

Research on the Applicability of Garbage Classification to Carbon Trading Market

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Abstract: Climate warming is one of the important environmental issues with global concern. The Bloomberg News has recorded temperature changes in the recent 135 years. As the hottest year, in 2014 the global surface temperature was as high as 1.39 degrees Fahrenheit, 0.68 degrees Celsius higher than the average in long-term. The severity of this issue has been proved with the refresh of the highest record^[1] and the increasing temperature as well as people's personal experience. There is a demand of in-depth discussion about comprehensive and efficient reduction of carbon and greenhouse gas emission and the development of low carbon economy, with garbage classification as the most efficient breach but also most easily to be neglected by people. This article attempts to find a feasible method of carbon emission reduction from the perspective of garbage classification and resource recycling and make quantitative estimation of its value combined with local practice and data in Chengdu.

Keywords: Climate Change; Garbage Classification; Carbon Trading

1. International Background of Carbon Trading

The Intergovernmental Panel on Climate Change (IPCC) has expected an average increase of 1.4°C–5.8°C^[2] globally from 1990 to 2100. However, there will be a series of threats to the environment when it rises up to 2°C, such as the rise of the sea level, disease infection, the survival and migration of plants and animals, etc. Therefore, countries all over the world are actively responding to the increasingly serious climate issue, and jointly seeking the effective ways for carbon emission reduction.

It is stipulated in the *Kyoto Protocol* signed in 1997 that the provisions will take effect on the 90th day after the emitted volume of greenhouse gases reaches up to

55% of the total volume of the specified countries in 1990 and with the signing of no fewer than 55 participant countries^[3]. Three kinds of mechanisms for reduction are put forward in the Protocol, which are Clean Development Mechanism (CDM), Joint Implementation (JI) and International Emission Trading (IET). Mechanisms are adopted as new paths to the reduction of greenhouse gases emission with the representative of carbon dioxide, namely the trading of the emission right of carbon dioxide (referred to as the carbon trading for short) is realized where the right of carbon dioxide emission is regarded as a commodity^[4]. The aim is to realize improvement of climate warming through joint efforts of all the countries. But in 2001 the U.S. announced its refusal to approve the *Kyoto Protocol* with the excuses of the possible adverse effect of greenhouse gases emission reduction to the development of the U.S. economy and the developing countries should be responsible for reducing and curbing greenhouse gases emissions. After the withdrawal of the U.S., there have been other big countries withdrawing from the Protocol in succession such as Canada, Russia, etc.

Although the *Protocol* has never been met for to take effect, the international trading of carbon emission right has been well developed with the formulation of the *Protocol*. Presently, quite good trading systems of carbon emission right have been established in the European Union and New Zealand. Great achievements have been made in the CDM of joint emission reduction by the developing countries and the developed countries, as well as the rapid development of the JI in Eastern European countries. The activities for carbon emission reduction in the U.S. have been continued even though it withdrew from the Protocol. Some regional trading systems of carbon emission rights have been established, such as the Western Climate Initiative Map (WCI), Regional Greenhouse Gas Initiative

(RGGI), etc.^[5]

April 22nd, 2016, the Earth Day, may be the most meaningful one in the history as well as another new starting point of climate issue control. The senior representatives of 175 countries signed the *Paris Agreement* at the UN headquarters of New York, a climate agreement jointly formulated in early December last year in Paris, aimed at keeping control of an average temperature increase of fewer than 2°C before the industrialization within this century and seeking efforts to keep control of an average temperature increase of fewer than 1.5°C. This treaty has again pushed global carbon emission reduction to the focus of economic development, acting as a strong signal of the promotion of low carbon economy.

2. The Domestic Development of Carbon Trading

Environmental issues have always been the priority in our country's development. After the extensive development mode with the sacrifice of environment for economic benefits, there have been a series of environmental pollution problems to be solved. As time goes by, more attention has been paid to environmental problems with achievements made in economic development gradually.

Ecological civilization has been included as the key element in the 13th Five Year Plan of our country. It is determined in the *Outline* that in the next five years 18% reduction^[6] of carbon dioxide emission per unit of gross domestic product will be realized, a double control system of energy consumption volume and energy consumption intensity will be put into practice and demonstration projects of near-zero carbon emission areas will be implemented. At the same time a national carbon trading market will be established as well as a large increase of forest carbon sinks, so as to lay a

solid foundation for the realization of our country's independence contribution.

