学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

A New Approach for Promoting Resource Recycling and Residual Waste Reduction in Malaysia
(マレーシアにおける資源リサイクルと埋立ごみ削減促進のための新しいアプローチ)

Malaysia is a developing country that highly dependence on landfills, as many developing countries in Southeast Asia. As the Malaysian population is still growing annually, it is predicted that resource limitation and landfill land scarcity will become more critical in the future. To resolve these issues, the Government of Malaysia has taken precautionary measures including mandatory recyclables separation at source. However, it is still the case that a very low amount of recyclables are separated at source. Hence, source separation is an indispensable option to increase the recovery of recyclables and to reduce residual waste going from directly disposed to the landfill sites. Economic incentive is a promising tool to enhance recycling. In Malaysia, an unique activity ”e-money incentive” started, where incentive for recyclables are given by e-money. The objectives of this study are to evaluate the effectiveness of the e-money incentives systems that implemented in Malaysia in terms of the amounts of collected recyclables and residual waste to landfill, to design a new incentive mechanism, and to predict the effectiveness of the new proposed incentive mechanism. In this study, we define residual waste as others wastes that are not separated for reuse or recycle including compost.

In the first study, we evaluated two e-money-incentive systems that were introduced by a private company. The two systems were ”Recycle for Life(RFL)” and ”Barcode”. We measured and compared the systems with other world practices to improve recyclables collection. The effectiveness of the ”Barcode” system was significant in reducing 3.4% residual waste generation compared with the RFL system (0.08%) because the Barcode system allowed residents who separate their recyclables at source, to be rewarded by e-money without the need for them to bring their recyclables to the designated points. Based on a comparative study with world practices elsewhere, Malaysia also needs to introduce a ”negative incentive system (charge system)” as well as ”positive incentive system”, such as the RFL and the Barcode systems, to enhance resource recycling and reduce residual waste.

In the second study, we designed a new incentive mechanism that we named as ’Zero Budget System’ to further enhance reduction of residual waste generation. This new system is hybrid approach to waste management that incorporates negative and positive incentives. In this study, we applied a two-step analysis via questionnaire (a) to identify attributes affecting residents’ acceptance of the charge system in Malaysia (b) to design the system. There are two waste management systems in Malaysia that are mentioned later in this study as a system of federalized and non-federalized states.

The first step analysis was conducted to clarify respondents’ willingness to pay and willingness to participate in the Zero Budget System, as well as to identify attributes that influence residents’ acceptance of the charging system via a questionnaire survey. The due to worldwide pandemic, this survey was conducted through an online platform. In total, the questionnaire managed to achieve 451 respondents. As the results we identified 5 attributes which consist of incentive amount, recyclables collection method, residual waste collection frequency, subsidy on waste bin and charge amount.

The second step analysis was also conducted by online platform using attributes and level obtained from the first. The form was distributed to the respondents that agreed to participate in the second questionnaire during the first. The response rate for the questionnaire was 40.7%. Through a conjoint analysis, we also found that the scenario with a residual waste charge (RWC) of MYR 0.20/kg for door-to-door recyclables collection (DtoDRC), monetary incentive for separated recyclables (MISR) of MYR 0.90/kg, residual waste collection (RWCol) twice per week, and 100% subsidy for waste bins (WB) showed the highest utility function for federalized states; for non-federalized states, the scenario

that showed the highest utility function was RWC of MYR 0.20/kg, DtoDRC, MISR of MYR 0.90/kg, RWCol three times per week, and a 50% subsidy for waste WB.

In the third study we conducted another online survey to clarify respondents' willingness to separate their recyclables at source based on the incentive and charge amount. In total, the questionnaire managed to achieve 174 respondents. As the result through ordered logistic regression analysis, we found that dummy for highest incentive amount for separated recyclables at MYR0.9/kg showed the highest coefficient and low p-value for all type of recyclables in both federalized and non-federalized states. This means that respondents' willingness to separate are strongly dependent on incentive amount that worth the effort. In the meantime, we also observed positive coefficient if charge amount, reduce from MYR 0.2/kg to MYR 0.1/kg. That indicated that respondents are unlikely to separate their recyclables if the charge amount increase. This because most respondents didn't see that source separation as a practical way to save their disposal cost.Finally, we predicted that the system is effective to reduce residual waste generation from 8.4% to 13%. The reduction percentage of 'Zero Budget System' are higher than currently implemented positive incentive only systems (RFL and Barcode System) that only effective to reduce residual waste from 0.08% to 3.4%. This mean, a hybrid system which cooperate positive and negative incentive will further improve resource recycling and residual waste reduction.

In conclusion, this study proved that 'Zero Budget System' is an effective approach to promote resource recycling and residual waste reduction in Malaysia. The system also had potential to be implemented in other developing countries especially to those that already adapted positive incentive system to further enhance resource recovery and residual waste reduction.