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End-of-life Electrical and Electronic Equipment Remanufacturing Prospects in Malaysia

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Abstract

Organized remanufacturing has to be an important alternative option instead of throwing-away of used electrical and electronic equipment's (EEE) in order to save our mother-nature and recover useful resources. The increase in awareness of environmentally conscious manufacturing making the remanufactured products most popular. The significant benefits of remanufacturing are: greater availability of products and low costs to customers, new employment and industrial skills training to workers, and conservation of material and energy resources to society. Remanufacturing not only focus on economic profits but also keeping contribution to minimize environmental impacts by utilizing end-of-life (EOL) products. This study attempts to find out remanufacturing opportunities, and main challenges, along with the dominant influencing factors in a fast-developing country like Malaysia based on authentic literature review and expert opinions. The paper presented a short description of e-waste status, potential remanufacturing areas, its current practices, possible policy measures, and the present barriers in remanufacturing. The findings and observations provide a foundation and clear idea about the prospective of remanufacturing in Malaysia and probable further research directions.

1. Introduction

At the present time, the whole world is facing resources shortage and environmental pollution threats, while lots of recyclable and remanufacturable end-of-life products are abandoned, or are just recycled in low level, such as smashing or melting them into new raw materials. High demand of electronic products and their short life cycles are generating enormous e-wastes every year all over the world, which are harmful for the environment and human health. United Nations Environment Programme (UNEP) estimates that between 20 and 50 million tonnes of e-waste are generated annually around the world [1]. This implies that the growth in global electronic production of 4.4 percent in 2002 and 6.8 percent in 2003 will result in similar growth in e-waste generation [2]. A recent annual estimation for Wastes from electric and electronic equipment (WEEE) was almost 6.5 million tonnes, and it has been predicted that by 2015 the figure could be as high as 12 million tonnes [3]. The increase of waste generation results is the permanent loss of valuable material, energy and housing or agricultural lands. E-waste also increases air, water and land pollution all over the world [4]. Similarly, the high purchasing ability of Malaysian population and rapid growth of electrical and electronics industries in Malaysia tend to produce serious e-waste and landfills' saturation. A research has shown that e-waste generation has been estimated to be 706,000 tonnes in 2010 and finally to about 1.2 million tonnes by 2020 in Malaysia [5]. Another estimation by Department of Environment (DOE) shown seven categories wastes where the personal computer waste projection will be total volume of 608.191 million metric by 2020 [6]. A short description of e-waste status of Malaysia is discussed in section 2. It is an alarming issue for Malaysian government need to be seriously think how to minimize those wastes from different kind of end-of-life EEE. Simply if we consider only an EOL personal computer,



then we have seen that it has a serious environmental impact by producing hazardous wastes such as (a) Cathode ray tubes are generating barium, lead and other heavy metals leaching into the ground water and release of toxic phosphor; (b) Printed circuit board (PCB) is responsible for air emissions, water pollution and landfilling. PCBs are generating beryllium, cadmium, lead, tin, mercury, brominated dioxin and dust; (c) Chips and other gold plated components are producing hydrocarbons, heavy metals, brominated substances discharged directly into rivers acidifying fish and flora. Tin and lead contamination of surface and groundwater. Air emissions of brominated dioxins, heavy metals and hydrocarbons; (d) Plastics from printers, keyboards, monitors, etc. are producing emissions of brominated dioxins, heavy metals and hydrocarbons; and (e) Computer wires are generating hydrocarbon ashes released into air, water and soil [7]. Therefore, when a product reached its end-of-life there are several recovery options are available like reuse, remanufacturing, recycling, and energy recovery. EOL product recovery can minimize the environmental effects of disposal, raw material extraction, and environmentally damaging substances. Thus, e-waste recycling, reusing or remanufacturing is an important issue, not only from the aspect of waste management, but also aspect of valuable materials recovery and reuse again and again. The remanufacturing prospects and challenges in Malaysia are discussed in this research because remanufacturing is environmentally desirable and industrially profitable by reducing energy and raw material consumption. Remanufacturing is disassembling, cleaning, refurbishing, replacing parts (as necessary) and reassembling a product to meet or exceed the original equipment manufacturer's quality standards and performance specifications. According to a statistics, remanufacturing products can save 60 percent of the energy, 70 percent of the materials, and 50 percent of the cost compared to the new products [8]. Indeed, remanufactured products are sold at 60–70 percent of the new products' price and production costs only 35–60 percent of the original casts [9]. Based on extensive literature review and a few field visits, this work used discussions and interviews with Malaysian remanufacturing, recycling and original equipment manufacturers (OEMs) companies. The purpose of this paper is to provide an overview of the existing remanufacturing practices to understand the current state or future remanufacturing business scopes, opportunities and its challenges in Malaysia to increase the use of EOL EEE and reducing environmental impacts.