After the *Kyoto Protocol*, China has been actively joined the CDM, namely the transfer and acquisition of carbon emission volume offsets in the projects between the developed countries and the developing countries and the implementation of greenhouse gases emission reduction projects in the developing countries. As of 2011, 2,941 CDM projects have been approved by the National Development and Reform Commission. CDM projects have received great attention of more and more local governments and enterprises. CDM technical service institutions have been or are to be established in many provinces in order to promote the joint development of CDM projects of Chinese enterprises and the developed countries^[7]. Meanwhile, there have been seven major exchanges of carbon emissions in China, namely Guangzhou Carbon Emissions Exchange, Shenzhen Carbon Emissions Exchange, Beijing Environment Exchange, Shanghai Environment and Energy Exchange, Hubei Emissions Exchange, Tianjin Emissions Exchange and Chongqing Emissions Exchange. It was reported by the Xinhua News Agency that this April Sichuan United Environment Exchange had been recorded by the National Carbon Trading Agency and become the first exchange in the non-pilot areas of national carbon emissions and the eighth carbon trading agency nationally. It also marks Sichuan's stepping into the national carbon emissions trading ranks as a big clean energy province^[8]. On December 16th 2016, the National Carbon Market Capacity Construction (Chengdu) Center was unveiled.

On November 30th 2015 the Chinese President Xi Jinping made a speech on the Paris Convention of Global Climate Change as follows: "China has always been an active participant in the global cause of climate change and we are sincere and determined to make our own contribution to the success of

the Paris Convention". He also put forward the realization of a peak of carbon dioxide emissions around 2030 and that we would strive for the earlier realization than expected, the carbon dioxide emissions per unit of gross domestic product in 2030 would reduce by 60% to 65% compared to that in 2005, non-fossil energy would account for 20% or so of primary energy consumption and forest stock volume would increase by 4.5 billion cubic meters or so compared to that of 2005^[9].

Thus it can be seen that in our country carbon emission reduction has been brought up to the height of national strategy and carbon emission reduction has become an important way to the realization of low carbon economy and sustainable development.

3. Applicability of Garbage Classification to the Carbon Trading Market

Garbage falls into four categories, which are recyclable waste, kitchen waste, other waste and hazardous waste. Although it is common sense, not many people can really care waste classification in practical delivery. In China there is an average production of nearly 1 billion tons garbage each year. As of the end of 2014, the production of municipal solid garbage in our country has reached as high as 178.99 million tons^[10]. Among them, recyclable waste accounts for 20% and kitchen waste good for organic fertilizer accounts for 40%. That is to say, as high as 60% of garbage will be recycled if there is strict garbage classification, and less greenhouse gases will be emitted from garbage processing so as to achieve the effect of carbon emission reduction.

3.1 Existing Domestic Garbage Disposal Methods

As early as June 2000, eight cities are determined as the national pilot cities for garbage

classification in collection including Beijing, Shanghai, Nanjing, Hangzhou, Guilin, Guangzhou, Shenzhen, and Xiamen^[11]. Meanwhile, Three requirements are clearly put forward for urban garbage disposal (harmlessness, resource utilization and reduction) in the *Measures for the Management of Municipal Solid Waste*. However, there are not good results achieved by years of efforts in garbage classification and through policy guidance. The traditional mixed collection is still being adopted for garbage removal and transport in a majority of cities in our countries with landfill and incineration as the disposal methods.

Landfill has the advantages of simple process, comparatively less investment of technology, larger disposal quantity, but there is no garbage harmless treatment for the garbage dumped and there remains a large number of bacteria and viruses. Generally, landfill covers a large area and secondary environmental pollution is serious at the same time, such as pollution of groundwater and soil by garbage leachate, the air quality of surrounding areas is seriously affected by the odor produced by garbage dump as well as the existence of potential risk of pollution caused by heavy metal and methane and other risks; most importantly, the methane produced by the fermentation of garbage accounts for 40% to 60% of all the emitted gases, the greenhouse effect of which after emission is 21^[12] times of that of carbon dioxide of the same volume. Thus it can be seen that landfill is an unsustainable garbage disposal method which should be eliminated and forbidden as early as possible.

