中国大連 国際資源循環リサーチセンター	
題目	廃プラスチックリサイクルシステムの評価手法の高度化に関する研究
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1. Background

Japan is known as the world's largest plastic waste and plastic scrap net exporter (Fig. 1). Since the China has enforced the plastic waste import ban in 2018, Japan had to upscale their plastic waste recycling capacity. In this research, the sustainability of plastic recycling is viewed from the environmental, energy, and policy perspectives. From the environmental and energy perspectives, we compared the environmental impact as well as the energy consumption of Japan's mechanical and recycling technologies. From the policy perspectives, we examine the indirect effects of national environmental policy on plastic waste recycling.

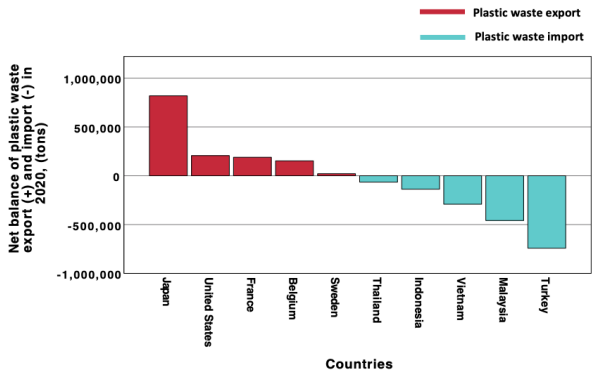


Fig. 1 Japan as the world's largest plastic waste and plastic scrap next exporter, data from United Nations Comtrade, 2022

2. Research results in academic year 2022

(1) Environmental impact comparison of mechanical and chemical plastic waste recycling

Our comparative study on mechanical recycling (MR), coke oven chemical recycling (CR), and gasification CR for plastic waste showed that in terms of global warming potential (GWP), MR is the best among the three technologies. On the other hand, coke oven CR is significant on its fuel scarcity potential (FFP) because it can reuse energy from its byproduct to partially suffice its operation. Finally, Gasification CR has significant effects on water scarcity potential (WCP) because it consumes as well as reuse underground water for its industrial water supply and steam requirements.

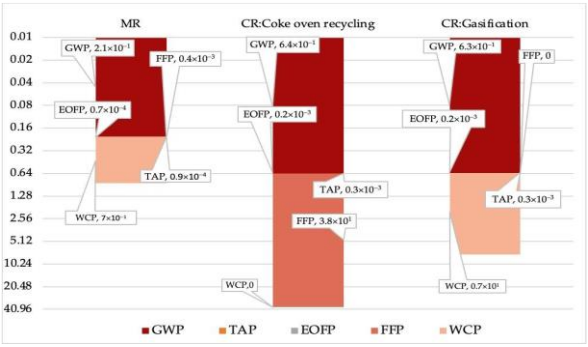


Fig. 2 Environmental impact comparison of the three technologies

(2) Energy reduction potential of various plastic recycling methods

The reuse of byproducts as shown in Fig. 2 led to the need of comparing energy reduction potential of the available technologies. We found that the performance of actual energy reduction of plastic recycling with various technologies in Japan over the past 10 years do not change much. However, there is a tendency of increase from the MR technology and decrease from the gasification CR technology (Fig. 3).

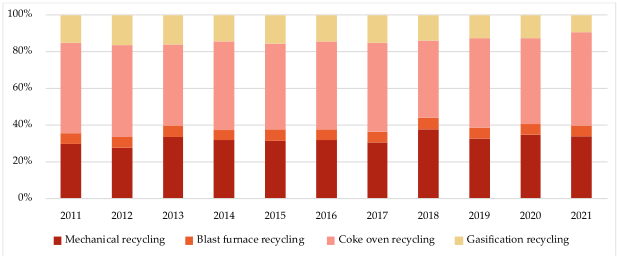
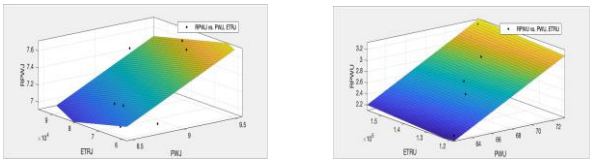


Fig. 3 Energy reduction of plastic waste recycling methods, data from The Japan Containers and Packaging Recycling Association, 2022

Although the environmental impact and energy findings, showed the superiority of MR. Our qualitative studies showed that MR do not produce the same high quality of recycled products produce by CR technologies. Furthermore, CR technologies has the potential to be integrated in the circular economy which may lead to more sustainable society.

(3) Indirect effects of national environmental policy on plastic waste recycling

From the policy perspective, we compared the national environmental policy of Japan and the United States, as these two countries are the world's major plastic waste net exporters (Fig. 1). We construct an ordinary least square (OLS) regression model using the amount of plastic waste outflow or discharge and environmental tax revenue as the independent variables, and amount of plastic waste recycled as the dependent variable. We found that there are significant correlations between the dependent and independent variables in both countries. However, the strength of correlation is higher in the United States (R^2:1.00) than in Japan (R^2:0.87). This finding indicates the existence of other unknown independent factors, outside of the tax revenue and plastic waste feedstock, that contributes to plastic waste recycling performance in Japan.



(a) (b)

Fig. 4 OLS regression goodness of fit results (a) Japan (b) United States

3. Next year's research plan

Following up findings in our academic year 2022 studies, in academic year 2023 we will examine further about the efficiency and effectiveness of plastic waste recycling in Japan as well as identifying possible roles of smart technologies adoption. Specifically, we will seek the determinants of plastic waste recycling performance of Japanese prefectures, identify strategies to reduce the percapita plastic waste generation of the Japanese consumers, and analyze the readiness levels and distribution of smart waste technology development globally.

4. Research Publications

1. (Scopus) Shan, C.; Pandyaswargo, A.H.; Onoda, H. Environmental Impact of Plastic Recycling in Terms of Energy Consumption: A Comparison of Japan's Mechanical and Chemical Recycling Technologies. Energies 2023, 16, 2199. https://doi.org/10.3390/en16052199
2. Shan, C.; Pandyaswargo, A.H., Onoda, H. The Environmental Policy Latent Effects on Plastic Waste Recycling: A Comparison Between the United States and Japan. The 3R International Scientific Conference on Materials Cycle and waste management (3RINCS2023), Kyoto, Japan, 13 – 18 March 2023