2. E-waste status in Malaysia

In Malaysia, waste generation is significantly increasing where solid waste generation is estimated to increase from about 10.9 million tonnes in 2010 to about 15.6 million tonnes in 2020 [5]. Malaysian scheduled waste (hazardous waste) generation based on the Department of Environment (DOE) was 1.1 million tonnes in 2006, increased to 1.7 million tonnes in 2011 [6]. Another estimation by DOE, based on the projection of selected seven categories EEE products project that the amount of e-waste will be increased by an average of 14 percent annually and a total of 1.17 billion units (21.38 million tons) will be generated by the year 2020 [10]. According to past years (1981 -2007) data, the total amount by weight of WEEE generation is calculated based on WEEE discarded by the household, business entities and institutions in metric tonne unit (Figure 1). It shows that the total amount of the seven categories of WEEE (Television=TV, Personal Computer=PC, Mobile Phone=MP, Refrigerator=REF, Air Condition=AC, Washing Machine=WM, and Mobile Phone Rechargeable Batteries=MPRB) will be 11.199 million metric tonnes by the year 2020. As per estimation from the year 1981-2020, the highest e-waste generated by personal computer with a cumulative total volume of 608.191 million metric tonnes where television sets are 244.226 million metric tonnes only. It seems that day by day, personal computer waste is increasing continuously all over the country. The air condition, refrigerator and washing machine waste are also gradually increasing with each year.

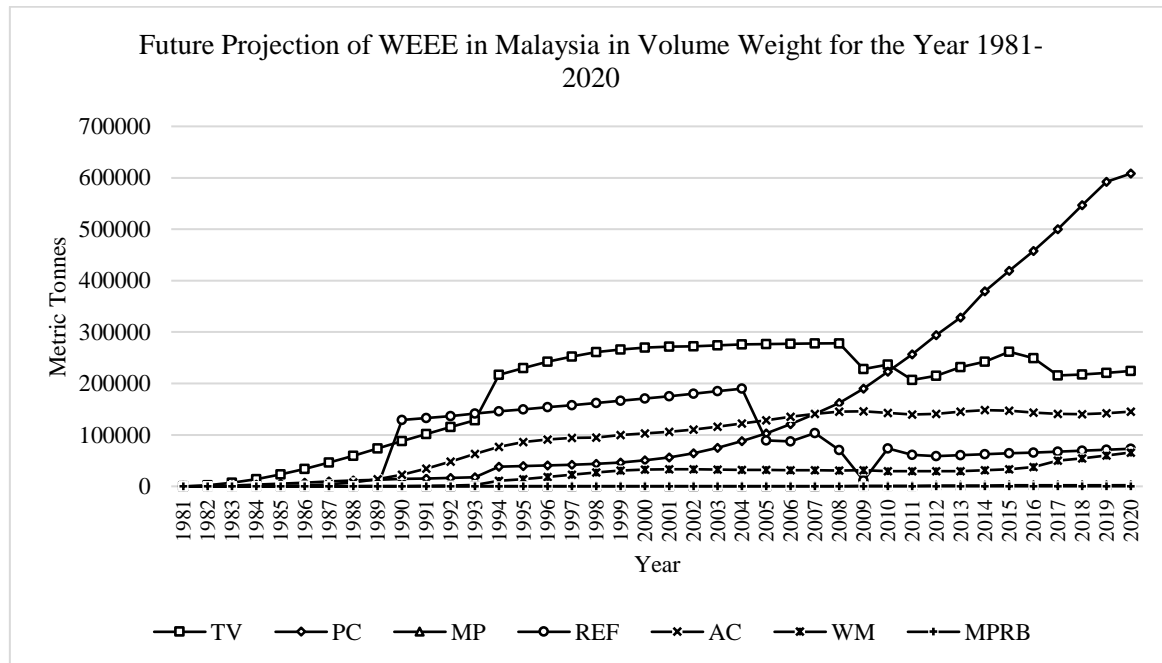


Figure 1. Projection of WEEE in Malaysia in Volume Weight for the Year 1981-2010 [10]

