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Best Practice of Reverse Logistics System for Plastic Waste Management: A Cross-Country Comparison

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Abstract- Plastic waste is one of the emerging environmental issues in developing country, particularly when the municipal solid waste management has not been carried out appropriately. Reverse logistics can be integrated into municipal solid waste management since it deals with the processing of the returned goods. To develop such management system, the best practice of plastic waste management system and its actors were identified from three developed countries that have more than 80% recycling rate. In the system, not only governmental agency is involved, but also private sectors as well as the residents who actively segregate their waste into some classification. The intermediate facility such as material recovery facility (MRF) is needed in this system in order to ensure the quality of plastic recycling materials. The framework of plastic waste management in developing country should be carefully developed to achieve its optimum efficiency and effectivity. It includes social, economy, and technological approach to make sure that the system can be carried out according to the action plan as well as enacting and enforcing the regulation.

Keywords- *Plastic Waste, Solid Waste Management, Reverse Logistics, Best Practice*

I. INTRODUCTION

Municipal waste management cannot be separated from the concept of city logistics where this concept is the development of the concept of green supply chain which consists of green logistics and reverse logistics. This program is realized in the form of waste minimization, waste reuse with recycling, alternative energy use, reduction of greenhouse gas effects and many other concepts. Solid waste management goes into reverse logistics management because it deals with the processing of returned goods, as well as plastic waste must be processed before being used again so that the problem of managing plastic waste can be considered as a problem of reverse logistics management. This program can be applied to a big city such as Semarang City, Indonesia. Indonesia is the second largest ocean polluters due to plastic waste generation and lack of proper waste management (Jambeck et al. 2015).

Reverse logistics is considered as one of the best strategies for the proper management of all types of waste because it is able to provide an efficient sustainable planning strategy and generate economic benefits (Pati, Vrat, and Kumar 2008). Reverse logistics is a process in an organization that includes an inverse distribution process (from the customer to the manufacturer) which causes the flow of goods and information to flow in the opposite direction from forward logistics activities. It supports the return of goods to be recycled, reused or destroyed in order to recover an appropriate value of the waste (de Brito and Dekker 2004). Therefore, based on the environmental aspect, reverse logistics also contributes to the reduction of hazardous waste, stockpiling and conservation of raw materials. Technically, this model indirectly supports the government's efforts as stated in the Regional Office Work Unit Strategic Plan (Renstra SKPD of Semarang City), namely the reduction of the volume of waste distributed to the final disposal and the involvement of related parties in sustainable integrated waste management.

The implementation of reverse logistics strategies in the management of municipal plastic waste becomes a very expensive and complicated agenda because it involves several activities across sectors (community, government and private) by providing various facilities that can improve performance along the system flow. So that in the management of plastic waste requires a framework, maintenance and repairs that are appropriate for all waste production operations, collection and storage, shipping and transportation, processing and disposal. This situation encourages the development of a model for the plastic waste management system in the city of Semarang. At the beginning of development stage of this model, an overview of the ongoing plastic waste management flow to find out the activities and actors involved to analyze the needs of the waste management system infrastructure based on reverse logistics systems is necessary. Various combinations of reverse channels structures and the role of channel members involved in activities along the flow of reverse logistics systems has been identified by Pohlen and Farris (1992). Implementation of reverse logistics in the management of plastic waste has also become the agenda of several developed countries such as

Denmark, Norway and Sweden. The practice results in a relatively high recycling rate in the world compared to other countries. They actively involve the private sector (importers and plastic producers) in the plastic waste management scheme either through financing schemes or directly involved in technical operational management. However, the success achieved by these three countries cannot be implemented directly in the Semarang City (Indonesia) because of differences in dimensions such as economy, culture, regulation (legality), so that in the design of plastic waste management models in Semarang adjusted to the situation or characteristics of the city, especially in institutional aspects which emphasizes the effect of reverse logistics on the reduction of the volume of plastic waste wasted in the landfill. Still, an in-depth review of the implementation of plastic waste management by reverse logistics is discussed in this paper.

II. Cross-Country Comparison

A. Denmark

In 1978, Denmark introduced the world's first recycling law. Since then Denmark's recycling rate has continued and at least 67% of the total amount of garbage in Denmark is currently recycled. While the plastic packaging beverage recycling rate is 89% which makes Denmark's deposit return system one of the most efficient collection systems in the world, only 5% of Danish waste ends up in landfills. This makes Denmark one of the best recycling countries. It is undeniable that the city government plays an important role in the success of Denmark's national recycling. The government is given autonomy to determine a plastic waste management system that is in line with regional characteristics and pro-active in building collaboration mechanisms between waste management companies and producers of plastic recycling products (see Figure 1).

