

Development of Japanese Recycling Policy for Electric Home Appliances by the Addition of Plastics Recycling

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Introduction

The Japanese system for recycling electric home appliances requires manufacturers to achieve the designated recycling target yield rate (%; weight basis) for each appliance. Target appliances are air conditioners, cathode ray tube (CRT) TVs, refrigerators and washing machines. The recycling target yield rate is the minimum weight of recycled materials as a percentage of the total weight of collected appliances. The rate is defined for each appliance (e.g., 50% for refrigerators). In this system, recycling means that recycled materials have a positive value and can be sold on the market.

As we previously pointed out (Aizawa et al., 2008), liquid crystal displays (LCDs), plasma display panels (PDPs) and clothes dryers should be added to the target appliances. To add these appliances, new recycling yield rates are required. We also suggested that developed recycling techniques have enabled Japan to achieve high recycling yields since the beginning of the recycling system. Particular progress has been made in plastics recycling.

For the further development of the recycling system, new recycling target yield rates should be established for existing appliances. The purpose of this study is to propose new recycling target yield rates by including plastics.

Materials and Methods

The method used for current recycling target rates was applied. The current method is based on the average content of recycled substances in a target appliance and the recycling efficiencies for the substances (Life and Environment Council, 2001). The following equation was used to calculate the recycling target yield rate:

$$r = \sum_{k=1}^n c \times y$$

where “r” is the preliminary recycling yield rate, “c” is the content of a substance (weight/weight), and “y” is the recycling efficiency for a substance. “k” indicates each substance, such as iron, copper and aluminum. “k” also includes glass from CRT TV sets. “r” is calculated by summing “c” multiplied by “y” for each substance.

Recycled substances are assumed to be metals such as iron, copper and aluminum from all appliances and glass from CRT TVs. An 80% recycling efficiency is used for each substance except the aluminum of air conditioners. This means that 80% of glass from CRT TVs and metals from all appliances are considered to be recyclable. For the aluminum of air conditioners, a figure of 50% is used due to the difficulty in separating it from copper, which is used together with aluminum in heat exchangers. The compositions of several target appliances are used as 10 to

20 years old because appliances in this age range will be disposed of. The sum of the average content of each recycled substance multiplied by its recycling efficiency is rounded up to the nearest 5%.

The new recycling target yield rates are derived by considering following five points: 1) assuming the recycling process for the newly added appliances, 2) updating the recycling efficiencies for metals, 3) assuming recycling of plastics, 4) assuming recycling of circuit boards for PDPs and LCDs due to their high proportion by weight, and 5) using updated composition data for all appliances. For the last point, we used updated composition data provided by the Association for Electric Home Appliances, Japan (AEHA).

Results

1) Assumed process for newly added appliances:- We assumed the process for added appliances for a product-specific disassembly line as for existing appliances under the cooperation of the AEHA and the Japan Electronics and Information Technology Industries Association (JEITA). The process is assumed to be similar: hand-disassembly line, then selection, then shredding or crushing. Because the panels of PDPs and LCDs are complex structures, we assume that currently panels are not recycled. From the assumed recycling processes, we suppose that clothes driers can be added to the dismantling line for washing machines.

2) Updated yield for metals:- Recycling yields for metals and plastics are calculated from recycling results. From longitudinal studies, the total metals recycled as a percentage of total treated weight in recycling plants has been constant or gradually increasing for most appliances (Ministry of Environment, Japan (MoE), 2008). Considering the tendency to use plastics as a substitute for metals, it seems that actual recycling yields for metals have been increasing. A comparison of the assumed metal composition and recycling results for fiscal year 2006, that is, five years after the recycling system started, shows that approximately 90 to 100% of metals were recycled (Life and Environment Council, 2001: MoE, 2008). We use the mean value, 95%, as the recycling efficiency for metals.

3) Yield for plastics:- Recycling efficiencies for plastics are calculated from current results. There are no plastics recycling statistics for electric home appliances. However, there is a category “other recycled materials except metal and glass” in official statistics. Plastics are included in this category and are considered to account for a high proportion of the “other recycled materials”. The results show that the amount of “other recycled materials” has been steadily increasing (Table 1).

Unlike metals, the recycling feasibility of plastics is affected by factors such as color, type and state of deterioration. Possible factors affecting plastic quality are ease of dismantling, dirtiness, state of contamination, state of deterioration, type of plastic, whether composite or single, and the presence of paints or inflammable detergents. Therefore, the quality of plastics for recycling must be considered. We assume that target waste plastics are plastics that can be recycled to plastic products such as household appliances or electric appliances (substitutable for virgin plastics). In particular, Japan has already established a Japanese Industrial Standard (JIS) for plastics for use in electric home appliances, “marking for identification of plastic parts for electrical and electronic equipment (C9912).” This standard requires the marking of plastic parts such as flame retardants (FR), recycled plastics and dismantling assistance. In particular, the marking system includes plastics recycled by closed-loop recycling

(recycling from plastics of electric home appliances to plastics of electric home appliances). This means that Japan has already promoted effective plastics recycling on the manufacturers' side. Our calculation of new target rates that include plastics is meant to promote plastic recycling on the recyclers' side.