3. Remanufacturing scenario and possible potential areas in Malaysia

Malaysian economic growth is consistently and constantly increasing due to its Government's transformation policy and lots of local and foreign investments. Obviously, economic growth is an outcome of increasing production (and better services), which increases consumption and thus piles wastes. After discussion and interviewing a few manufacturing experts, academia, and reading journal articles or newspapers related to remanufacturing in Malaysia we have found that remanufacturing practices in Malaysia is still in its commencement stage. There are some automotive companies and third parties (tonner, printer, and computer etc.) practicing remanufacturing business in Malaysia to a small range. But the growth of remanufacturing activities in Malaysia is still modest due to absence of e-wastes business analysis, complete ecosystem and awareness. According to the Department of Environment in Malaysian remanufacturing possible potential sectors are (a) Computer and telecommunication equipment and office photocopiers (laser toner cartridges); (b) Aerospace and robots; (c) Automatic transmissions and rolling stock (railway vehicles); (d) Bakery equipment, defense equipment, industrial food processing equipment, and excavation equipment; (e) Gaming machines and machine tools; (f) Light and heavy duty automobile engines; (g) Carpet tiles, office furniture, and musical instruments; and (h) Compressors, pumps, starter motors, electrical motors and apparatus, vending machines, power bearings, and air-conditioning units [11]. Its represent that there have lots of opportunities for remanufacturing business in Malaysia. But according to the below statistics (Figure 2) it is found that remanufacturing product by sectors is not increasing in Malaysia. Number of companies along the X-axis and remanufacturing products based on the companies' claim along the Y-axis are shown that a few companies or third-party industries are doing remanufacturing activities here. So Malaysians are not only losing valuable product recovery, energy and profit, but also generating lots of wastes all over the country every year which will be hazardous and environmentally harmful.

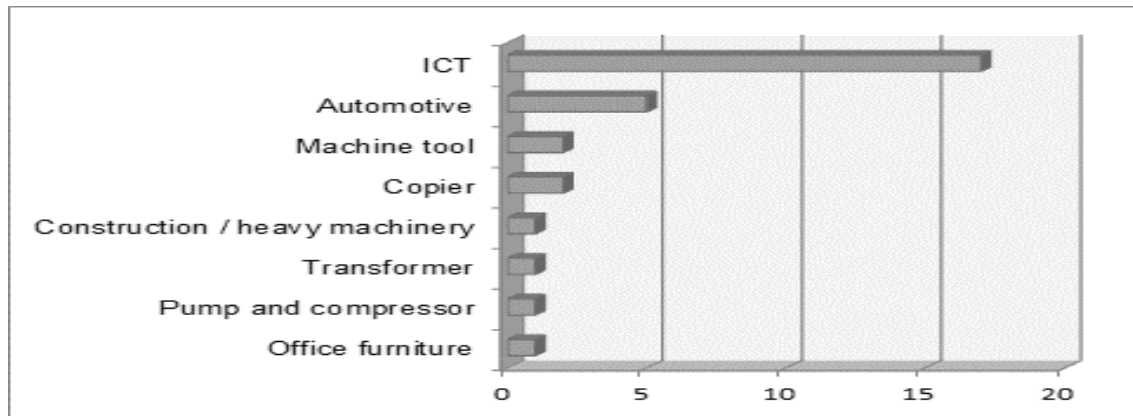


Figure 2. Remanufacturing product by sector in Malaysia [12]

Another conceptual graphical presentation (Figure 3) on remanufacturing and fast-growth industries in Malaysia is done by the Ministry of International Trade and Industry (MITI). This portrays that compares the growth of remanufacturing industries is very slow compared with the fast-growth industries in the country.

