ENERGY EFFICIENCY IMPROVEMENT AND COST SAVING OPPORTUNITIES FOR THE AUTOMOTIVE MANUFACTURING INDUSTRY

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have been that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

The automotive industry in the Malaysia is growing rapidly with the increasing demand for vehicles. This situation will increase the rate of energy consumption and might has spends about billion kwh on energy annually. This research focus on automotive manufacturing assembly plants for DRB Hicom Automotive (HA) Complex. HA is the leading automotive assembler in Malaysia that include 5 customers to running manufacturing of vehicles at this plant. The aim of this research is to propose improvement measures that could be taken by HA to further reduce energy consumed during manufacturing processes, particularly focusing on thermal management of low-temperature heat sources that are extensively present in the whole manufacturing plant and in the paint workshop. Through an extensive literature review on the topic, this research will discuss more on vehicle production processes and strategies towards sustainability by improving the energy efficiency opportunities. Firstly, this research will present a summary of the vehicle production process and its energy use. This is followed by the improvement measures of energy efficiency opportunities available for vehicles manufacturing plants. If possible, this research will provide specific energy savings for each energy efficiency measure based on types of vehicles to be manufactured, and to listed each of the costs and its simple payback periods. It will include experiences of manufacturing plants with energy efficiency measures that reviewed in the report. It is because as per current findings, although most vehicle manufacturing plants have energy management teams or programs, there are still opportunities available at individual plants to reduce energy consumption cost effectively.

ABSTRAK

Industri automotif di Malaysia berkembang pesat dengan peningkatan permintaan untuk kenderaan. Keadaan ini akan meningkatkan kadar penggunaan tenaga dan mungkin telah membelanjakan kira-kira bilion kwj untuk tenaga setiap tahun. Penyelidikan ini memfokuskan kepada kilang pemasangan pembuatan automotif untuk Kompleks DRB Hicom Automotive (HA). HA ialah pemasang automotif terkemuka di Malaysia yang merangkumi 5 pelanggan untuk menjalankan pembuatan kenderaan di kilang ini. Matlamat penyelidikan ini adalah untuk mencadangkan langkah penambahbaikan yang boleh diambil oleh HA untuk mengurangkan lagi tenaga yang digunakan semasa proses pembuatan, terutamanya memberi tumpuan kepada pengurusan haba sumber haba suhu rendah yang banyak terdapat di seluruh kilang pembuatan dan di bengkel cat. Melalui ulasan *literature* yang meluas mengenai topik tersebut, penyelidikan ini akan membincangkan lebih lanjut mengenai proses pengeluaran kenderaan dan strategi ke arah kemampanan dengan menambah baik peluang kecekapan tenaga. Pertama, kajian ini akan membentangkan ringkasan proses pengeluaran kenderaan dan penggunaan tenaganya. Ini diikuti dengan langkah penambahbaikan peluang kecekapan tenaga yang tersedia untuk kilang pembuatan kenderaan. Jika boleh, penyelidikan ini akan menyediakan penjimatan tenaga khusus untuk setiap ukuran kecekapan tenaga berdasarkan jenis kenderaan yang akan dikeluarkan, dan untuk menyenaraikan setiap kos dan tempoh bayaran baliknya yang mudah. Ia akan merangkumi pengalaman kilang pembuatan dengan langkah kecekapan tenaga yang disemak dalam laporan. Ia adalah kerana mengikut penemuan semasa, walaupun kebanyakan kilang pembuatan kenderaan mempunyai pasukan atau program pengurusan tenaga, masih terdapat peluang di loji-loji tersendiri untuk mengurangkan kos penggunaan tenaga dengan berkesan.

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LIST OF ABBREVIATIONS

HA	-	Hicom Automotive
OEM	-	Original Equipment Manufacturers
ELV	-	End-of-life Vehicle
R&D	-	Research and Development
SEC	-	Specific Energy Consumption
NPS	-	New Paint shop
CVO	-	Commercial Vehicle Operation
CPS	-	Current Paint shop
VWO	-	Volkswagen Operation
SSO	-	Shared Service Operation
MBO	-	Mercedes Benz Operation
MMO	-	Mitsubishi Motors Operation
TNB	-	Tenaga Nasional Berhad
LED	-	Light-Emitting Diode
CO_2	-	Carbon Dioxide
kWh	-	Kilowatt Hour
AHU	-	Air Handling Unit
UTM	-	Universiti Teknologi Malaysia
ESM	-	Energy Saving Measures
UTM	-	Universiti Teknologi Malaysia
RM	-	Ringgit Malaysia

LIST OF SYMBOLS

%	-	Percentage
$	-	Dollar
=	-	Equal to
m	-	Material
n	-	Produce Material
j	-	Material Production Process
e	-	Electricity
i	-	Productive Process

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Automotive manufacturing is a complex and energy-intense process which consumes a significant quantity of raw materials and water. To remain competitive, automotive original equipment manufacturers must strive for better product quality by continuously improving their production process and driving towards low-carbon emissions and enhanced sustainability.

