Environmental Economic Benefit Assessment Research of Recycled Phosphor in Obsolete CRTs

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Abstract
Lots of phosphors including rare earth elements (Y, Eu, Ce, Te, etc.) exists in the obsolete CRT TV sets and PC Monitor in recent years, on the other hand, the rare earth resources are scarce, and environmental pollution caused by primary rare earth ore mining is serious. To investigate the environmental benefits derived from recycling phosphors in CRT, the authors used treatment cost model for assessment from the viewing angle of environmental economic benefit. The environmental impacts of two rare earth elements flow modes: single flow mode and recycling flow mode have been evaluated respectively from both actual and virtual costs perspectives based on the treatment cost method. Considering the pollution and ecological destruction from the mining and the emission and mixing risks of pollutants from smelting, the treatment cost percentage of various stages and total treatment cost is estimated. It has been found that the virtual cost for the single flow mode is much higher than the actual cost. Moreover, the pollution control costs for two phosphor recycling processes have been studied as well. Compared with the single flow mode, the average actual and virtual savings for two recycling processes are estimated respectively, corresponding to the high cost of the single flow mode. Take 29 inch CRT as an example, the environmental benefits from the recycling flow mode save actual and virtual costs are estimated. Finally, the paper suggest the authorities support some fiscal subsidies to CRT recycle enterprise because their operating cost is higher than the economic benefits.

Keywords: Obsolete CRT; Phosphor Powder; Rare Earth; Recycling; Environmental Benefits; Treatment Cost Model

1. Introduction

The amount of TV sets before 1980 in China are less than 10,000 units, and this number increased to 128 million units in 2012(Habuer, Nakatani, & Moriguchi, 2014). At present, China has become into the biggest production, consumption and export country of the TV(Kahhat & Williams, 2012). In the prior production stage, most of TV were manufactured with a cathode ray tube (Cathode Ray Tube), namely CRT monitors, according to their average life projections, taking into account the factors of economic development and technological progress, China has entered a peak period of retirement, It is estimated that three times the normal amount of solid waste when discarded household appliances in recent years, the amount of scrap CRT televisions nationwide in 2013 reached 35 million units. (Kuo, 2013)

From a global perspective, all scrapped CRT in only 26.75% was recycled, landfill accounted for 59%, accounting for 14.75 percent were burned(Li et al., 2013). Preliminary estimates (temporarily only consider starting in 2001), has not been effective recovery of CRT TV in 2013 has more than 200 million units, if not interfered, 2020 will reach 270 million units(Kahhat & Williams, 2012). The output and cumulate can be seen in Figure 1.

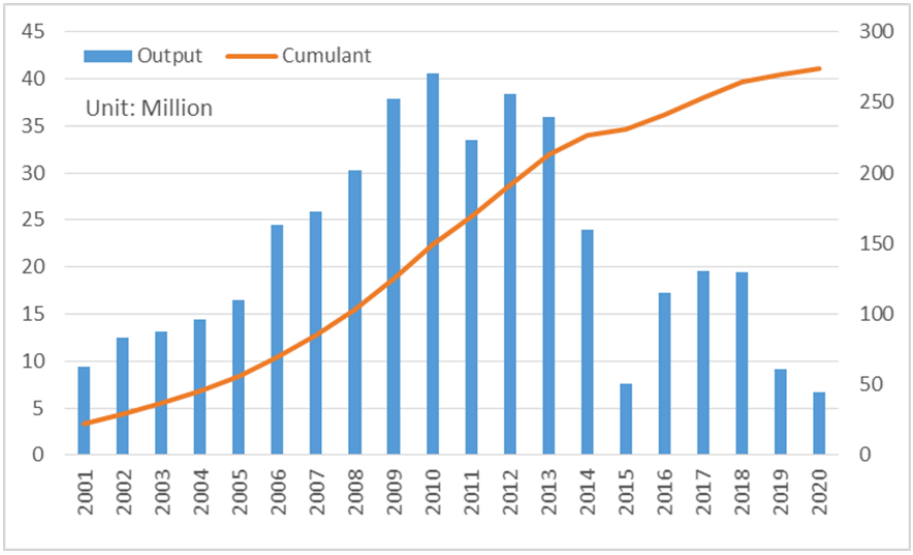

Figure 1 the output and cumulate of scrap CRT in China

A CRT contains 10-60g phosphor, which rare earth (RE)content accounted for more than 20% CRT phosphor quality, waste rare earth only produced in 2010 at least 80 tons(Mear, Yot, Cambon, & Ribes, 2006). RE as an important strategic non-renewable resources, because of its excellent optical, electrical, magnetic, and many other characteristics, are widely used in many fields of electronic information, national defense and so on. Although China is the most abundant rare earth resources in the country, but with the domestic rare earth consumption continues to increase, a large number of cheap exports and long-term predatory exploitation, resulting rare earth reserves plummeted(Song, Wang, Li, & Duan, 2012). According to the survey, China's rare earth resources have been from the 1970s accounted for 74% of the world total dropped to around 23% currently(Chung & Zhang, 2011). Therefore, the recovery of rare earths from discarded CRT phosphor, which can effectively improve

resource utilization and achieve sustainable development of rare earth resources, a move to save energy and protect the environment are equally important.

