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Abstract

This thesis studies Japanese PET bottle recycling system and its functions. Effectiveness of the existing models is evaluated and then problems and potential approaches for the sound material cycle are addressed. This study suggests that promotion of 3R—Reduce, Reuse and Recycling—can direct humans to reduce municipal waste and to conserve energy and precious materials. Implementation and people's awareness on 3R activities with regard to PET bottle recycling are investigated.

Polyethylene terephthalate (PET) bottle is one of the most commonly consumed and disposed plastic products in our daily life in Japan. The collection rate of recyclable PET bottles has been increasing and reached 77.9 percent in 2008. On the other hand, the production rate of PET bottles has also been steadily growing; 571,000 tons of PET bottles were consumed in the same year and it is about 100 percent of increase from 10 years ago. The growth of the production rate must be limited for the sound material cycle before promoting recycling activities. Therefore, PET bottle waste management is an important entry point for Japanese society to reconsider mass-production, consumption and disposal behaviors.

The objectives of this research are 1) to investigate existing PET bottle recycling methods and compare their environmental impacts; 2) to investigate people's consumption behaviors for PET bottles and propose a new beverage consumption method that has lower environmental impacts; 3) and to simulate economic applicability of the new beverage service in society. As a new beverage service, the beverage Refill model is considered. In this thesis, it is hypothesized that people can refill beverages into their own bottles or washed PET bottles at convenience stores or supermarkets. From the viewpoint of sustainability, it is important to investigate economic feasibility of the new drink system in addition to its environmental impacts. Thus, it is the final goal of this research to find out appropriate prices of the beverage Refill service in various external conditions.

Life Cycle Assessment (LCA) and Conjoint Analysis (CA) are the primary methodologies in this research. LCA is a research tool that estimates environmental impacts of a product or service from its production stage to disposal stage. CO2 emissions of the whole cycle of PET bottle (one kilogram) for each recycling method are calculated, including Refill. CA is a statistical research method that is commonly used in the various fields of social sciences and applied sciences, especially in marketing, production management and

operations research. It is conducted to statistically investigate social acceptance of proposed recycling methods based on answers from the questionnaire survey on the general public. Finally, results from two analyses are combined to simulate CO2 reduction potential for Refill service.

The following six PET bottle recycling models are the research objects for LCA: Incineration with energy recovery, Material Recycling, Chemical Recycling, Mechanical Recycling, Reuse and Refill. From the viewpoint of waste reduction, PET bottle recycling systems that enable us to use the same bottles for various times are recommended; therefore, Refill is a perfect approach in this regard. Sensitivity of LCA results are examined for each recycling method due to changes in distance, collection rate, and bottle weight. Credibility of the results is also examined by comparing with LCA results of the Ministry of the Environment. According to the results, it is revealed that Refill is the most environmental-friendly recycling method of all, regardless of external conditions for recycling.

For the second part of the analysis, a web-based survey was conducted for PET bottle consumers. The objective of the survey is to examine what kinds of external conditions affect people to use the beverage Refill service. Price, variety, and washing service are considered as determinant attributes. In this survey, CA is conducted by the Random Utility Model, applied with the Conditional Logit Model. CA is applied to estimate partial utilities for three attributes mentioned above. Also, Marginal Willingness-to-Pay (MWTP) for variety and washing service is estimated. It is clarified from the results that existence of washing service is very important when the beverage Refill service is introduced. Expectedly enough, people's elasticity toward price change is quite high. Variety is not the most important factor, but its effect could be considerable when the variety increase is significant.

Finally, diffusion of the beverage Refill service is simulated according to changes in price, variety and washing service. The diffusion rates of 50 percent and 80 percent are the diffusion targets to replace the existing recycling model. As a result, it is found out that usability of the beverage Refill service stands comparison with the current beverage sales when 20 kinds of beverage and washing service are available. However, it is necessary to note that the type of a bottle for Refill service was not specified in the survey. Therefore, existence of washing service may have affected the result more significantly than expected as actual cleanliness and appropriate bottle types are hardly imagined without an on-site experiment. For the future study, it is expected to investigate the diffusion model of the beverage Refill service at on-site experiments in various communities.