Garbage incineration is also an old way of garbage disposal, which is land saving and quick in garbage reduction. Meanwhile, reutilization of the wasted resources is made possible through energy conversion from heat to electricity. However, energy generation by garbage incineration is always controversial at home and abroad. It is pointed

out by the Environmental Protection Agency of the U.S. that a large number of greenhouse gases produced in the process of incineration of municipal solid waste is pollutive to the air, so the public holds a very negative view over this method^[13]. It is reported in several documentations that about 5,000 cubic meters waste gases will be produced after the incineration of every ton of garbage and ashes which is half the original garage volume will be left as well. The constitution of hundreds of pollutants emitted in the waste gases in the incinerator is quite complex, including many greenhouse gases and toxic substances especially pollutants like the dioxin which is recognized as first grade carcinogen. In the mean time, according to the introduction of professional personnel, the carbon content in the composition of domestic garbage is about 15%–20%, while about 0.3 tons of carbon dioxide is produced by the incineration of one ton of garbage. Therefore, based on the annual production of 1 billion tons of garbage, the carbon dioxide produced by garbage incineration will reach as high as 300 million tons. Consequently, garbage incineration is not conducive to carbon emission reduction but will lead to more serious temperature rise.

A report about energy generation by garbage incineration in the *Wall Street Journal* pointed out that efforts in the change of product packaging and consumer behaviors should be made by both the government and enterprises. The discarded materials should be reduced and garbage recycling and compost should be combined. All of these efforts would be helpful for the reduction of environmental pollution caused by garbage landfill and garbage incineration.

3.2 The Economic Benefit of Garbage Classification in Carbon Trading Market

3.2.1 Recyclable Waste

Recyclable garbage can be roughly divided

into the following categories, which are glass, metal, paper, plastic and fabric. Calculation and comparison were made by the scholars Hanna Merrild and Thomas H. Christensen between the amount of carbon dioxide generated during the recycling process of the above waste materials and the decreased amount of carbon dioxide compared to completely new materials, and it was shown that about 0~70 kg carbon dioxide is generated from the production process by the recycling and utilization of one ton of waste glass, however, there is an decrease of 600~1,500 kg carbon dioxide emitted compared to the production by new materials. Similarly, recycling of one ton of metal scrap will produce 12.8 ~ 526.6kg carbon dioxide with emission reduction of about 5,040 ~ 19,340kg (aluminum scrap) and with emission reduction of about 560 ~ 2,360kg (iron scrap). Recycling of one ton of waste paper will produce 4~38kg carbon dioxide with emission reduction of about 390~1,230kg. Recycling of one ton of waste plastic will produce 5~600kg carbon dioxide with emission reduction of about 60~1,600kg^[14]. Besides, according to statistics of Planet Aid (an American non-profit clothing recycling organization for the promotion of global humanitarian and environmental protection work), recycling of one ton of fabric can reduce 3~4 tons of carbon dioxide emission^[15]. Compared to the use of new materials for production, the carbon dioxide emission reduction by recycling = carbon dioxide emission amount by using new materials in production - carbon dioxide emission amount in the recycling of wastes. The results are as follows.

Table 1: the actual carbon emission reduction of various kinds of recyclables (unit: kgCo₂/t)

	Upper Limit Value	Lower Limit alue	Average Value
Glass	1430	600	1015
Metal	21173.4	5587.2	13380.3
Plastic	1000	55	527.5

Paper	1192	386	789
Textile	4000	3000	3500

Take the central urban area of Chengdu City as example, the daily garbage disposal capacity is about 4,835 tons in 2013 and the annual garbage disposal capacity is about 1,764,775 tons, including 8.25% paper, 8.99% plastic, 4.30% fabric, 1.68% glass and 1.61% metal^[16]. A generation of about 131,458.09 tons of carbon dioxide will be emitted to the atmosphere by incineration of the above recyclable wastes. By garbage classification, the contribution to reduction of carbon emission of the recycling of above recyclable wastes is as indicated in the following table (the reduced emission of carbon dioxide):

Table 2. Reduction of carbon emission after garbage classification in the central urban area of Chengdu (Unit: ton)

	Upper limit Value	Lower Limit Value	Average Value
Glass	42396.95	17788.93	30092.94
Metal	601597.22	158748.43	380172.82
Plastics	158653.27	8725.93	83689.60
Paper	173547.97	56199.26	114873.61
Fabric	303541.30	227655.98	265598.64
Sum	2371048.37	469118.53	874427.61

Compared to the carbon dioxide emissions by garbage incineration or landfill, the total reduction of carbon dioxide emissions by recycling and utilization of recyclable garbage = reduction of carbon dioxide emissions by recycling and utilization of recyclable garbage + carbon dioxide emissions due by incineration. As a result, the total reduction of carbon emissions by the recycling and utilization of recyclable garbage is about 1,005,885.7

tons (874,427.61+131,458.09) in the central urban area of Chengdu City in 2013. The newest carbon price was 49.2 RMB /ton in Beijing carbon market, based on which, there will be an economic income of 49,489,576.44 RMB by reduction of carbon dioxide emissions through recycling and utilization of wastes in the central urban area of Chengdu City.