The manufacturing community is concerned more and more about the production energy consumption both due to the constantly increasing energy cost and to the ecological burden related to the energy production and use. Energy efficiency has quickly become a top priority of both international and national policies. The great use of energy for industrial operations is responsible for significant CO_2 emissions and thus, climatic changes.

Considering that most of this energy in manufacturing is supplied in the form of electricity, and that about 66% of all electricity is generated through fossil fuels, it is fair to say that CO_2 emissions resulting from manufacturing (also called carbon footprint of manufacturing) have a strong correlation with energy efficiency. However, their impact is not proportional, since electricity is generated and consumed regionally, whereas CO_2 emissions, have a global impact. There may be unnecessary energy use in the industrial sector in the order of 20-40%.

In automotive manufacturing industries, they consume high energy due to the processes of manufacturing. Organizations within the automotive manufacturing sector are placing important emphasis on efficient energy consumption due to the steady increase of energy prices and negative environmental impacts caused by

energy consumption. Governments and companies are both determined to discover the most efficient procedures to enhance energy efficiency in manufacturing processes.

While today's automotive manufacturing facilities are modern and relatively efficient, there is significant opportunities remain to reduce energy demand through better energy management, technology innovation, and research and development (R&D). The benefits could be great in conservation of energy, and will be less impact on the environment, and an enhanced competitive position for the automotive industry.

There are many opportunities to reduce energy use where vehicles are manufactured, as well as in supplier operations. Among these are developing more efficient technologies and materials, implementing best energy management practices, and increasing use of energy resources such as waste heat. There are also opportunities to use alternative energy resources such as hydrogen, biomass, solar, geothermal, and wind to provide power and heat for manufacturing operations.

Figure 1.1 shows that Malaysia Motor Vehicle Production was reported at 485,186.000 Unit in Dec 2020. This records a decrease from the previous number of 571,632.000 Unit for Dec 2019. Malaysia Motor Vehicle Production data is updated yearly, averaging 501,986.500 Unit from Dec 1997 to 2020, with 24 observations. The data reached an all-time high of 614,664.000 Unit in 2015 and a record low of 128,571.000 Unit in 1998. (International Organization of Motor Vehicle Manufacturers).

In Malaysia, the energy uses per capita shows increasing trend. It was related to the production of motor vehicle. The trending graph are shown in Figure 1.2.

