

# CONCEPTUAL MODEL OF SUSTAINABLE LEAN AND GREEN MANUFACTURING MANAGEMENT SYSTEM: INITIAL STAGE

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## Abstract

*The concept of lean and green manufacturing management has recently gained interest among the researchers and practitioners in the area of manufacturing management because it can promote good business sense and being environmentally friendly at the same time. The manufacturing process in automotive industry is exceptionally challenging, characterized by increasing complexity and significant relationship with the deterioration of environment. This paper proposes a framework for a sustainable lean and green manufacturing management system with specific emphasize on the automotive industry. The framework consists of a conceptual model which focuses on the initial stages in moving towards planning, design and implementation phases of sustainable lean and green manufacturing management system.*

**Keywords:** *Lean manufacturing; green manufacturing; environmental sustainability; automotive industry.*

## Abstrak

*Konsep pengurusan pembuatan langsing dan hijau semakin mendapat perhatian pengkaji dan pengamal bidang pengurusan pembuatan kerana ia memberi faedah dari segi perniagaan dan alam sekitar pada masa yang sama. Proses pembuatan dalam industri automotif adalah industri yang sangat mencabar kerana ia semakin kompleks dan menyumbang kepada kemusnahan alam sekitar. Artikel ini mencadangkan satu kerangka untuk sistem pengurusan pembuatan langsing dan hijau yang mapan dengan penumpuan diberikan terhadap industri automotif. Kerangka ini terdiri daripada satu model konseptual yang berfokuskan kepada peringkat permulaan dalam usaha menuju kepada fasa-fasa perancangan, reka bentuk dan pelaksanaan sistem pengurusan pembuatan langsing dan hijau yang mapan.*

**Kata kunci:** *Pembuatan langsing; pembuatan hijau; persekitaran mapan; industri automotif.*

## Introduction

As Malaysia is moving in the direction of environmental sustainability, the Malaysian government has emphasized more on the green technology adoption. Hence, under the 10<sup>th</sup> Malaysia Plan, the Malaysian government has proposed a fund of RM1.5 billion to promote the green technology in 2010 through the National Green Technology Centre (Mohd Najib Abdul Razak, 2009). Although, this technology may give positive impacts on environmental

sustainability, it always involves high cost, high level of knowledge sharing and a clear comprehensive framework which enforces the need for a proper planning, design and implementation, which is effective and efficient (Tiwari, 2010).

Green technology is defined by Kementerian Tenaga, Teknologi Hijau dan Air (KETTHA) as “the development and application of products, equipment and systems used to conserve the natural environment and resources, which minimizes and reduces the negative impact of human activities” (KETTHA, 2011). However, before we try to implement this technology, we need to have a clear picture and brief understanding of the knowledge associated with it. This paper will glance on the theoretical framework associated with the adoption of environment sustainability component into the automotive industry. Prior to this, we will review some of the theory background which includes lean and green manufacturing management and sustainable elements in order to build the conceptual model for sustainable lean and green manufacturing system.

### **Lean and Green Manufacturing Management**

Lean Manufacturing Management (LMM) is a philosophy of manufacturing that focuses on delivering the highest quality product at the lowest cost on time. It is a systematic approach to identifying and eliminating waste through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection (Schroer, 2004). In the other hand, Green Manufacturing Management (GMM) is a management system that contains only required resources and materials, manufactures only required quantity of quality products on time that meet customers’ demands, and aims to reduce environmental impact (Allwood, 2011).

Perhaps the most important element for a company to practice GMM is to execute Environmental Management System (EMS) into their business operations. The United States Environmental Protection Agency defines EMS as “a set or system of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency” (Rendell & McGinty, 2004). An EMS integrates environmental management into the organization’s overall management system by identifying the policies, environmental targets, measurements, authority structures and resources necessary to produce both regulatory compliance as well as environmental performance (EPA, 2003). A continual improvement cycle is established through this process. There are plenty model or conceptual framework for EMS but the most famous and well accepted model is ISO 14001 standards. ISO 14001 is indeed an ideal measure for EMS in such that it is general enough to apply to any business environment, yet specific enough to assure that the right set of policies and procedures are in place to drive green waste reducing activity.