On the basis of information from recyclers, we assume high quality plastics to be plastics sold for more than 10 yen/kg (about US\$0.1/kg). The information obtained shows that the recycling efficiencies of high quality plastics are 2, 40, 20, and 40%, for air conditioners, CRT TVs, refrigerators and washing machines (Table 2). Due to a lack of data for PDPs and LCDs, we assume that the efficiencies for PDPs and LCDs are same as those of CRT TVs.

Table 1 Plastics recycling results for target appliances

	2001	2002	2003	2004	2005	2006	2007
Air conditioners	434 (1%)	1,487 (2%)	2,439 (3%)	3,185 (4%)	4,742 (6%)	5,552 (7%)	6,969 (9%)
CRT TVs	4,291 (5%)	5,756 (6%)	7,481 (8%)	9,823 (10%)	15,820 (15%)	21,645 (18%)	27,190 (20%)
Refrigerators	1,909 (1%)	4,890 (3%)	9,115 (6%)	10,888 (7%)	14,999 (9%)	22,762 (14%)	25,741 (16%)
Washing machines	828 (2%)	2,652 (4%)	6,365 (8%)	8,903 (10%)	15,190 (16%)	19,385 (20%)	21,709 (23%)

(Unit: tonnes.) (Sources: MoE, 2008; AEHA, 2007)

Note: Figures in parentheses indicate the rate for "other recycled materials" in total treated weight, including non-metal materials. The table shows the "other recycled materials" from annual recycling results since there is no category of plastics. However, most of the category can be considered as plastics on the basis of information from manufacturers.

Table 2 Estimated recycling yields of high or middle grade plastics

	Air conditioners	CRT TVs	Refrigerators	Washing machines
High or middle grade plastics	2%	40%	20%	40%
Low grade plastics	98%	60%	80%	60%

The table was prepared by the authors on the basis of information from manufacturers. Weight percent.

4) Yield for circuit boards:- Circuit boards in PDPs and LCDs accounted for more than 10% of the weight. Therefore, we examine the addition of circuit boards to the recycling target yield rate. Circuit boards can be roughly divided into two kinds. One is power boards, which control the electric power to an appliance; these are called "low quality boards" by recyclers. The other kind is control boards, which control visualization, and these are called "high quality boards" by recyclers. We add control boards which include precious metals such as gold. Information obtained from JEITA shows that control boards account for 24% of all circuit boards in LCDs and 20% of all circuit boards in PDPs. This result was obtained from the dismantling and counting by recyclers of 97 LCDs and PDPs actually collected by retailers. Because the boards were dismantled by hand, it is assumed that there were no losses through the dismantling process. Therefore, we use 24% and 20% as the respective recycling efficiencies of circuit boards in LCDs and PDPs.

5) New recycling target rates:- With the new recycling efficiencies and new compositions, the newly calculated

target recycling rates were higher than current rates by 10 to 15% (Table 3). The new recycling target rate for PDPs and LCDs is 50%. For CRT TVs, we did not calculate a new recycling target yield rate due to their unique situation: 1) the global shift from CRT TVs to PDPs and LCDs and 2) the expected large-scale replacement and disposal of TVs because of the shift from analog to digital broadcasting to be completed by 2011.

Table 3 Comparison of current and proposed recycling target yield rates

	Air conditioners	CRT TVs	Refrigerators	Washing machines	PDPs & LCDs
Current rate	60%	55%	50%	50%	-
Proposed rate	70%	55%	60%	65%	50%

Conclusion and Discussion

We propose new recycling target yield rates including plastics which are higher than the current target yield rates by 10 to 15%. This shows a possible new direction of plastic recycling policy in Japan. Management of FR by closed-loop recycling is one possible new policy, rather than continual chains of phasing out FR, examining the risks of new alternatives, and then phasing out the alternatives.

Plastics in TVs may contain FR. For example, Sakai et al. (2006) estimate that 27 kg of DBDE is emitted annually from recycling plants of electric home appliances in Japan. Information from manufacturers shows that no PBBs or PBDEs have been used by domestic manufacturers in LCDs since 2002 or in PDPs since 2007. A closed-loop recycling policy for plastics should be carefully implemented, in view of the risks associated with the alternatives.

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