According to relevant statistics, consumption of 100 degrees electricity is equivalent to emissions of 78.5 kg carbon dioxide, while consumption of 100 kl gasoline is equivalent to emissions of 270 kg carbon dioxide. A tree can neutralize 18.3 kg carbon dioxide.^[17] By calculation, the reduction of carbon dioxide emissions by recycling and utilization in the central urban area of Chengdu City is equivalent to the saving of 1.3 billion degrees of electricity, over 300 million kl gasoline as well as planting over 50 million trees.

3.2.2 Kitchen Waste

Kitchen waste include discarded leaves, leftovers of dishes and rice, peels, eggshells, tea leaves, bones and so on. Due to containing large amount of water, these wastes are more likely to spoil and generate odors in daily life as well as easier breeding of bacteria and viruses, which are headache problems of residents. However, there is also a high value in use due to large amount of organic compound with

a complete set of trace elements such as nitrogen, potassium, calcium, phosphorus and others. Presently in our country, in most cases, kitchen wastes are collected and transported together with other wastes, which is not conducive to recycling and compost. Besides, the harmless disposal ratio of garbage in our country is only 50%^[18] lower than that abroad, bringing high pressure to the disposal of municipal solid garbage.

Such a disposal method is applicable after garbage classification and separate collection of kitchen waste, press pretreatment + dry component incineration + wet component anaerobic fermentation. In this treatment, primary kitchen waste is crushed and separated into dry components of 30% water and wet components of 90% water by high pressure (600~1000 standard atmospheric pressure). Dry components are used for incineration and power generation and wet components are used for compost fermentation. It is found that after studies, compared to landfill, this disposal method for kitchen waste has the biggest potential in reduction of carbon emissions with reduction of carbon dioxide of 947.6kgCO₂/t^[19].

Take the central area of Chengdu City as example; the garbage disposal amounted to 1,764,775 tons or so in 2013, in which kitchen waste accounted for 60.28%. With garbage classification by residents, separate collection and transport of kitchen waste, as well as the above mentioned waste disposal method, there will be an decrease of 1,008,062.92 tons of carbon dioxide emitted to the atmosphere. Meanwhile, based on the newest carbon price of Beijing carbon market 49.2 RMB /ton on May 3rd, this emission reduction will bring us with an economic income of 49,596,695.66 RMB.

Thus it can be seen that garbage is indeed resource misplaced. The effect of garbage classification in low carbon economy development and slowing down of temperature increase is amazing. Dominated

garbage classification



by the government, the introduction of garbage classification to carbon trading market will generate economic profit. With the participation of residents, the introduction of garbage classification to green life and everyone's practice is compliant with the important principle of "Government dominance, market operation, social participation and steady advance" and the practical demand of low carbon transformation of the country.

3.3 Garbage Classification's Contribution to Low Carbon Recycling Industry

Although with vast territory and abundant resources in our country, the natural resources per capita is far lower than the world average level with long-term contradiction between economic development and resources. Since the strategic decisions made in the 18th National Congress of the CPC vigorously promote the construction of ecological civilization, the scale of recycling industry has gradually expanded with technical level to be improved and policy guidance to be strengthened.

There is close link between the promotion of garbage classification and the development of recycling industry. Without garbage classification, professional collection and transport, there are several times of reselling of garbage from residents to the final recycling enterprises. The whole recycling resources market are out of order, which makes it difficult to monitor and manage, due to complex recycling sectors, scattered recycling staff, and a lack of standardized and scientific recycling system.

As a major part of China's circular economy, the development of resources recycling industry is helpful for the transformation of economic growth mode from extensive expansion to intensive development, further to reduce its dependence upon natural resources. The garbage classification mode, with government guidance, residents classification,

professional organization recycling, acts as not only the starting point of recycling industry promotion, but also the power source for providing recyclable waste.

