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Study on Waste Incineration and Electricity Conversion in Macau, China

Yile Chen
Faculty of Humanities and Arts, Macau University of Science and Technology
Corresponding Author: Yile Chen 2009853gat30001@student.must.edu.mo

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A B S T R A C T

Under the rapid development of the city, our city also produces a large amount of garbage, including ordinary household garbage, construction waste, and hazardous waste. With the advocacy of the concept of eco-city construction, Macau's urban waste treatment has also added a number of sustainable development measures, such as waste incineration, the production of fertilizer, and the recycling of household food waste. Based on field investigation and interview research, this study finally puts forward corresponding suggestions for the predicament of waste incineration in Macau

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INTRODUCTION

From the perspective of historical particularity, Macau has its own unique side. For example, during the administration of the Portuguese government before the reunification, the Portuguese brought advanced reclamation technology, bridge construction technology and airport construction technology in Europe. The waste incineration center, one of the infrastructures, was also completed during the Portuguese government in Macau. In the management system, it also has its own way. From the adoption of EU emission standards in the waste incineration center to the social nature of capitalism after the return, the different forms of property rights and the different legal systems, it also leads to its sustainable development. The direction of planning is very different from that of mainland China and Hong Kong. Based on preliminary research on the conversion of incinerated waste into electrical energy by the Macau Waste Incineration Center, this study proposes experience and follow-up improvement suggestions for urban waste treatment in Macau SAR for sustainable development planning research in other cities in the Guangdong-Hong Kong-Macau Greater Bay Area.

This research was funded by the China Youth Elite Project (Foundation)-One of the phased research results of the 2019 Youth China Walk Guangdong-Hong Kong-Macau Greater Bay Area SDG project "Research on Sustainable Development of Urban Waste Recycling in Macau". Compared with the existing academic achievements, this research focuses more on interviews with relevant staff, visits and visits to obtain first-hand content and conclusions. This can provide a more realistic understanding of the current status of Macau's waste incineration and energy problems.

Macau Waste Incineration Center

The Macau Waste Incineration Center is located in the industrial zone of Pac On, Taipa, Macau (see Fig. 1). It covers an area of approximately 40,000 square meters. It is close to the Taipa Ferry Terminal and Macau International Airport. It is one of the most important infrastructures in Macau. The task of reducing, reducing and resourcing Macau built its first waste incineration center in 1992. It had 3 waste treatment lines with international advanced standards at that time. The design capacity of each treatment line was 288 tons per day; that is, the total treatment capacity was 864 tons per day. The capacity is 283,800 tons, and the exhaust gas meets the EU emission standards at that time[1,2].

After stable operation and reconstruction and expansion, there are 6 processing lines with a total processing capacity of 1,728 tons per day and 576,650 tons per year[3]. At the same time, indicators such as noise and sewage have reached the international advanced level. The heat generated in the waste incineration process is used to generate electricity, and the boiler conducts heat exchange to generate steam, which is collected into a turbine generator to generate electricity. The power generation capacity of the incineration center is not only sufficient for its own power consumption but can also output a maximum of approximately 21 MWh of electricity per hour to the public grid, which is sufficient for approximately 33,000 residents in Macau. In addition, the volume of slag produced after incinerating garbage is only one-tenth of the

original garbage volume, which greatly reduces the landfill needed. It is extremely important for Macau, which lacks land resources and can leave valuable land for other developments[4,5].

Figure 1. Overlooking the Macau Waste Incineration Center from Taipa Mountain in Taipa
(Image Source: Photographed by the Author)

Choices for the Shortage of Land Resources in Macau

Looking back at history, from 1978 to 1988, the population of Macau has increased dramatically in the past ten years. The amount of rubbish that government departments have to deal with on a daily basis has also continued to rise. According to statistics, in 1983, 25 tons of garbage were collected every day. In 1984, the daily processing volume was 28 tons, and in 1985, it was 32 tons. Since 1986, more than 40 tons of garbage have been processed every day. Based on these figures, 139,000 metric tons of waste are currently processed annually. The problem of garbage is a social problem. Whether it is handled well or badly will directly affect the environment; in other words, it will also affect the physical and mental health of citizens[6].