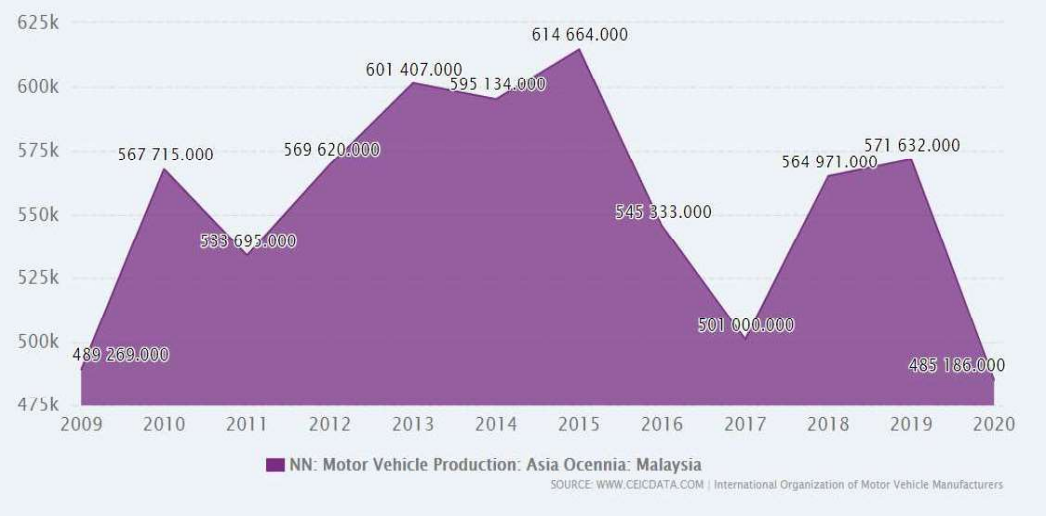

Figure 1.1 Malaysia's Motor Vehicle Production from 2009 to 2020

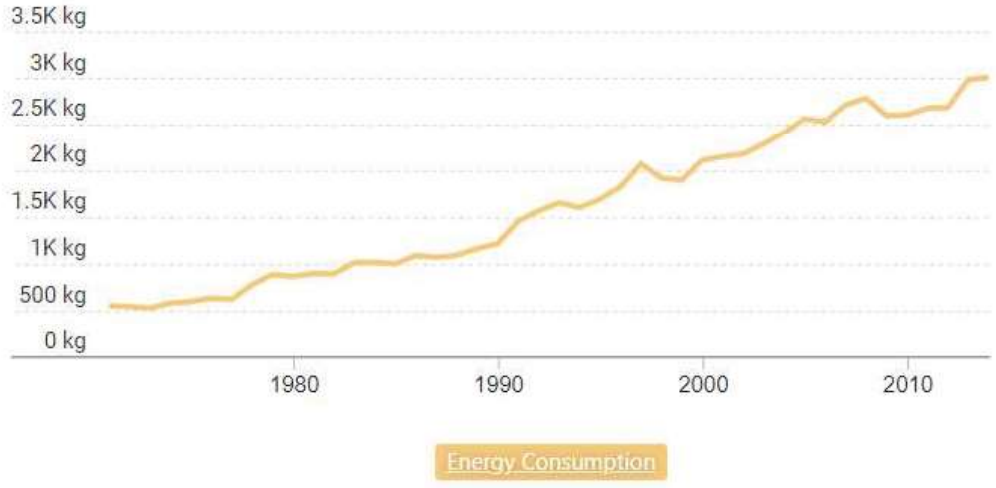

Figure 1.2 Energy use (kg of oil equivalent per capita) in Malaysia

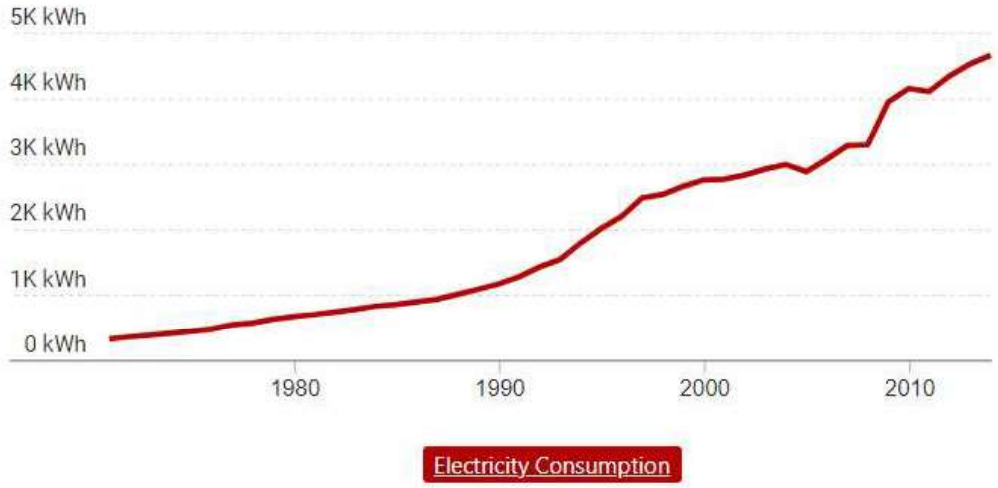

Figure 1.3 Electricity consumption per capita in Malaysia

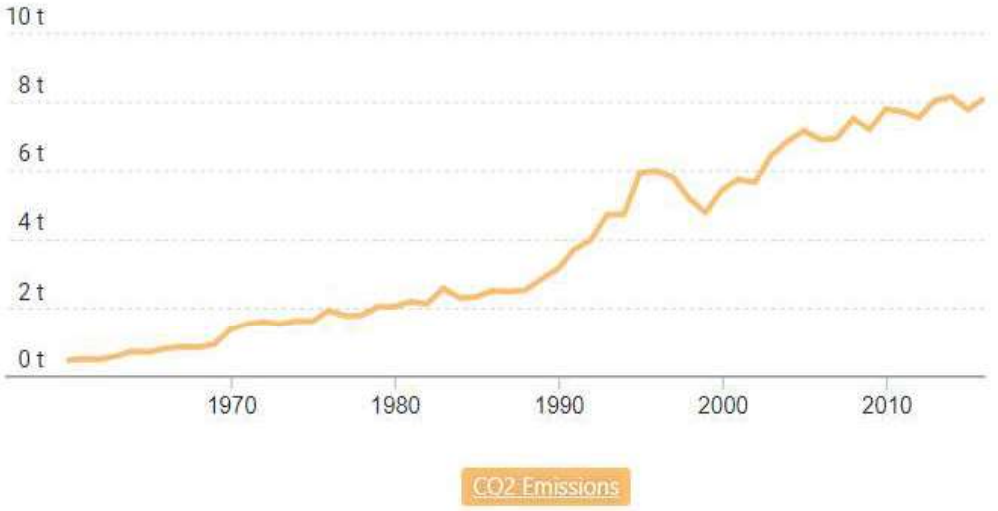

Figure 1.4 CO_2 emissions per capita in Malaysia

Figure 1.3 and 1.4 shows the electricity consumption CO_2 emissions per capita in Malaysia and the In Malaysia, the main policy that governs the energy sector in Malaysia which the overall energy policy was formulated in 1979 (National Energy Policy 1979) with broad guidelines on long term energy objectives and strategies to ensure efficient, secure, and environmentally sustainable supplies of energy. The National Energy Policy 1979 has identified three objectives, which are:

I. The supply objective

The Supply Objective was aimed to ensure the provision of adequate, secure, and cost-effective energy supplies through developing indigenous non-renewable and renewable energy resources using least cost options and diversification of supply sources both from within and outside Malaysia.

II. The utilization objective

The early stage of the utilization objective was to focus on providing electricity to as many residents as possible.

III. The Environmental Objectives

This objective was intended to minimize the negative impacts of energy production, transportation, conversion, utilization, and consumption on the environment. All major energy development projects are subjected to the mandatory environmental impact assessment requirement outlined in the national environmental policies such as the National Policy on the Environment 2002. The environmental objective has strong pressure from the rapid energy demand growth in Malaysia.

The focus in this research is energy efficiency goals for the automotive industry. Energy efficiency is a key factor in the automotive industry. Production plants of Original Equipment Manufacturers (OEM) in this sector are in a global competition within their corporation. Headquarters expect top level quality, on time delivery and great flexibility at competitive costs from their production plants. Because energy consumption at average OEM car production plant is high, energy costs are high too. Hence, energy efficiency became a relevant issue to be discussed especially paint workshop and body shop are highly energy intensive areas of production.