Most of the recyclable plastic waste is reprocessed abroad, while Danish, private and public companies separate the plastic waste based on the polymer before being exported. Plastic waste is now a national priority and in the city collection scheme always strives to increase the collection and sorting of plastic waste from the beginning, so that community participation in separation becomes very important. Although collection is the responsibility of the local government, usually in technical implementation the local government contracts a private waste management company to carry out collection and transport operations. The local government charges the community for trash bins and all operations ranging from collection, transportation and sorting.

Unlike plastic packaging waste that is fully managed by the local government, PET bottle type plastic waste is recycled in two ways. Figure 2 shows the PET bottle managing system. The first system, PET bottles in its management use the extended producer responsibility (EPR) scheme. The EPR scheme gives full responsibility to bottle producers and importers in managing their used bottles. In carrying out this executive order, bottle manufacturers and importers located on the Danish market are under the "*Dansk Retursystem A/S*" organization which regulates all operations from collection to recycling. Whereas the second system, PET bottles were returned to the producing company to be washed and reused by the factory.

B. Norway

Plastic waste management in Norway uses the concept of expanding producer responsibility or commonly referred to as extended producer responsibility (EPR) which is a policy approach that requires producers to be responsible for the entire product cycle and packaging of the products they produce. Companies that have the potential to produce such waste are both financially and physically responsible for the products and packaging reached of its end-of-life. Arrangements regarding EPR in Norway were enacted in 1995 and renewed in 2003, where the agreement applies to all plastic packaging for all types of products but does not include packaging containing hazardous chemicals.

To simplify the process of implementing EPR, packaging manufacturers and importers in the Norwegian market formed the *Grønt Punkt Norge* organization on behalf of *Plastretur*. *Grønt Punkt Norge (Plastretur)* is responsible for managing funds from fees paid by plastic packaging manufacturers and importers and handling the collection process at the recycling station and the recycling process of the plastic packaging. Meanwhile, the city government in Norway is responsible for collecting plastic packaging waste that has been separated from households to recycling stations. The city government is given full autonomy to decide what kind of solid waste is collected separately and what solid waste collection system is chosen. Many cities in Norway are relatively small in area and to fulfill their responsibility for plastic packaging, many of which form collaborative processing of plastic waste between regions.

Same as Denmark's, PET bottles have their own recycling flow system, not being integrated to the flow of packaging plastic waste recycling systems. However, if in Denmark PET bottles use the EPR scheme, in Norway PET bottles for drinks are not part of the EPR agreement even though they both apply a deposit return system. In practice, this deposit-based return system is managed by an independent organization called *Norsk Resirk A/S*. This organization does not have a business relationship with producers of PET bottles.

C. Sweden

Extended Producer Responsibility was introduced by the Swedish Government in 1975 as an executive order to producers to be responsible for the waste they produce with the intention of being able to be managed appropriately from environmental aspects and the sustainability of resources. Before the creation of a product begins, the producer must know how the waste that is the result of the production process is treated, as well as how the product is managed when disposed of.

Until 1994, plastic packaging manufacturers and importers were legally responsible for regulating their collection and recycling systems for packaging plastic waste that entered the Swedish market. Producers are responsible for the collection and processing of packaging waste that is disposed of in their collection and recycling systems. Whereas the collection and processing of packaging waste that is not sorted in a mixture of

other solid waste fractions remains the responsibility of the city government. The introduction of the regulation on Producer Responsibility 1994 SFS also requires all citizens in Sweden to participate in recycling waste and sorting their garbage from the household level. This has led to the development of a number of different source sorting and sorting systems in each city (Dahlén et al. 2007).

To facilitate actors under the responsibility of EPR, a service organization called *Förpacknings-och Tidnings Insamlingen* (FTI) on behalf of *Plastkretsen* was formed. Nearly 10,000 companies that market plastic packaging products (excluding PET bottles) on the Swedish market are affiliated with FTI. In addition to the duty to ensure that the manufacturer's obligations are fulfilled, FTI is also responsible for carrying out the operational work of their services. Although, FTI is the main actor representing packaging producers and importers in the Swedish market, there are other actors who fulfill the responsibility of producers for their customers, namely TMR AB. The framework of this system can be seen in Figure 3.