One of the distinguishing features of Macau as an island city is its small geographical area. At the end of 2016, the total resident population of Macau was 644,900, and the total land area of the region was 30.5 square kilometers. Based on this calculation, the population density of Macau is 21,400 people per square kilometer. The total number of tourists visiting Macau in 2016 was 30.95 million. Based on this calculation, the daily floating population during the year was 84,794. Combining the two data of resident population and floating population, Macau has a population density of 24,180 people per square kilometer, making it the city with the second highest population density in the world. According to the estimates of the Macau Statistics Department, the resident population in Macau will increase from 513,000 at the end of 2006 to 829,000 at the end of 2031, with an average annual growth rate of 1.9%. During the first five years from 2007 to 2011, the population growth of Macau was relatively fast, with an average annual growth rate of 4.6%; thereafter, the growth rate gradually narrowed (see Fig. 2).

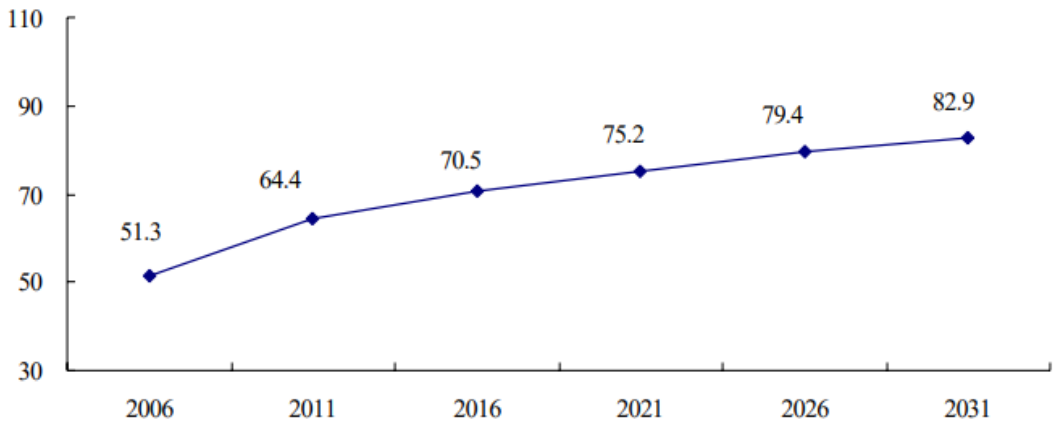

Figure 2. 2006-2031 Macau Residential Population Forecast (Unit: 10,000 People).

On the other hand, Macau's land resources are very limited. Macau mainly relies on reclamation to expand the available land. Shallows are widely distributed along the coast of Macau and have become a land resource for reclamation in Macau. According to the available data, in the 100 years from the end of the Qing Dynasty (1912) to the present, the land area of Macau has increased by nearly 300%, and more than 20 square kilometers of land was obtained by reclamation. In 2018, the total area of Macau was 32.8 square kilometers. The scarcity of land resources and the rapidly growing population have resulted in limited options for the disposal of urban waste in Macau.

International Experience in Waste Incineration

There are many places in the world that use waste incineration, such as Japan, Germany, the UK, Taiwan, China and Hong Kong, China. However, in Taiwan, China, only 2% of the waste is handled by incineration, and 98% of them are landfilled, composted and other methods. The four waste incinerators in Taiwan failed to achieve the expected results for various reasons. Hong Kong has abandoned plans to build incinerators and plans to demolish those already in use because the pollution problem is not easy to solve[7-11].