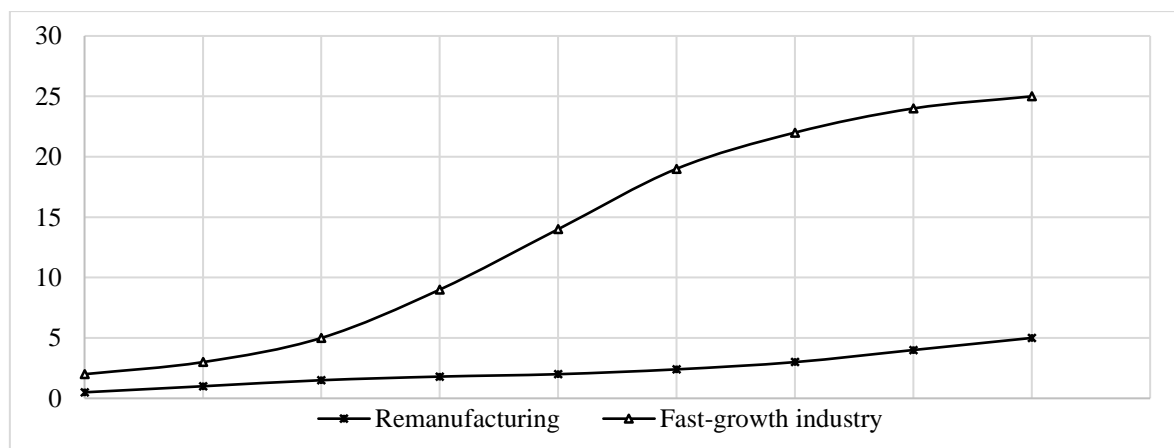


Figure 3. Comparison of growth remanufacturing industries [12]

Remanufacturing activities of several companies and other relevant features are summarized in Table 1. The Table 1 shown that remanufacturing products have market demand and the companies cannot fulfill the customer requirements due to Malaysian remanufacturing industries are practicing only initial techniques of remanufacturing like inspection, disassembly, cleaning, and testing. Merely a few manufactures are using heavy machineries for giving the second life of the product. Even though remanufacturing has lots of benefits, only lack of remanufacturing business analysis and market information are the primary barriers for remanufacturing growth in Malaysia. After analyzing our expert opinions and remanufacturing related papers published in Malaysia, we come to the point that most of the original equipment manufacturers (OEM) are not practicing remanufacturing due to lack of business information and remanufacturing business analysis for remanufacturing decision making with consideration of organizational factors. Remanufacturing business has challenging activities due to its products have to conform the same or similar quality specifications of the respective new products. Hence, lack of analysis about remanufacturing economic profits and performance of

manufacturing industry is responsible for slow growth of remanufacturing industries in Malaysia. We tried to find out remanufacturing barriers in Malaysia and major problems being faced by manufacturing industries to make remanufacturing decision as follows: (1) product verity and product selection problem for remanufacturing; (2) technological and tools problem for remanufacturing; (3) lack of specific procedures and policies for remanufacturing; (4) lack of awareness for remanufacturing and raw material (EOL) collection; (5) lack of design for recovery; (6) insufficient skill and expert personnel; (7) lack of market research of remanufactured product; (8) lack of study for remanufacturing challenges consideration; and (10) lack of remanufacturing industrial master plan.

Table 1. Some remanufacturing companies' activities in Malaysia

Company Name	Remanufacturing Product	Process	Market	Remarks
Malaysia Transformer Manufacturing Sdn Bhd	Power and Distribution Transformer	Inspection, disassembly, cleaning, drying, repair/ replace of cores, repainting, testing, and upgrading (if needed)	Domestic and International	OEM products are 80 percent and remanufacturing products are 20 percent. Fulfilling remanufacturing product criteria
Hitachi Construction Machinery (M) Sdn Bhd	Hydraulic pumps and motors	Inspection, disassembly, cleaning, replacement of cores, reassembly, and testing	Domestic and International (Europe)	Fulfilling remanufacturing product criteria. Stiff competition with other OEM brand such as Komatsu (Japan), Caterpillar (US), Soosan (Korea).
Motor Teknologi Industri Sdn Bhd	Highway and off highway diesel engines. Army and Police trucks, cylinder head, crank shaft, cam shaft and crank case	Inspection, disassembly, cleaning, repair/ replace of cores, repainting, and testing	Domestic and International	Fulfilling remanufacturing product criteria
Prota Remanufacturing Sdn Bhd	Laser toner of HP, Canon, Samsung, Brother and Lexmark.	Inspection, disassembly, cleaning, testing, and refill services	Domestic Market	Fulfilling remanufacturing product criteria
Esyink Remanufacturing Sdn Bhd	Cartridge remanufacturing (Inkjet and Toner) of HP, Canon, Samsung, Brother, Lexmark, and Xerox	Inspection, disassembly, cleaning, testing, and refill services	Domestic Market	Fulfilling remanufacturing product criteria
Shin Etsu Denso Co., Ltd.	Remanufacturing of Automotive Rotating Electrics Automotive Parts. Alternators, Starters, A/C Compressors, Power steering pump, and Transmission	Core sorting, disassembling, cleaning, painting, sub-assembling, assembling, testing, and packing	Domestic and International (North America, Europe, Middle East, South East Asia, South America, and Oceania)	Fulfilling remanufacturing product criteria

