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Operational characteristics and performance evaluation of the ELV recycling industry in Taiwan

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ABSTRACT

In order to realize a circulative society, enhancement on resource productivity has been sought in many ways to upgrade the recycling industry, such as implementing governmental regulations, building up control and management schemes, and improving treatment technologies. While some positive progresses have been achieved, the information on operational conditions of recycling business is seldom addressed. This study tries to examine the operational characteristics of recycling and treatment industry for end-of-life vehicles (ELVs) in Taiwan and its relationship to recycling performance. Geographical relationship between dismantlers and shredding plants are discussed to demonstrate the influence of market size on a self-sustained recycling system. Information on 22 out of the 245 registered dismantlers and five shredding plants were retrieved from official database and on-site visits were conducted to confirm the data regarding basic setup, facility capacity, and operational conditions of the selected business. Indicators representing production capacity and power efficiency were postulated for performance analysis. Monthly production capacities of the dismantlers surveyed in this study ranged 0.17–73.14 units/worker and that of the shredding plants was 67.87 units/worker in average. Power efficiencies of the shredding plants were found in the range of 42.82–56.61 kg of ELV processed/kWh, or 17.66–23.36 kWh/ton. For shredding plants, power efficiency decreased with increase of power consumption and lower recycling rate likely happened at lower production rates. This study introduces a preliminary approach to examine the operational characteristics of ELV recycling business which can be useful in planning of ELV recycling strategy. It is suggested that existing shredding plants and dismantlers need to enhance their competitiveness by improving the operational performance. Energy management in the ELV shredding plants deserves more attentions for future improvement.

1. Introduction

Traditionally recycling business has been positioned by general public as scavengers to remove wastes discarded in the society. It survives with the need for someone to take care of the throw-away. Recycling business for end-of-life vehicles (ELVs) has found its niche as the automobile industry grows. For environmental management purpose, environmental compliance has been the first concern when the regulatory authority came in place to prevent potential secondary pollution. As resource conservation and material recycling emerges to become the prevailing goal worldwide, the business has to grow along with the rising value of recycled materials. Recycling of ELV is a vivid example for evolution of a resource recycling society. A well-developed ELV recycling industry can effectively facilitate various channels of materials flow in shaping up a circulative society. When EU announced her decisive attempt, Directive 2000/53/EC (EU, 2000), by setting the ELV recycling recovery rates at 85% and 95% before 2015, the industry has been working aggressively to meet the target (Kim et al., 2004; Daniels, 2007; Gerrard and Kandlikar, 2007; Beck, 2009; Sakai et al., 2011; Santini et al., 2011). Although the recycling schemes may vary in different countries, necessary role-players in the system are quite similar. For materials flow, it involves collectors, dismantlers, shredding plants, final disposal facilities, recyclers and dealers of reused and secondary products, and the consumers. Economic tool is often introduced in one form or another to encourage the market mechanism in different recycling schemes. Description on several recycling systems and review of the policy and strategy development which lead to current environmental performance and projections of treatment and recycling goals are found in

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literatures (Mazzanti and Zoboli, 2006; Smink, 2007; Kim, 2007; Chong et al., 2009; Chen et al., 2010; ARC, 2011). Although it does not directly affect either automobile industry or ELV recycling business in Taiwan, EU Directive 2000/53/EC is considered as a milestone in advancement of ELV recycling and a benchmark for policy makers to examine the performance of domestic ELV recycling business. The automobile industry also reached voluntary agreement on design and production which is compatible to the principles of the directive. Concerning the performance of the ELV industry, there are studies dealt with operational activities in shredding plants. Das et al. (1995) evaluated energy consumption patterns in the life cycle of vehicles and pointed out that changes in material composition to reduce the weight of vehicles has resulted in less fuel consumption during the vehicle use stage. They projected that retrieving heat value of automobile shredded residue (ASR), which account for 25% by weight of shredded materials in the US, by incineration could contribute to energy saving at the recycling/waste stage of vehicles. Electricity consumption was found to be the major contribution to climate change in ELV recycling. Coates and Rahimifard (2009) modeled the efficiency of shredding plants with material separation capacities. The authors noted that, as separation technologies are adopted to recycle various plastic and metallic materials used in production, facility specific industrial data are needed to validate process performance in practical plant operation. While pursuing higher recyclability and recoverability seems to be the ultimate goal, Reuter et al. (2006) indicated that recycling legislation should be harmonized with the flexibility of plant operation, consumer behavior and product design. Optimal performance of a recycling system shall be evaluated in view of operation of plants from economic and environmental perspectives. A market/industry-driven approach is required to sustain the system. In Taiwan, a recycling system has been established with recycling fund as subsidies for designated items, such as ELVs. Operation of recycling business is closely related to the domestic regulatory and market environment.