In Japan, waste incineration is a common practice. Waste treatment plants not only reduce waste by incinerating combustible waste but also generate electricity and use waste heat to provide heating and heated swimming pools. The incinerated ashes can be used for landfill construction after harmless treatment and will not pollute the environment. According to the data of the Ministry of the Environment of Japan, in fiscal year 2012, the total amount of general garbage in Japan was 45.22 million tons, of which direct incineration accounted for 79.8% of the total garbage disposal, and landfills accounted for only 1.3%. As of the end of fiscal year 2012, Japan had a total of 1,188 waste incineration plants, with a daily waste processing capacity of approximately 184,100 tons, of which 314 had power generation equipment, accounting for approximately 30%, with a total power generation capacity of 1,748 MW. In addition, 780 waste incineration plants have waste heat utilization facilities, which can provide heating and hot water required in the factory and can also

provide warm water and thermal energy to the heated swimming pools outside the facilities. The Toyohashi Urban Recycling Center in Japan (completed in March 1980) treats 300,000 people in the city with rubbish and feces, including 200 tons of rubbish and 200,000 liters of feces. Incineration is also used. The remaining steam from incineration can also be supplied to the surrounding vegetable farmers and the sports training center, and it can also be used to generate electricity.

In the UK, government departments have emphasized the need to reduce the generation of waste from the source and continuously improve the recycling rate, but under the existing technical conditions, landfills and incineration are still the main methods of waste disposal in the UK. In 1870, the world's first waste incinerator was put into operation in the UK. In the 1950s and 1960s, with economic development and the improvement of the living standards of urban residents, the combustible and combustible substances in garbage increased rapidly, and the application of garbage incineration technology was further promoted. However, since the 1980s and 1990s, the environmental problems caused by waste incineration have become increasingly prominent, and the voices of opposition from the public have become increasingly louder, so this method of disposal has gradually been restricted. The UK's attitude towards waste incineration plants is strict standards, strict monitoring, and cautious new construction. Its perfect laws and regulations and relevant regulations of the European Union also make all behaviors related to waste incineration carried out within a strict framework. Under continuous pressure from the government and the private sector, waste incineration companies can only achieve the corresponding standards by improving their technology and win the trust of the people in the surrounding areas through open and transparent processing methods.

In Germany, the trash cans of some houses are specially placed in the locked garbage room. The trash cans are equipped with black, green and yellow lids, which are used to collect general garbage, paper garbage and plastics, respectively. However, the simple three classifications often have difficulty solving all classification problems in daily life. Therefore, the sanitation department specially posted pictures in the recycling area of the garbage room and pasted samples on the cardboard to guide residents to properly dispose of garbage. In fact, waste disposal has always been a problem for many cities in Germany, and Germans began to explore waste incineration very early. Take the port city of Hamburg in Germany as an example. Before 1890, household waste in Hamburg was used as fertilizer to be transported to farmland near the residential area. However, this method of disposal is not only not environmentally friendly but also unsanitary. In 1892, a single cholera attack killed 8,000 people, prompting the Hamburg authorities to build the first waste incinerator in 1896. Today, Germans follow the principle of minimizing the total amount of domestic waste and recycling it. According to 2011 data, the recycling rate of German municipal solid waste was 65%, and the incineration rate was 35%.

The most famous in Germany is the Ruhr recycling center. It can handle household waste, industrial waste and hospital waste. First, after the household waste is processed, glass, scrap iron and metal are separated, the coarse waste is incinerated, and the waste is used to generate electricity. The exhaust gas is discharged from the smoke window after being treated by the dust collector. Industrial and hospital waste is also incinerated to generate electricity.

Selection of the Design Scheme of the Macau Incineration Center

There are five modern methods of disposing of garbage: terrestrial, incineration, partial resource recovery (that is, waste disposal, useful recycling), terrestrial and composting. The incinerator combustion method used in Macau is to incinerate waste, the heat energy will be converted into steam, and the pulley will be driven to generate electricity. However, incineration of garbage produces exhaust gases such as hydrogen chloride (HCL), sulfur oxides (SOX), nitrogen oxides (NOX) and soot. In addition, wastewater is also produced. According to statistics, incinerating one ton of garbage produces approximately one ton of wastewater.