Therefore, in this research report, automotive manufacturing plant of Hicom Automotive (Manufacturers) Sdn Bhd has been use as case study. The first process is describing the trends, structure, and production of the automotive industry at Hicom Automotive manufacturing plant. Then, describe the main production processes. Following with summarize the energy use in vehicle assembly plants and its main end uses. Hicom Automotive Manufacturer plants has a few units of operations which consist of New Paint shop (NPS) building, Commercial Vehicle Operation (CVO), Current Paint shop (CPS), Volkswagen Operation (VWO), Shared Service Operation (SSO) including Facility Management Office, IT Department, Safety Health and Environment Department, Purchasing Department, Human Resources Department and Admin Department, Mercedes Benz Operation (MBO), and Mitsubishi Motors Operation (MMO).

Finally, the discussion on energy efficiency opportunities in vehicle assembly plant will be made to identify the suitable energy saving measures that can be implemented to help these automotive industries to improve on its energy consumption and energy saving.

1.2 Problem Statement

This research aimed to identify possible energy recovery opportunities currently unexploited or not effectively exploited in automotive manufacturing plants which could further increase economics and sustainability of the manufacturing process. The identification of energy recovery opportunities as presented in this review is the first step towards potential exploitation of innovative technology for the industry.

The research on sustainability of environment towards automotive industry will be conduct by focusses on sustainability, energy efficiency, heat recovery, environmental impact, energy consumption modelling, painting, low carbon related to the automotive industry.

Most of parts and components will be delivered from outside suppliers. All the required components and parts arrive at the assembly line right in time as scheduled

before they get assembled. As usual most of the automotive assembly plants usually are divided into five major departments. The assembly line considered in this study line has five important departments: (1) body shop, (2) paint shop, (3) assembly shop (trim-chassis-final), (4) rectification shop and (5) material logistics department.

