究生小吴扔了一年垃圾换回一辆小汽车 5 年使用权. Retrieved 11 22, 2015, from Hangzhou Daily Press Group 杭州日报报业集团 : http://hzdaily.hangzhou.com.cn/dskb/html/2014-06/03/content_1737946.htm