The advantages of the incineration method are that it does not require much land, the administration is easier to coordinate, the secondary pollution is easier to control, and it is more hygienic. The transportation cost is reduced because the incinerator can be built in the collection area, and the waste gas has a utilization value. However, the construction and operation maintenance costs are higher. According to Japanese research data, if a city has a population of 30-1 million people and there are 300-1,000 tons of garbage every day, the waste generated after incineration is used for power generation. Electricity can be supplied to the outside, and it is feasible to incinerate waste based on Macau's population and daily waste volume.

History of waste incineration center

To be lasting, effective, and profitable without causing pollution and to solve the increasing garbage problem in Macau, in 1993, the Macau government hired PROFABRIL/CESL/TECHINVEST for technical research, ranging from landfill, composting, incineration (without energy recovery) and incineration for power generation. An optimal solution is screened out of 4 technically feasible solutions. Taking into account the small geographical area, high land prices, the need for environmental protection, and maintaining utility for at least 20 years, it is finally determined that the incineration power generation scheme has more advantages than other schemes. Because it occupies a small area, it can meet the economic and geographical conditions of Macau, and the energy recovery can greatly reduce the cost of operation and maintenance.

The incineration power plant is managed by CGS, a specialized waste management company in Macau. After more than a year of trial operation, it entered a mature stage in early 1994. To date, the safe disposal of municipal waste has finally been properly resolved.

Garbage disposal process

It is understood that the cleaning company in Macau (CSR - Companhia de Sistemas de Resíduos, Limitada Macau Residue System Company) collects the domestic solid waste to the waste incineration center every day. Automatically

recorded for statistical purposes and then transported from the lift ramp to a lift platform above the ground. The platform is located in the east of the industrial building and can be used for 7 municipal vehicles to unload garbage at the same time. In addition, there is a large entrance for unloading large-volume garbage. These large-scale garbage must be crushed by cutters before being mixed with other garbage (see Fig. 3).

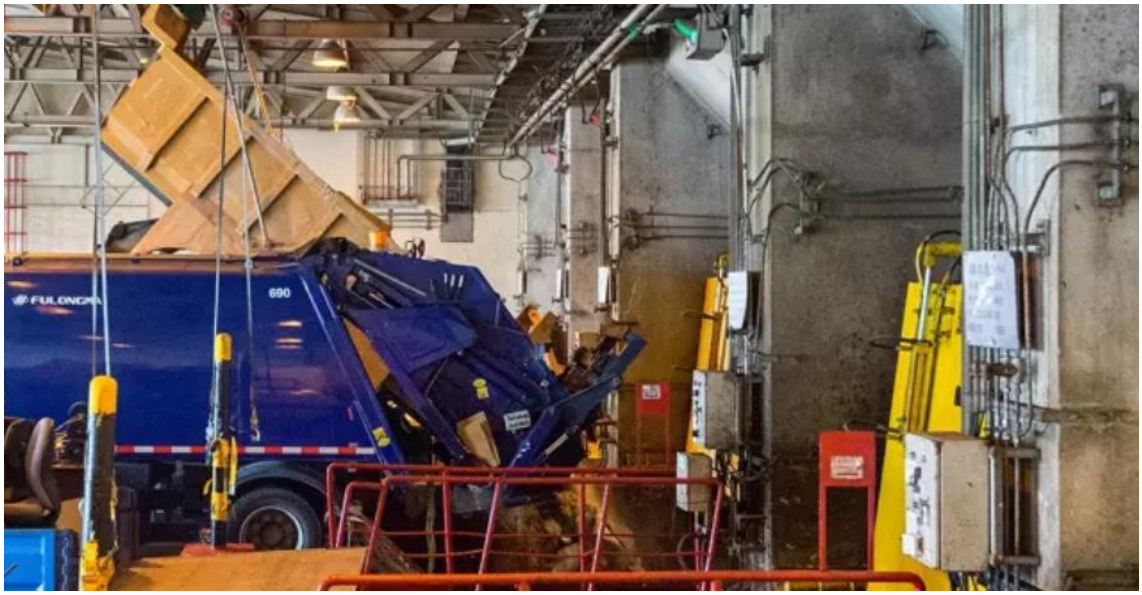

Figure 3. Dump the Trash Into the Pit
(Image Source: Government Information Bureau)