4. Remanufacturing - challenges in Malaysia

We tried to find out the present remanufacturing challenges in Malaysia from the outcomes of interview of manufacturing experts and literature. The identified potential factors are (a) raw materials collection, (b) technology & method, (c) product design, (d) skill manpower & experts, (e) marketing & competition, and (f) environments & government which are causing an overall effect.

(a) Raw materials or cores collection: Raw materials or cores are the heart of remanufacturing business. It is the most essential and important issue for remanufacturing business decision. In order to collection of cores require some polices or system to get back EOL product from the end user. After discussing with some recycling and remanufacturing industries (at Penang) in Malaysia we have found that they don't have any standard system for collecting cores. At present, they are collecting cores by directly buying from end customers, but they don't have any standard collection system. If customers are willing to inform them, then they contact if it is nearest distance. Some multinational companies like Dell, Nokia and Motorola etc. are trying to get back their EOL products by offering a promotion. Price of the EOL product is the major issue for returning back to remanufacture or OEMs. So OEMs can offer promotions to customers to return back EOL product by proposing discount on a new product. The cost or price of EOL product, quality of EOL product, uncertainty cores supply and demand, cores inventory management and control, cores collection system, transportation, public awareness, and core collection cost are making cores collection so challenging for Malaysian remanufacturing and recycling business.

(b) Technology and method: Technology and method are certainly challenging for remanufacturing business. The initial stage of remanufacturing is fault identification and inspection of product for remanufacturing decision. That's why standard fault identification technologies are required to make the remanufacturing business profitable and reliable. A high level of remanufacturing technologies and methods are helping remanufacturing industries to make remanufacturing decision properly. The technical test (like visual testing, mechanical testing, electrical testing, audio testing, display testing, and logical testing etc.) at initial stage and final stage is essential due to remanufacturing product warranty and quality have to be as like new manufacturing product. Thus the degree of organizational remanufacturing technology, remanufacturing testing cost, technology cost, and the method of remanufacturing are making remanufacturing business more challenging day by day.

(c) Product design: The efficiency and effectiveness of the remanufacturing process significantly depend on product design features like joining and fastening methods, product architecture, and material choice can have an effect upon ease of testing, ease of disassembly, ease of reassembly, ease of reprocessing, and so on. Recently, environmentally friendly design and design for remanufacturing are the greatest challenges for engineers to provide potential benefits to the society by increasing the use of recordable materials. Lack of designing factors consideration makes the remanufacturing process more complex, very labor intensive, high cost, low quality, time consuming, and finally EOL product produce hazardous waste. So Malaysian government also can make some plans for OEMs to inspire or force them to produce as per consideration of designing factors.

(d) Skill Manpower and experts: Skill manpower and experts are another important challenges for remanufacturing business in Malaysia. Remanufacturing processes are essentially labor intensive. Remanufacturing business is profitable if the organization can analyze their business efficient way from the remanufacturing decision making stage to deliver remanufactured product to the end customer. The inspection and identification of faults, disassembly of product, cleaning and storage of parts, replace parts or remanufacturing operations, reassembly of product, testing to verify functioning as new product are the main process of remanufacturing. Thus, every phase of the remanufacturing

process requires technically skilled operators and expert's decision to satisfy or exceed the original equipment manufacturers (OEMs) product qualifications, warranty and performance specification.