The material logistics department receives inventory, ensuring they match the purchase order specifications, and applying receipt and storing procedures. The main function is to receive and deliver parts for the weld, assembly, and paint departments on a 'just in time' basis. The body shop produces complete welded car bodies from supplied panels. The car body then moves through a series of spot-welding operations, both robotic and manual, to assemble the body. The car bodies are then moved into the paint shop, where a series of processes are performed to paint the car body. The painted car bodies are then transported to assembly shop for trim-chassis-final. Finished passenger cars are then finally transported to motor pool area for storage before shipping to the business dealers.

Figure 1.5 below shown the summary of the logistical flow of the vehicle manufacturing process, the flow of materials, from inventory (parts and components) arrival to a finished passenger car (stored in the motor pool).

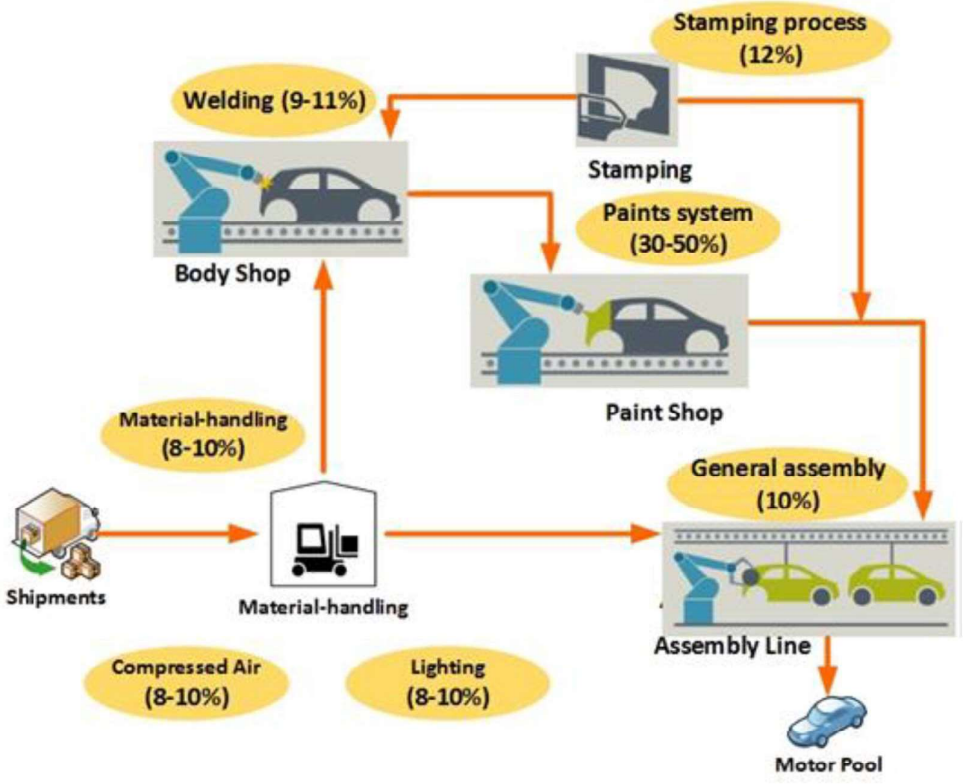

Figure 1.5 Logistical flow of the vehicle manufacturing process

1.3 Research Objective

The main objectives of this study will be as follows.

1. To compare and identify the most efficient operation system based on low cost and energy consumption for vehicle manufacturing process.

2. To improve the energy efficiency on automotive manufacturing industries and strategies towards sustainability.

1.4 Scope and Significant of Study

1.4.1 Scope of Study

In order to implement this research, a careful consideration of the scope of study are identified and defined as below.

1. Performing state of analysis on each different operation plant of vehicle production process in automotive industry.
2. Identifying parameters of energy efficiency opportunities from current systems in Hicom Automotive Manufacturing Sdn Bhd.
3. Performing data collection from actual manufacturing process in Hicom Automotive.
4. Performing total energy consumption based on data collected.
5. Comparing and analysing results of different operation plant of production process to identify the most energy efficiency improvement based on low cost and energy consumption.

1.4.2 Significant of Study

Through this research, it can contribute positively to the Hicom Automotive Manufacturing Sdn Bhd based on the output that obtained. This benefit is described as below;

1. This study shall be able to help automotive industries to improve on its energy consumption by propose the improvement measures.
2. An improved energy efficiency system and vehicle production process will be able to save a lot in terms of cost, and electricity consumption.
3. The research finding will lead to an enhanced the energy efficiency with reduced energy wastages as well as increased productivity rate.

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