After the garbage is unloaded, it is stored in a garbage storage pit with a volume of 8,000 m^3, and then the garbage is mixed and compressed by two jib cranes. The incineration centre has two waste storage pits that can hold up to approximately 6,500 tonnes of waste. Each garbage storage pit is equipped with 2 powerful booms. The staff will control the powerful booms in the control room of the garbage crane to mix the garbage in the garbage storage pit evenly and then put it into the incinerator for incineration.

Each crane can pick up approximately 6 m^3 of waste at a time and put it into the feeding funnel. Each grate of the incinerator is approximately 6 m long, driven by hydraulic pressure, and moves obliquely upwards and reversely with a certain frequency and stroke. From the combustion point of view, the burning garbage on the bottom layer is continuously transported upwards and backwards, which is conducive to the preheating and burning of the newly fed garbage and can make the mixing and stirring on the whole grate very strong. After 30-45 min of incineration, the garbage can be completely burned into ashes. The temperature inside the incinerator is kept above 850 degrees Celsius, and the heat generated during the incineration process can be used to generate electricity (see Fig. 4). The incineration center can generate approximately 28.7 megawatts of electricity per hour at full capacity, of which approximately 7 megawatts is used for its own operation and the remaining 21.7 megawatts is fed to the public grid. The slag remaining after incineration enters the slag extractor for cooling

with water, and the iron metal stored in each furnace is removed by electromagnets. The remaining waste slag is stored in the slag pit and transported to the reclamation area in batches. fill. The incineration center has two plants, new and old, with a total of 6 incinerators, which can process 1,728 metric tons of waste per day, or 576,650 metric tons per year. All this is monitored by the technicians in the central control room of the incineration center to realize intelligent management (see Fig. 5).

Figure 4. Garbage is Incinerated at Temperatures Above 850°C
(Image Source: Government Information Bureau)

Figure 5. The Central Control Room of the Incineration Center
(Image Source: Photographed by the Author)

Treatment of waste gas and soot during waste incineration

After on-site interviews, it can be seen that the Macau Waste-to-energy Power Plant attaches great importance to environmental protection issues. The cost of the plant's equipment for the treatment of waste gas and smoke accounts for one-third of the total cost. Each incinerator is also equipped with a semiwet gas purifier with a volume of approximately 300 m^3. A lime-based solution is injected into the device. This solution can neutralize the gas and remove acid gas components (HCl, HF, etc.) in the form of copper salts.), SO_2 and NOx.)).

The residence time of the gas in the purifier is 13 s, the waste gas is 55270 m^3/h, and the consumption of lime slurry is 32 kg/t garbage. The gas purifier also includes an electrostatic precipitator. The voltage used is 50 kV, and the lime solution is sprayed into mist droplets with a sprayer so that the formed calcium salt is easily mixed into the gas flow, and the fly ash is collected by the electrostatic precipitator. removed and precipitated. After being filtered by the dust collector, the treatment effect of the exhaust gas is analysed by automatic instruments (one set of HCl, HF, CO_2, CO, O_2, CH_4, and particle analysers), and the results can be reflected on the computer screen in the general control room. The operator can make appropriate corrections to the waste incineration and exhaust gas purification process according to the treatment effect. The amount of dust generated per ton of waste incineration is approximately 70 kg/t, which is collected by the dust collector and stored in two basements and then transported to the landfill.