2. Research Method

This article uses the cost method of environmental governance, according to the disposal of the current situation in the main CRT phosphors, will be divided into single flow and recycling modes(Noon, Lee, & Cooper, 2011), for which emissions are calculated for each stage, come with their own environmental costs itemized total item value, after comparing the results produced using recycled environmental benefits.

A typical single flow of rare earth resources in CRT in the process is shown in the dashed box in the upper half of each unit as follows(Lim & Schoenung, 2010): natural rare earth mine through artificial mining, smelting, as the raw material entering the production enterprises, manufactured after CRT TV sales to consumers, reach retirement age discarded after use. In the rare earth mining, smelting and manufacturing sectors, mainly produce waste water, waste gas and solid waste, environmental protection enterprises in the investment part of the cost of treatment for most pollutants, will discharge a small amount of pollution. See

Figure 2.

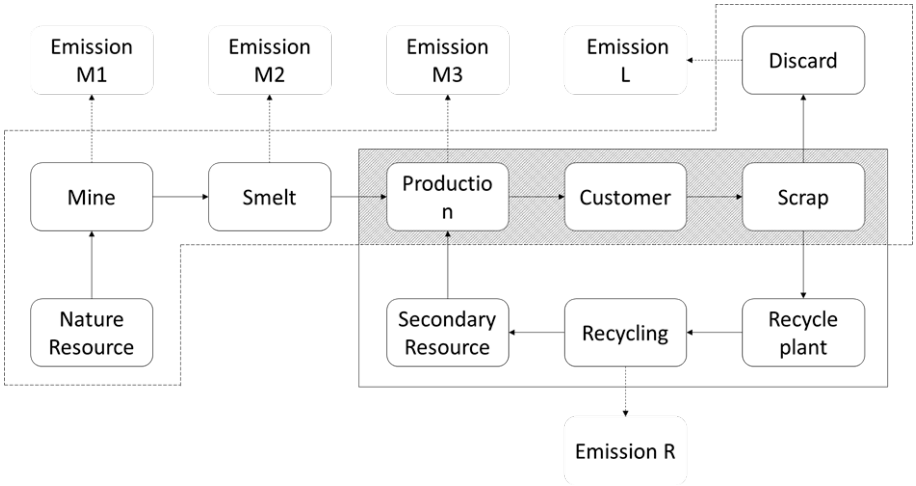

Figure 2 Emission of 2 types of flow-mode of phosphor in CRT

The process flow of a typical recycled RE in CRT is shown in the lower right part of RE shown by the solid black frame units(Ahluwalia & Nema, 2007): the consumer product flow by the manufacturer, after using, the waste recycling after the hazardous waste collected, using various types of technology for its recovery, and then processed into renewable resources, to the use of production enterprises, eventually forming a loop.

3. Result and Discussion

According to each mode of governance and the generation of pollutants per ton of RE emissions of various pollutants combine real and virtual control unit cost(Li, Richardson, & Bricka, 2009;Niu, Wang, Song, & Li, 2012;Xu et al., 2013), calculated to bring treatment costs per ton of phosphor various pollutants, the unidirectional flow patterns in the actual and imputed treatment cost was 329.2 with a 322.56 yuan / t, which is four times the former; actual and imputed treatment cost recycling process were 37.80 and 3.73 yuan / t, compared with the one-way mode, the actual savings and imputed treatment cost was 242.75 and 1313.16 yuan / t of phosphor, a total savings of 94.2% of the total cost of the environment.

Table 1 Total environmental costs of single-flow phosphor in CRT (cny/t)

Item		actual costs	virtual costs
M11:Mine stage waste	Waste water	12.19	22.96
	Waste gas	0.01	0.01
	Waste solid	240.20	540.83
	Sum up	252.40	563.79
M12:Mine stage ecology	Under mine	0.00	319.99
	Open mine	0.00	110.67
	Sum up	0.00	430.67
M2:Smelte stage	Waste water	63.75	10.05
	Waste gas	4.98	3.86
	Waste solid	8.07	4.75
	Sum up	76.81	18.67
L:Discard	Waste water	0.00	280.37
	Waste solid	0.00	29.07
	Sum up	0.00	309.44
Total		329.20	1322.56

Table 2 Total environmental costs of recycled phosphor in CRT (cny/t)

Item		actual costs	virtual costs
R: Recycle Mode	Waste water	12.75	2.01
	Waste solid	1.00	0.77
	Sum up	24.05	0.95
Total		86.54	9.4

4. Conclusion

To 29-inch CRT for example, the actual treatment cost savings phosphor after recovery was 0.49 yuan / set, imputed treatment cost savings of 2.63 yuan / set, this method of resource recovery and data for enterprise subsidies provided new ideas and method, the Government will be fully taken into account where there are price and other harmful elements to develop a scientific and reasonable subsidies.

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