(e) Marketing and competition: Original equipment manufacturers already have almost all required technologies to remanufacture a product at low cost to make competition with lower end product manufacturers. If OEMs are not starting remanufacturing, then other competitors will inspire to start to control market share. Most of the time OEMs is giving their product remanufacturing to third party industries, but the poor quality of remanufacturing product may damage their brand reputation. Sometimes customer is not willing to pay for remanufactured product due to lack of advertising and marketing, even though the product function and quality are same as new. Market research may increase the profitability of the company by forecasting market demand, return flow of EOL product and change of technology. Remanufactured product acceptance to the customer depends on product price, quality, warranty and early launching. So marketing is an important challenge to create a remanufacturing product demands inside to the market by delivering essential information to the customer.

(f) Environmental and government: Remanufacturing business is economically profitable and environmentally desirable to all as well as the environmental issues are most important for every country to minimize the waste of end-of-life electrical and electronic equipment. So during remanufacturing or manufacturing a product need to consider its environmental impacts because most of the EOL products contain hazard substance and its disassembly can pollute the environment. Green manufacturing or remanufacturing, green supply chain and environmental friendly design can help to e-waste reduction. Some governmental policies may inspire and increase remanufacturing business activities by providing some facilities like ordinary take-back laws, public information campaigns, investment opportunities, tax free or low taxes for raw materials or technology import, financial supports for new business, and incentive and subsidy for EOL product collection.

5. Discussion and conclusion

Since decades, e-waste and waste material has been treated as a cost addition in reproducing and waste management for this reason original equipment manufacturers (OEMs) was not interested to recycle or remanufacture EOL products. But today, sustainable practices and environmental issues are legally forced by governments for OEMs to recycle and remanufacture EOL products. Malaysian government has been implementing some policy and regulations by establishing different departments for sustainable waste management system like the Action Plan for a Beautiful and Clean Malaysia (ABC) in 1988 followed by the Environmental Quality Act (EQA) 1974 in 1996, the National Strategic Plan for Solid Waste Management (NSP) in 2005, the National Solid Waste Management Policy (NSWMP) in 2006, and the Master Plan on National Waste Minimization (MWM) in 2006 [5]. Those organizational activities show that the Malaysian policy-makers only focused on waste management of both solid and scheduled wastes on the basis of EOL product collection, recovery, and disposal [13]. But policy makers should think about parallel alternative solutions to reduce the e-waste generation and valuable resource recovery. Recovering resources through remanufacturing will improve the overall organizational efficiency, cash flow as well as remanufacturing can minimize environmental impacts. The relevant authority can make some policies to inspire responsible organizations or manufacturer for product repairing, reusing and remanufacturing. So Malaysian authority may consider some policies for increasing the growth of remanufacturing business, such as: (1) specific policies and procedures to ensure that the industry is developed strategically and in accordance to the domestic legislations; (2) raise awareness - promoting remanufactured products as new products; (3) involve OEMs for evaluating impacts - comparing life-cycle impacts of remanufactured and manufacturing new goods for key product lines; (4) determine appropriate factors and criteria for standardizing EOL product management legislation; (5) force original equipment manufacturers for ensuring design for recovery during new product manufactured; (6) force the OEMs

to increase the use of recyclable materials and to reduce the use of hazardous substance; (7) force OEMs to take-back EOL products (such as returning with new, promotion, and offer); (8) government facilities for industrial collaboration; (8) financial support providing for recovery business exploration; (9) regulatory framework strongly monitor; and (13) EOL product recovery industrial master plan. This paper also addresses remanufacturing practices, barriers and challenges to take advantage of regional-scale benefits of remanufacturing to reduce the e-waste generation. In summary, remanufacturing business is still in its early stage in Malaysia. Indeed, the remanufacturing barriers which are identified by the interview and discussion with remanufacturing and recycling companies are also confirming that those issues are influencing remanufacturing business growth in Malaysia. This paper also highlights the present challenges of remanufacturing in Malaysia. Expectation of quality, raw material supply limitation, competition, product design and change of pace of technology are the key factors requiring consideration before starting remanufacturing businesses. Remanufacturing can be grown industries in Malaysia due to its potential scale of local and foreign investments. Common trade and tax policies for remanufacturing industries need to be formulated to enhance and facilitate its growth.

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