For cities that use a kerbside collection system in their collection scheme, each household has a multi-compartment (four-compartment) container with two containers per household and a total of eight compartments. Each container has a compartment with two different sizes, two smaller and two larger.

The organization of the waste fraction in the first container was filled with residual waste, food waste, colored glass and packaging paper waste. Food waste and colored glass are disposed of in two smaller compartments. The first container is usually emptied every second week. Then the second container contains metal packaging, transparent glass, plastic packaging, and newsprint. Metal packaging and transparent glass are sorted into two smaller compartments while the second container is usually emptied every month (Nordic Council of Ministers 2014).

Same as Denmark's and Norway's, PET bottles have their own recycling flow system called deposit return systems and PET bottles for drinks are not part of the EPR agreement. When companies and importers sell drinks using PET bottles to the store, they charge a bottle per bottle (SEK 1 or SEK 2 depending on the size of the bottle) and administrative costs. When consumers buy the drink, they are subject to a deposit and the grocery store gets the amount of money they pay to the company and importer. As long as the bottle is not returned to the deposit system, the deposit is still paid by the consumer. The grocery store is compensated by *Returpack* for disbursement. *Returpack* is an organization that is responsible for implementing this deposit-based return system (Nordic Council of Ministers (NORDEN), 2014).

Countries that have developed economies and high GDP per capita continue to conduct research and development of environmental mitigation primarily focusing on reducing environmental impacts through processing plastic waste and conserving resources from plastic waste. Based on this, fiscal policies in these countries are targeted at environmentally acceptable plastic waste disposal lines. Such an approach is lost in developing countries and wherever the offer is not fully effective (Zhang, Keat, and Gersberg 2010).

III. Overview of Plastic Waste Management System

A. *Storaging*

In developed countries the practice of garbage collection is more prominent through separating waste efforts from its sources, while in Semarang City people still keep the mixed waste. Waste disposal before collection by the city government for proper disposal has attracted attention as a policy issue. In many countries, especially developed countries, legislation and policy schemes do not only target household waste services but also focus on economic efforts to minimize plastic waste. In developed countries local communities have introduced household plastic waste collection systems by using the collection system and charging fees for services and the objective is to minimize the generation of plastic waste. As in Denmark there has been an increase in recycling rates of 25% due to the introduction of packaging plastic waste collection with a kerbside collection system that has improved sorting efficiency. The process of storage and storage of plastic waste is intended to minimize risks to health and safety against access by pests and prevention of environmental pollution.

B. *Collection*

Collection of household waste is one of the most difficult operational problems faced by local governments in waste management of most cities in developing countries. The local government only serves a portion of the urban population so that the low income population in urban areas is underserved which in many cases is not accessible because of the minimal width of the road. Often the collection points are inadequate, encouraging people to dispose of garbage into urban and suburban environments, creating a large risk of water resources and public health.

C. *Recycling Process*

The plastic waste management sector in developed countries has been developing towards resource management approach aimed at conserving resources through intensive and coordinated efforts in developing the recycling industry (Zhang, Keat, and Gersberg 2010). The study conducted by Sonesson (2000) European countries prefers to manage plastic waste by reusing and recycling so that the economic costs charged contribute positively to employment.

IV. Reverse Logistics in Waste Management

Reverse logistics is different from waste management in general because it focuses on adding value to the product to be recovered and then the results enter a new supply chain while conventional waste management management mainly only involves the process of collecting and processing waste products that are not through new uses (de Brito and Dekker 2004). Reverse supply chain is a network of activities involving the process of reuse, recycling and final disposal of products including related components and materials. Williams

et al. (2008) mentioned that based on economic perspectives, reverse logistics provides opportunities for opening jobs and generating income for people involved in a series of activities on the network, while socially this industry contributes to the development of industrial technology along with multiple sectors. sector that is interested in recycling waste.

The use and reprocessing of products into supply chain flows requires a process of separation and sorting to produce new products that are often of lower value (Sarkis, Helms, and Hervani 2010). Hu, Sheu, and Huang (2002) argued reverse logistics as a basic concept to improve and protect the environment from hazardous waste and emphasize this in the definition of reverse logistics as a logistical management process consisting of planning, managing, and controlling waste flows for reuse or final disposal. Kinobe, Gebresenbet, and Vinneras (2012) illustrated the basic reverse logistics related to waste management in handling the return of unwanted products to the center of product recovery facilities (material recovery facility) to be processed, stored and then recycled and reused to various flows in new markets.

