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## Automotive Remanufacturing Capability for End of Life Vehicle (ELV) in Malaysia



**Abstract:** - The Malaysia Automotive Remanufacturing Roadmaps (MAAR) outline policies and technologies to transform the automotive used part sector into remanufacturing. Remanufacturing processes offer significant benefits, hence the need for transformation, despite the substantial availability of used automotive products. The automotive industry in Malaysia has experienced considerable growth and development, leading manufacturers to incorporate remanufacturing into their business operations. Recently, research has concentrated on end-of-life vehicle (ELV) management. Malaysia has no specific period for the end-of-life (ELV) regulation policy. It is essential to consider the proper disposal of these vehicles once they have reached the end of their useful life. The number of abandoned cars is increasing, leading to significant costs for society regarding removal and disposal expenses and other indirect costs due to environmental degradation. Addressing this issue will positively impact both the environment and the economy. This study explores how industries' capabilities can face sustainability goals under the National Automotive Policy (NAP) 2020 and gain insights into how the remanufacturing process works. Therefore, it is imperative to establish remanufacturing as a norm within automotive practices.

**Keywords:** remanufacturing, End of Life Vehicle (ELV), remanufacturing capabilities and maturity, National Automotive Policy (NAP)

### I. INTRODUCTION

The UK Centre for Remanufacturing and Reuse defines remanufacturing as a series of manufacturing steps that are performed on an end-of-life part or product to restore it to like-new or better performance, with a warranty to match. However, remanufacturing is often confused with other aspects of the circular economy, such as refurbishment, reconditioning, and repairing. Despite this confusion, remanufacturing has immense social, economic, and environmental potential if the right measures are put in place to support the industry and its development. Remanufacturing is a promising approach to creating a more sustainable future. It can help reduce waste and conserve resources, which can have a positive impact on the environment. By reducing the amount of waste that ends up in landfills, remanufacturing can help reduce greenhouse gas emissions and other environmental impacts. It can also help conserve natural resources by reducing the need for new raw materials. Firms' adoption of remanufacturing is influenced by both internal and external factors. According to [1] internal factors include resources and capabilities, while external factors include regulations. This means that firms' ability to adopt an innovation is determined by their own resources and capabilities, as well as the regulatory environment in which they operate. Ensuring that remanufactured products meet the same quality standards as newly manufactured products. However, remanufacturing rebuilds a product instead of building it from scratch, resulting in other challenges that must be conquered. The model will illustrate how a company's resources and capabilities can be utilized to achieve sustainability in remanufacturing in Malaysia.

### II. LITERATURE REVIEW

#### A. Remanufacturing Overview

The government conducted research on sustainability advancements to promote a more competitive market for both domestic and foreign automotive companies. The National Automotive Policy (NAP), introduced by the International Trade and Industry Ministry, has several objectives. These objectives include transforming and integrating the domestic automotive industry into competitive regional and global networks. The NAP has identified six automotive roadmaps, two of which are related to 4R2S activities. By prioritizing SDGs, the goals and objectives align with Malaysia's capacity and global role. Remanufactured products are treated the same as

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new ones. As a result, the increased demand for automotive products and the excessive use of natural resources have led manufacturers to employ the Extended Useful Life (EUL) methodology through remanufacturing. The environment is negatively impacted by vehicle waste, particularly from End-of-Life Vehicles (ELVs), as they cannot be recycled. Typically, vehicles contain harmful fluids, gases, and heavy metals, which pose a potential threat to the environment when disposed of, regardless of whether it is done legally or illegally. The advancement of technology and innovation in the automotive industry is one of the factors contributing to the growing issue of ELV waste. However, the obstacles hindering the adoption of remanufacturing can be overcome through the collective efforts of various businesses, governments, investors, society, and researchers.

Fortunately, industry 4.0 has created vast opportunities for remanufacturing by lowering the transformation cost through higher connectivity and efficiency. In Malaysia, the Ministry of Investment Trade and Industry (MITI) (2020) has identified this as a policy objective, aiming to improve design engineering, manufacturing processes, service planning, and execution management through enabling technologies. Recent research has focused on standard End-of-Life vehicle (ELV) component repair methods and the environmental impact of the remanufacturing process. However, Malaysians do not have a formal regulation governing ELV enforcement. Furthermore, the management of ELVs has become a complex issue that requires immediate attention. According to [8], ELVs can be categorized as premature or natural. Premature ELVs are cars that are no longer used due to fire or involvement in an accident, while natural ELVs are cars that reach their end of life due to obsolescence and mechanical deterioration that makes them impossible to repair. In other words, the remanufacturing process helps preserve worn goods. Additionally, examining the industrial process and capability is essential for achieving sustainable development goals (SDGs).