After treatment, the gas discharged from the chimney is nearly colorless, the temperature is lower than 150 ℃, and it is difficult to see smoke discharged from the chimney throughout the year. The composition of toxic substances in the flue gas is also far lower than the EU's emission standards, and the treatment effect is excellent.

Table 1. Solid Waste Incineration Center Pollutant Discharge Value
(Unit: Mg/M³)

Contaminant Type	Incineration center (maximum value)	EU Standard (Maximum Value)	Measured value of incineration center
Hydrogen chloride	100	50	26
Hydrogen fluoride	5	2	0.2
Sulfur dioxide	200	300	17
Dust	100	30	30
Lead, Chromium, Copper, Manganese	5	5	<0.11
Nickel, Arsenic	1	1	<0.0013
Tin, mercury	0.2	0.2	<0.0013

Source: Incineration Center and Sewage Treatment Office,
Drawn by the Author After an Interview

Economic analysis of waste incineration power plant

The construction cost of the first phase (the first and second units) of the Macau Waste-to-energy Plant is approximately 300 million patacas, the second phase (the third unit) is approximately 120 million patacas, and the cost of the incinerator civil works is 98 million patacas.

Beginning in 1990, it took 3 years to complete the entire project. The three incinerators have a combined processing capacity of 650 t/d and a power generation of 12 MW, of which 30% is used internally by the factory, and the remaining 70% is integrated into the power grid of the Macau Electricity Empowerment Corporation (CEM). The purchase price of CEM is 0.2 patacas/kWh, and the annual benefit can save the Macau government approximately 13 million patacas in expenses, which is equivalent to the average cost of CEM to purchase diesel in 1992. According to calculations, if CEM's purchase price for electricity is doubled, the revenue can basically maintain its operations.

Incineration mode of special and hazardous waste treatment stations in Macau

The Macau Special and Hazardous Waste Treatment Station is located next to the Waste Incineration Center. According to the relevant person in charge, the station has been operating since May 2007, and the joint solicitation body (CSS)

is composed of Ruiding Waste Treatment Co., Ltd. and Xinding Technology Co., Ltd. began to be responsible and maintain. The Macau Special and Hazardous Waste Treatment Station is mainly aimed at the special waste currently generated in Macau and adopts high-temperature incineration treatment technology to deal with the waste that cannot be treated by the waste incineration center, including waste tires, solid and liquid hazardous waste, horses and dogs. Other animal carcasses and slaughterhouse waste, medical waste, oil residue sediment and other special and hazardous waste (see Fig. 6).

Figure 6. Treatment Station Stacks used Tires for Further Processing
(Image Source: Photographed by the Author)

Table 2. The Current Total Processing Capacity of Special and Hazardous Waste Treatment Stations in Macau (as of March 2018)

Disposal Type	Total	Disposal Type	Total
Scrap tires	6600 tons	Animal carcass	576 tons
Incineration of hazardous waste	5078 tons	Horse carcass	637 tons
Solidification of hazardous waste	92 tons	Medical waste	4373 tons
slaughterhouse waste	8219 tons	Oil sludge	153 tons

Source: When the Author Visited, the Other Party Explained the Data in the PPT, and the Author Drew it After Sorting Out

Its incinerators are designed to handle 24 metric tons per day and an average of 1 metric ton per hour of special and hazardous waste. The treatment system mainly includes two combustion chambers, namely, "first combustion chamber (rotary kiln)" and "second combustion chamber", in which all combustible wastes will be gasified and burned. Since a large amount of exhaust gas will be generated

during the combustion of the waste, the exhaust gas needs to stay in the second combustion chamber for no less than 2 seconds to ensure that all the exhaust gas is completely burned. The second combustion chamber is also equipped with an oxygen content analyser to monitor the concentrations of O_2 and CO to effectively control the concentrations of CO, NOx and volatile organic substances produced by incomplete combustion. After the exhaust gas leaves the second combustion chamber, it first enters the "heat exchanger", which uses the effect of heat exchange to cool the high temperature of the hot exhaust gas. After that, the exhaust gas enters the reactor, and $NaHCO_3$ and activated carbon are injected to neutralize the acid gases (such as SO_2 and HCl) in the exhaust gas and remove harmful substances such as heavy metals and dioxins[12,13].