Based on Pohlen and Farris (1992) stated that the reverse logistics network in plastic recycling requires additional facilities that can perform special handling or processing. Examples of specialties that are carried out include the establishment of material recovery facilities (MRF) to sort and store recycled goods or act as brokers in connecting supplies (consumer or industrial producers) to the source of demand (end users). The source or producer of recycled materials that do not have the sorting capability or market intelligence, can rely on MRF to perform this function.

This is in line with the experience of North America (1980-1990) which showed that collecting some recycled waste material was better than collecting single material waste in several types of flow. Post collection in material recovery facilities (MRF) is considered more profitable because centralized collection will result in higher flow densities and transport is relatively easy to do. Likewise in the flow chart of the waste recycling process for Quezon City, Philippines, the material recovery facility (MRF) in Baranguays, plays a key role in processing materials to increase added-value waste.

Rutkowski (2008) in Rutkowski and Rutkowski (2017) explained that the Intermediate Recovery System (IRF) facility in the low and middle income countries whose two recycling chains are linked by the informal sector was played by scavengers and collectors who collected goods. recycled goods from trash bins, roads, landfills, households and companies and treated them then sold them as raw materials to the recycling industry. Figure 4 shows the productive chain of this recycled waste. Thus, the Material Recovery Facility (MRF) is one of the important facilities in increasing the recycling of plastic waste as well as the provision of quality of plastic recycling materials. In accordance with Semarang City Government Regulation No. 6 of 2012 it is stated that waste management has the aim of improving public health and environmental quality and making waste as a resource not just a mere waste. By improving the transfer depo (integrated temporary waste processing facility or TPST), the best practice of plastic waste management system can be achieved. The first step is to educate the society for encouraging them to separate their waste. This is the hardest part of this system because it involves social factor. The role of government, law enforcement, and knowledge are the influential factor in behavior changing of the citizen (Ulhasanah and Goto 2018). Meanwhile, the local government should be the one who enforce the regulation of solid waste management. According to Indonesian Act No. 18/2008, the extended producer responsibility has to be enacted which is in accordance to Denmark's practice. This is important particularly in managing plastic packaging waste.

V. Conclusions

Plastics are inherently recyclable and become an alternative in reducing plastic waste disposal in the open. In addition to creating benefits in the environmental aspect, recycling also has the potential to create economic benefits at the macro scale if managed properly because recycling can produce plastic raw materials amid the scarcity and increase in the cost of virgin plastics. The integration of reverse logistics strategies in the management of municipal plastic waste requires a number of system infrastructures including standardization of good storage between plastic waste and other solid waste and collection systems that are in accordance with the characteristics of settlements in Semarang City.

Further development of the plastic waste management model should be accomplished by integrating reverse logistic and municipal solid waste management. The existing management system, amount of generated plastic waste, involved actors, current regulation, actors, and economic feasibility are the key factors to develop the framework and the model.

Acknowledgment

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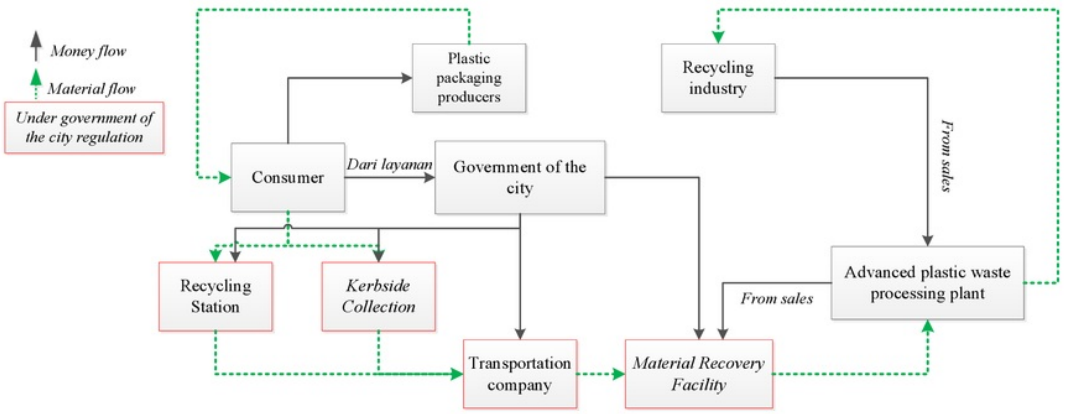