#### B. Scenario ELV in Remanufacturing

Remanufacturing is a sustainable process that involves recovering, repairing, and rebuilding used products to extend their lifespan and reduce waste. Research on remanufacturing highlights both the drivers and barriers that influence its implementation and growth. The study by [2] identified the drivers as including economic, environmental, and social benefits, such as reduced manufacturing costs, decreased greenhouse gas emissions, job creation, and enhanced corporate social responsibility. However, the survey conducted by [3] revealed that in addition to enablers, several barriers hinder the growth of remanufacturing, including a lack of awareness and education, technological limitations, high investment costs, and inadequate government policies. Addressing these challenges requires policymakers to provide incentives for manufacturers to adopt remanufacturing practices and invest in research and development of remanufacturing technologies. Despite the obstacles, remanufacturing presents a valuable opportunity to promote sustainable production and consumption practices while providing economic, environmental, and social benefits. Table 1 provides an overview of the challenges of remanufacturing in different countries, as well as general barriers and risks associated with promoting remanufacturing. The findings from various studies indicate that the categories of drivers and barriers vary, but common themes include environmental benefits, cost savings, and technical improvements as drivers, and weak institutional support, limited market demand, and inadequate logistics infrastructure as barriers.

Table 1. Literature overview driver and barrier in remanufacturing

Author	Driver	Barrier	Comment
Venkatesan and Singh (2021)	Environmental benefits, economic benefits, government incentives	Weak institutional support, complex regulatory environment, lack of infrastructure.	ELV recycling in India
Mustafa et al (2020)	Environmental benefits, cost savings, resource conservation	Lack of technical expertise, weak institutional support, limited market demand.	Reman in Malaysia
Sakai and Oyama (2019)	Environmental benefits, cost savings, legal compliance	Complex supply chain, technical complexity, weak institutional support.	EU ELV directive

Wang and Chen (2019)	Cost savings, environmental benefits, technical improvement	Limited market demand, weak institutional support, insufficient R&D investment.	Case study reman part in China
Oliveira et al (2018)	Cost savings, environmental benefits, competitive advantage	Lack of technical capability, limited market demand, inadequate logistics infrastructure.	Reman in Brazil (expert views)
Oyama and Kikuchi (2018)	Cost savings, environmental benefits, technical improvement	Lack of industry standards, insufficient R&D investment, inadequate logistics infrastructure.	Reman in China
Bocken and Short (2016)	Cost savings, environmental benefits, product quality	Lack of customer awareness, weak institutional support, limited market demand.	Reman in UK

According to the comprehensive consideration from the economic profit, environmental conversation and social ethics viewpoints, the ELV recycling channels are diversified based on the degradation of parts. However, [4] described the selection of recycling way for the disassembly ELV part is close related to the degradation degree, failure mode, economic value, material composition and technique level. The pre-evaluation and classification need to be performed in advance.

### C. Assessment in Remanufacturing

A study of the process assessment was conducted by [5] with eleven remanufacturing companies across Europe. The study used a maturity model to assess remanufacturing processes and improve operations, which is expanded in level 1 and level 2. The same approach was used by [6] to develop the Remanufacturing Maturity Model (RMM). The RMM is a framework that uses the maturity model theory to assess responsible resource management in a remanufacturing process. It consists of two layers, the descriptive layer and the prescriptive layer. The descriptive layer of the remanufacturing maturity model narrowed down to five maturity levels is defined with regard to responsible resource management. The relevant responsible resource management practices are analyzed for water, emissions, energy, and materials, which are linked with maturity levels 1. The self-assessment tool is also designed, which utilizes the existing expert's knowledge of a company. On the other hand, the prescriptive layer is a method for the identification of the maturity gap and areas for improvement is proposed. A procedure for prioritizing the measures, which shall be implemented in order to achieve a higher level of responsible management in a remanufacturing company.

According to [7], the company has developed dynamic remanufacturing capabilities (DCRem) that enable them to produce remanufactured parts based on market demand using existing resources and current plant capacity. The outcome the company believes that DCRem could have a positive impact on their business performance and is interested in exploring this further. The table shows the relationship between DCRem and their outcomes.

Table 2. Summary outcomes of dynamic remanufacturing capabilities [6]

Study	Outcomes
DCRem's impact on supply chain resilience	Positive opportunities to explore.
Factors that positively influenced DCRem	Market factors, management factors, and technical factors.
Pricing strategy for remanufactured products	A pricing strategy that is tailored to the market segments could increase demand for remanufactured products and reduce the possibility of cannibalization.