A better understanding on the business from economic and operational aspect can help the business to transform into a modernized industry and assist the government to incorporate practical strategies with the market development. This study tends to examine the operational characteristics of two essential players in the ELV recycling business, i.e. dismantlers and shredding plants by using production capacity, power efficiency, and recycling rate as indicators. Power consumptions in shredding plants are compared with power efficiency and production capacity. Opportunities for future improvement are suggested and discussed.

2. Methods and approaches

2.1. ELV recycling scheme in Taiwan

Before waste vehicles have been announced as one of the regulated recyclable items in Taiwan, most of them were abandoned randomly which exerted severe environmental hazards and deteriorated the landscapes seriously. Since the establishment of Resource Recycling Fund in Taiwan in the 90s, waste vehicles have been one of the items targeted for recycling by the Taiwan Environmental Protection Administration (TEPA, 2009). Under the regulatory framework, ELV recycling and treatment is subject to specific permission from administrative agencies. The application procedure constitutes a mandatory registration with local government and an optional registration as a recycling and treatment business. The latter registration is required to be qualified for recycling subsidies from the Recycling Fund Management Board (RFMB) of Taiwan EPA. Registered business must install necessary equipment and perform operations specified and approved

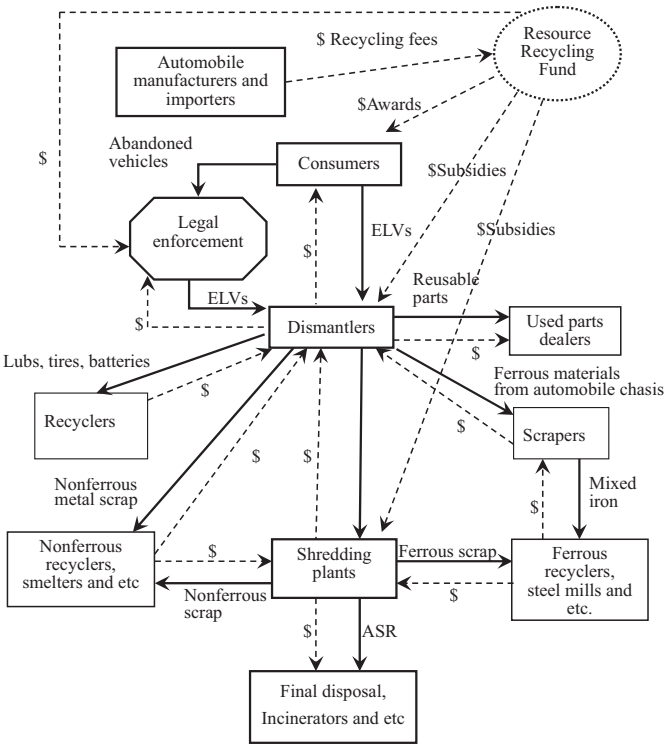

Fig. 1. Recycling scheme and related parties of ELV in Taiwan. Dashed lines represent monetary flows and solid lines represent material flows. Monetary flow includes subsidies to different receivers and transactions for trading of recycled items.

by the competent agency (TEPA, 2010). As of 2011 there were 245 dismantlers and five shredding plants registered to receive subsidies from the Resource Recycling Fund. These businesses, operating under the ELV recycling scheme, Fig. 1, are required to submit operational data and receive regular auditing and monitoring administered by the RFMB to ensure that their operation meet the regulatory requirement (TEPA, 2008a,b). Dismantlers are required by law to separate designated automobile parts, including tires, lubricants, refrigerants/coolants, and lead-acid batteries, from the ELV before the retired vehicles are transported to shredding plants for further treatment. Change in sales of vehicles and motorcycles and number of waste units recycled during the period of 1997–2010 reveals that the size of ELV market in Taiwan has been relatively stable in recent years (Fig. 2).

Dismantlers report monthly to the RFMB on the quantity of ELV they processed, as well as types and quantities of regulated recyclable items handled. Shredding plants are required to upload their daily operational records to the database center managed by the RFMB through internet. Volume of waste vehicles, quantities of due-recycled items, and weight of recovered materials are audited and verified by third parties contracted with the RFMB.

2.2. Sample selection

Since field investigation to cover all the business in the registry was not feasible in this study, a sampling procedure was proposed. First, all the 245 dismantlers were ranked in descending order by number of vehicles processed annually which are reported to the RFMB. Then, dismantlers with a reasonable working force, i.e. at least four workers including the owner, and show relatively higher capacity, i.e. monthly processing capacity above 100 vehicles and cumulative yearly capacity exceeding 1000 vehicles in the past three years, were considered. There were 61 dismantlers meeting the above criteria. One sample was picked from every six