Figure 1. Material and Money Flow of Recycling System in Denmark

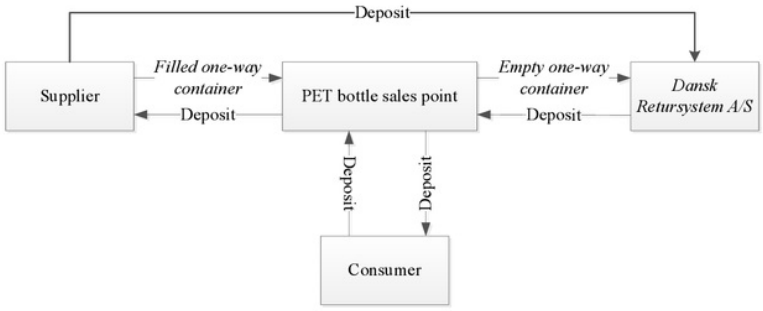

Figure 2. Deposit Return System in Denmark (EPR scheme)

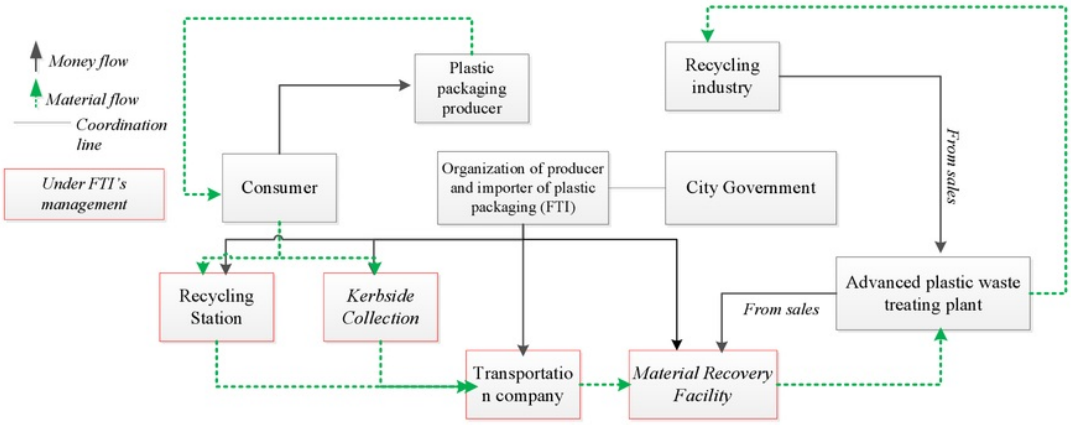

Figure 3. Material and money flow in plastic packaging waste management system in Sweden

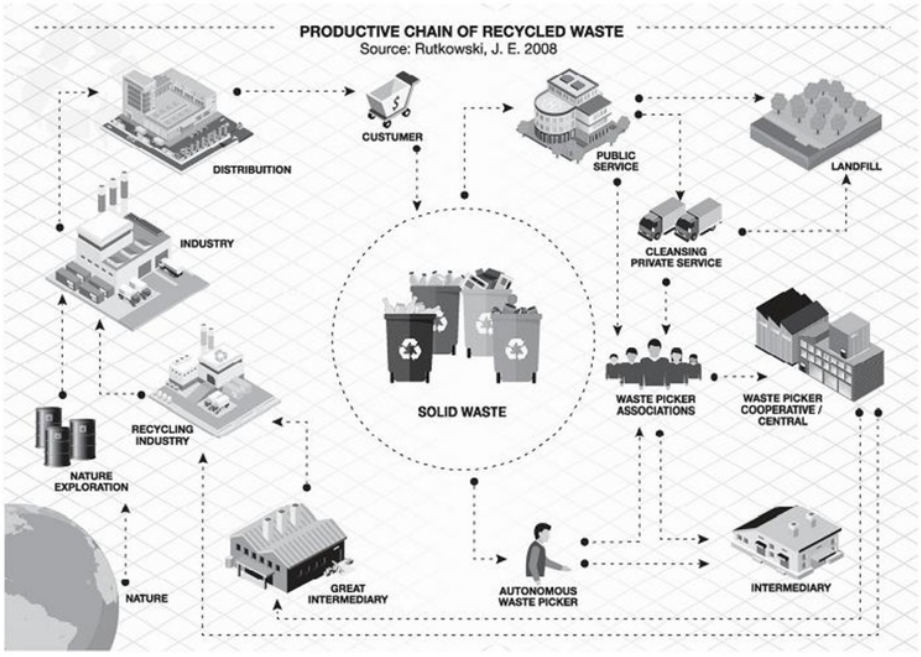

Figure 4. Productive chain of recycled waste (Rutkowski, 2008 in Rutkowski and Rutkowski, 2017)

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