DCRem's impact on stakeholder engagement	DCRem has the potential to influence end-users willingness to return products through advertising and buy-back programs, manage the acquisition of used products, monitor the life cycle of remanufactured products, plan and control the production of remanufacturing, and manage inventory control for remanufactured products.
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#### D. Methodology

The strategies are needed for implementation and readiness in terms of the capabilities and expertise of the workforce. Primary data collection for this research from industry interviews and observation methods for remanufacturing in the Malaysian industry. The following exploration approach will validate a case study on remanufacturing automotive components. An exploratory review of the literature on the recovery of products with different end-of-life strategies (EOL) was performed to understand their differences. Additionally, remanufacturing, the life strategy focuses on this work, as defined, and some of the characteristics for its implementation as described. Industrial visits of two companies, which specialize in rebuilding and expanding used commercial vehicles, particularly trucks. The visits aimed to demonstrate the compression test process for engines. Both companies rebuild trucks to original specifications and provide warranties with a three-month warranty for the engines and gearboxes.

The primary components involved in the rebuilding process of trucks at both companies include the radiator, intercooler, alternator, starter, turbocharger and braking system. These components are disassembled and tested for performance, and some parts, such as carbon brushes and bearings in used alternators and starters, are compulsory to change. Figure 1 (a) and (b) show a man performing an alternator and starter profiling test at the station. In the event of any component failing the test, it will be sorted and proceed to the next process, which is disassembly. During this process, a thorough inspection of the faulty parts within the components will be conducted. However, if the damage to the parts is severe, the component will be sent to a third party for further repair.



Fig. 1(a): Starter test station

Fig. 1(b): Alternator test station

The statement highlights the importance of alternators and starters as crucial components of a vehicle that can be easily refurbished and maintained, thereby reducing the cost for vehicle owners to purchase new ones from the manufacturer. Furthermore, it presents an opportunity for entrepreneurs in the automotive industry to establish a business focusing on repairing alternators and starters. Figure 2 depicts a comprehensive visual guide for the re-manufacturing of an alternator. The step-by-step instructions cover various tasks, including dismantling the regulator and diode assembly, replacing the regulator's carbon brush and spring, and assembling the components. However, this process is specifically designed for servicing or replacing individual parts such as carbon brushes, springs, or bearings in case of wear and tear.

Standard Work Instruction						
Work Element Sheet						
Instruction Title	Re - Manufacture of Alternator		Issue Date		Page	
Element Name	Inspection and repair of alternator		Element #	EPB/4R2S/ALT	Prepared By	
Symbols	Step#	WORK STEP	Symbol	KEY POINT HIGHLIGHT	COMMENT / NOTE	
Quality <b>Q</b>	1.4	Disassemble regulator and diod assembly	☹️	a) Remove rotor stator assembly from front cover to get access to the regulator and diod assembly.		
HSE <b>+</b>				b) Remove regulator flange fastener.		
Knack <b>😊</b>				c) Remove regulator flange		
Special Requirement				d) Remove diod assembly		
	1.5	Change regulator carbon brush and spring with new one	☹️ <b>Q</b>	e) Remove regulator assembly		
	1.6	Assemble back regulator and diod assembly	☹️	a) Remove old carbon brush and spring and replace with new one.		
				b) Install regulator assembly in its' place		
				b) Install diod assembly in its' place		

  

Visuals	
ALTERNATOR COMPONENTS	

Fig.2 Standard word instruction for remanufacture of alternator

CONCLUSION

Remanufacturing recaptures the value-added of End-of-Life (EoL) products by rebuilding and replacing their parts and components with a matching warranty. However, the used car market is being exploited illegally, with improper recycling processes causing serious environmental pollution at facilities, as well as the illegal extension of a vehicle's lifespan without permission and illegal remanufacturing. There is still room for businesses and government agencies to invest more in research and development related to design for remanufacturing. Therefore, expertise in various related fields needs to be provided and individuals should be trained with adequate knowledge and know-how.

In Malaysia, the readiness to face IR 4.0 is a new challenge in exploring new opportunities with the latest technology. The development of the industry over time has encouraged industry players in Malaysia to remain competitive and developed. Instantly, the government has mobilized various incentives for industry players to explore new markets, especially those related to IR 4.0 in remanufacturing. This contributes to the market and improves the country's economy in general. Next, it is a challenge for IR 4.0 technology to be absorbed into the structure of manufacturing development. Here, it requires a comprehensive guideline or work structure for smooth operation. The visit also highlights issues such as unclear remanufacturing guidelines and the need for government input to improve remanufacturing companies.

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