Before the exhaust gas is discharged, it will pass through a bag filter to remove particles in the exhaust gas, and the treated gas will be discharged to the atmosphere through a chimney (see Fig. 7). There is an "emission monitoring system" in the chimney for 24-hour continuous monitoring of the exhaust gas to ensure that the quality of the exhaust gas can meet the requirements of the relevant emission standards in the EU guidelines.

Figure 7. Filter Bag to Remove Dust
(Image Source: Photographed by the Author)

DISCUSSION

Problems faced before incinerating garbage

First, all garbage cannot be disposed of together, such as scrap iron, which must be separated first. If it cannot be sorted during collection, different types of garbage must be separated after collection. Burning everything together will only reduce the efficiency of the incinerator. The garbage in Macau is not sorted at the time of collection, so it must be sorted after collection.

To reduce waste and make good use of the earth's resources, the Municipal Affairs Bureau of Macau began to promote the waste sorting and recycling program at the end of 1999. There are three-color sorting recycling bins at each collection point, "blue waste paper, yellow aluminum can, and brown plastic bottle", for citizens and tourists to dispose of waste paper, metal, plastic and other resource waste, respectively. Initially, it focused on school publicity and education and then gradually expanded the level of the recycling program, extending it to associations, commercial organizations, government departments, and establishing public recycling points in various districts of Australia. Since the implementation of the scheme, the recycling rate and the number of recycling units have continued to increase[14].

At present, many trash cans only rely on text or color to distinguish recyclable, nonrecyclable, or even more detailed categories, but the problem is, if they are colorblind, children, or old people who have no education, how should they be placed? Judging from the special-shaped trash cans currently placed by the Macau Environmental Protection Bureau, this problem has been well solved, and it has a certain scientific and educational significance. However, there are still shortcomings (see Fig. 8). For example, the categories are more focused on aluminum cans, plastic bottles, paper, etc., with recycling value.

Figure 8. Three-color Sorting Recycling Bins at Macau International Airport "Blue Waste Paper, Yellow Aluminum Can, Brown Plastic Bottle" (Image Source: Photographed by the Author)

The control problem of garbage quality

According to Taiwanese data, the incineration method failed completely for four reasons. The first is that because people are very frugal, the waste that can be sold for money, such as cardboard, newspapers and magazines, is left to sell to "scavengers", and the remaining garbage that can be burned is greatly reduced. The second is that Chinese people like to eat fresh food. Fresh fish and vegetables are washed first. The water content of garbage is generally high, and it is not easy to incinerate. The third is that because living standards have improved, everyone is reluctant to eat old meals. In addition, no one in the city collects kitchen waste, so plastic bags are used to store cold vegetable juices and then throw them away. This approach is more disadvantageous for incineration. The last item is that the garbage thrown by Chinese people is not classified, and the incinerator incineration of unclassified and treated garbage will be damaged[15].

In addition, the power fluctuation of garbage power generation is large, and the reliability is poor. Such electricity cannot be sold for a good price. Japan's experience is that the government needs to be subsidized. Therefore, the power generated by the incinerators in Macau is similar to that in Japan and requires government subsidies. Not only does the government make no money, but it also increases the burden on taxpayers.

Electric energy converted from incineration faces problems

Today, Macau's power generation is handled by one power plant on the Macau Peninsula and two power plants on Coloane Island. However, in fact, two power plants have been scrapped, and total power generation can only reach 10% of Macau's overall electricity consumption. The main power supply in Macau is transmitted from the mainland, which accounts for 80% of the power supply in Macau. The power transmission network consists of 19 major substations established by CEM. The volt substation and a 220 kV substation connecting the Gongbei and Zhuhai substations supply electricity to Macau. Then, how much of the electrical energy converted from waste incineration in Macau can be used in the urban power grid? In the end there is no effect? According to the statistics of the Macau Energy Office, the electricity obtained by the Macau Incineration Center is converted into urban electricity, accounting for only approximately 3% (see Table 3).