4. Foreign Cases of Garbage Classification in the Context of Low Carbon Development

4.1 Japan

As a typical island country of scarce natural resources, Japan is facing with huge threats by temperature rising. Therefore, it has been committed to the practice and publicity of greenhouse gases emission reduction and resource recycling. It attaches great importance to low carbon development, which can be reflected in many aspects. Firstly, it has a sound legal system. As early as 1979, the Japanese government issued the *Energy Conservation Law*, and from formulated 1991 to 2001 several acts including *Laws on the Promotion of Renewable Resources*, the *Law on Rational Use of Energy and Renewable Resources*, the *Waste Disposal Law*, the *Law on the Management and Promotion of the Discharge of Chemicals*, *A Long-term Outlook for Energy Supply and Demand*, etc^[20]. Secondly, it adopts incentive fiscal and taxation policies. In the budget of 2009 with total amount of 88.5 trillion Japanese yen, the tax deductible amount registered 210 billion Japanese yen, 190 billion Japanese yen and 240 billion Japanese yen respectively for environmentally friendly vehicles, energy saving and environmental protection investment and promotion of transformation of small and medium-sized enterprises to low carbon economy, which accounts for 60% of the fiscal budget of that year^[21].

At the same time, the Japanese government puts a high value on the role of every citizen in the process of creating a low carbon society.

Consequently, the public are enthusiastic in participating in the process, and their garbage classification is worth mentioning. Since 1980 Japan has started the work of garbage collection pilots and has accumulated over 30 years of experience in this field. Take Obihiro city as example, solid wastes fall into four categories, which are burnable garbage, resource garbage (recyclable garbage), unburnable garbage and hazardous garbage (dry batteries, mercury thermometers, daylight lamps, etc.). The burnable garbage is collected twice a week, and branches and leaves must be regarded as burnable garbage and centralized for collection as well. Resource garbage is collected at door by professional institutions entrusted by the government once a week. Unburnable and hazardous garbage are collected once every two weeks. The collection time varies in different regions so as to improve the utilization efficiency of transport vehicles^[22].

4.2 Germany

As a technological superpower, the German government also attaches great importance to the technology of development of low carbon economy. Government subsidies are available for any renewable energy projects. In the recent years, there is a rapid development of renewable energy industry in Germany, which has become a new economic growth point. In 2010 the sales volume of renewable energy in Germany amounted to 29 billion Euros, and power generated by renewable energy accounted for 15% of the total power generation capacity. The output value of renewable energy enterprises in Germany reached 25 billion Euros, which provided over 250 thousand job opportunities^[23]. In addition, Germany has the most complete and sound legal framework of low carbon economy among all the European countries.

As well as being a technological superpower, Germany is a superpower of garbage classification.

As early as 1904, municipal solid garbage classification was implemented in Germany and there has been a history of over 100 years. A complete set of mature and reasonable system has been formed after development of over one century. Usually every residential building is equipped with 3 to 4 garbage bins, where packages, non recyclable waste, paper waste and glass bottles are temporarily stored. The size of garbage bins and garbage disposal charge for residents are determined by the garbage disposal company with consideration of the resident density of the buildings. Fixed points for collection and disposal are set for garbage such as household appliances, batteries, and furniture, etc.

Besides the construction of the legal system and policy guidance by the government, both of the two countries have set up carbon trading systems in common in terms of carbon emission reduction. The German government set about the preparatory work of carbon trading in 2002, and has formed a comparatively complete and sound legal system and management system. Since Nov 21st 2009, Japan has piloted carbon emission trading system, namely domestic enterprises set up their own total quantity of emissions. If enterprises achieve a lower emission level than the set limit, the remaining quota can be offered for sale as an emission right. As for those enterprises which fail to meet the target for emission reduction, they can purchase extra quota from other enterprises.

5. Conclusion

Against the background of the global big issue of slowing down pollution and temperature rising, green low carbon economy and circular economy are the development direction of every country in the future and it is every citizen's responsibility to participate in carbon emission reduction. Probably we cannot feel the improvement in environment

and climate by garbage classification, however, it is proved that the garbage classification will make huge contribution to carbon emission reduction.

The advance of the implementation of garbage classification and the establishment of a sound carbon trading system is a mutually beneficial process. Although garbage classification seems to be a public welfare act, it can make outstanding achievements in the development of low carbon economy and circular economy and can be well integrated in the market mechanism. As a breakthrough of carbon emission reduction, the introduction of garbage classification to carbon trading market can not only practically reduce the emission of greenhouse gases but also help the country gain huge economic benefits. The garbage classification is dominated by the government

with all the citizens' participation and publicity of garbage classification strengthened. At the same time, garbage classification can also be the culture and name card of one city, helping build a fresh new image of the city.

Since April 2016, Sichuan Joint Environmental Exchange has become the eighth carbon trading institution in our country, as a symbol that our big clean energy province Sichuan province has stepped into the national carbon emissions trading ranks. Therefore, in this best time, the government should fully play a dominating role, promote the establishment of the CDM based on garbage classification, and guide the development of garbage classification and resource disposal through carbon trading system and market means.

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