Table 3. Macau Electricity Demand Statistics for the First Quarter of 2022

Type of power source	Units	First quarter 2021	Fourth quarter of 2021	First quarter 2022
Maximum load	MW	752.8	908.0	754.9
Total power consumption	GWh	1096.9	1253.7	1122.3
Purchase from Mainland China	GWh	1047.0	1095.2	1070.0
Purchase of waste incineration center	GWh	42.7	43.4	43.2
Local power plants produce electricity	GWh	7.1	115.1	9.1
Natural gas power generation	GWh	0.0	101.8	0.0
Fuel power generation	GWh	7.1	13.2	9.1
Photovoltaic grid-connected purchase	GWh	0.0261	0.0284	0.0230

Source: The Author Draws After Sorting Out Data from the 2022 Quarterly Statistics of Electricity and Natural Gas by Macau Environmental Protection Bureau

CONCLUSIONS AND RECOMMENDATIONS

In summary, although it is feasible to incinerate waste and generate electricity, it requires a huge investment to achieve the desired effect. The living habits of the Chinese living in Taiwan and Macau are similar, and the methods of producing garbage and the attitude towards garbage disposal are not very different. However, at present, the incinerator in Taiwan is not performing as expected, and I am afraid that the plan of the incinerator in Macau will suffer the same fate.

The Macau solid incinerator plant is still an old facility in the past. With the increase in the total amount of MSW, the introduction of a waste sorting production line can be considered in the future to achieve the classification and treatment of incoming waste. At the same time, the incineration technology should be actively improved, and the furnace temperature should be increased, preferably more than 1300 degrees Celsius, which can greatly reduce the generation and overflow of harmful and toxic gas substances (especially dioxins) and can also shorten the residence time and reduce residual residues.

Currently, waste incineration centers in Macau are still lacking in the classification and recycling of food waste. You can refer to the food waste recycling of Hong Kong's "Green Wisdom Commune" to separate the lipids to make handmade soaps, instead of the current single food waste recycling to produce fertilizers. Various aspects of recycling and production can be considered to improve the utilization rate after recycling. At the same time, the Macau Waste Incineration Center is also a very important base for science and education, but there are few opportunities to visit at present. We can consider

setting up "open days" and other methods to further open up to the public to increase the coverage of science and education and further improve public environmental awareness.

Speaking of the landmarks of Macau, many people may think of the traditional A-Ma Temple, the Grand Lisboa Hotel, which symbolizes the casino, or the Macau Tower, the Saiwan Bridge. However, the meaning behind these surfaces rarely represents environmental protection. Therefore, it can be boldly conceived that the exterior of the waste incineration plant, especially the chimney part, can be beautified and become a new landmark in Taipa New City and Pac On after the new city reclamation. At the same time, many European and American cities are trying to use kitchen waste to generate electricity, that is, "green electricity". The kitchen waste generated by Macau's tourism and hotel industries has gradually become the most important urban waste in Macau. You can consider learning from them. Carry out food waste power generation, further increase transmission to CEM, and increase the proportion of Macau's own power supply.

ADVANCED RESEARCH

Although the discharge of waste is unavoidable in daily life, the quantity and method of waste discharge can be controlled artificially. At this stage, it should be combined with the pilot work of waste-free city construction and the promotion of urban domestic waste classification work nationwide. Vigorously publicize laws, regulations, policies, and systems on municipal solid waste management so that the concept of green development and ecological environment protection can be deeply rooted in the hearts of the people. Advocate residents' green living and production methods, reduce waste generation, realize waste classification, and promote resource recycling and reuse.

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