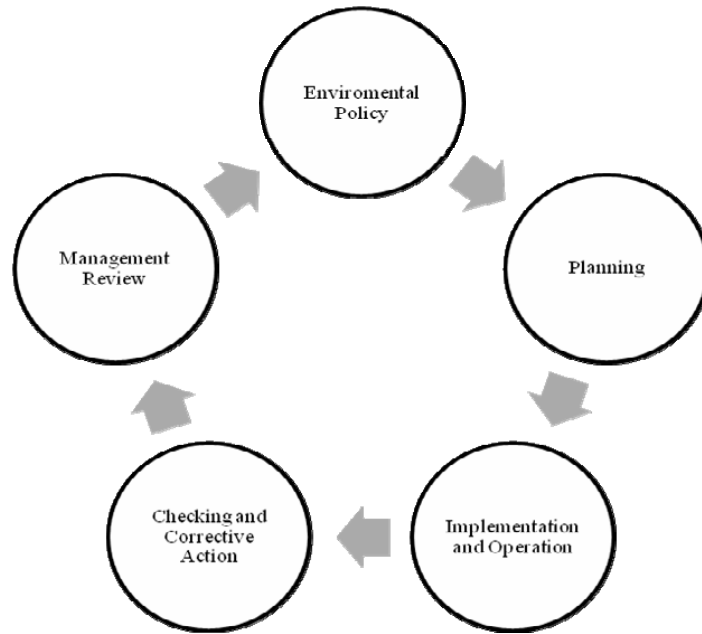


Figure 1. EMS Continual improvement cycle

Based on EMS concept, we review several well-known framework/models introduced in GMM body of knowledge. Russo (2001) conducted a study to determine the influence of EMS using ISO 14001 standards towards the electronic industries' environmental performance which was measured in terms of toxic emissions. His main finding shows that there is significant correlation between the electronic manufacturing plant/facilities that applies ISO 14001 and increased environmental performance. Meanwhile, Melnyk, Stouffe and Calantone (2003) explored the effect of EMS have on the implementation of environmental options on operations performance. They found out that the presence of certified EMS significantly reduced overall cost and lead time, and therefore increased quality. Based on these two studies, we conclude that EMS and ISO 14001 is crucially essential for company to practice GMM. Notice that these studies exclude the essence of Lean Manufacturing Management (LMM) practiced by most of the companies today.

Majority of the study conducted shows that the 'waste elimination' thinking of LMM is consistent with the philosophy of 'pollution reduction' in GMM. The definition of waste in LMM can be suited with the inclusion of environment waste in GMM. This is supported with the studies of Florida (1996), Rothenberg (2001), King and Lenox (2001) and Environmental Protection Agency (EPA) (2003), Sawhney, Teeparakul, Aruna and Li (2007) and Bergmiller and McCright (2009) which proved that the company which practices Lean are more likely to exhibits better enviromental performance. Hence, we conclude that it is pretty irrelevant to exclude LMM philosophy in order to develop a better GMM framework.

### **Lean and Green Manufacturing Theoretical Framework**

Here, we review the studies which combines LMM and GMM concept together. Florida (1996) investigated the connection between advanced manufacturing practices which includes LMM and environmental performance. He concluded that company which applied advanced

management techniques (e.g. the use of teams, technology investment, process improvement, involvement of suppliers and customers, pursuit of zero waste, involvement of all types of employees) are heading towards minimizing environmental waste. This study indicated that these techniques are associated with both LMM and GMM. Rothenberg (2001) focused on the case of the automotive industry where the study illustrated that lean manufacturers are proven to be more energy efficient than non-lean manufacturers thus making them 'greener'. King and Lenox (2001) demonstrated that ISO 9000 (International certification for Total Quality Management Systems) certified manufacturers with low inventories of hazardous materials have lower emissions of toxic chemicals. However, this study assumed that ISO 9000 standards are equivalent with LMM concepts where this assumption may not be true. In addition, EPA (2003) showed that the Boeing's LMM program reduced environmental waste as a byproduct of process efficiency and quality improvements.

More recently, Bergmiller and McCright (2009) concerns on the relationship between lean and green where they believed that lean manufacturers transcend to GMM. They proposed a comprehensive Lean and Green framework which fills the gap of all previous LMM model and GMM model. The study developed an improved framework of LMM namely, Advance Lean System Model and GMM framework namely, Advance Green System Model before combining it into their Lean and Green framework. These three frameworks were developed and classified under three main categories which are Management Systems, Waste Reducing Techniques, and Business Results. In spite of this, the current unresolved debate in the body of knowledge is the true nature of association between LMM and GMM. The major question still exist whether Lean and Green should be addressed as parallel, complementary, transcendence or synergy elements (Bergmiller & McCright, 2009).

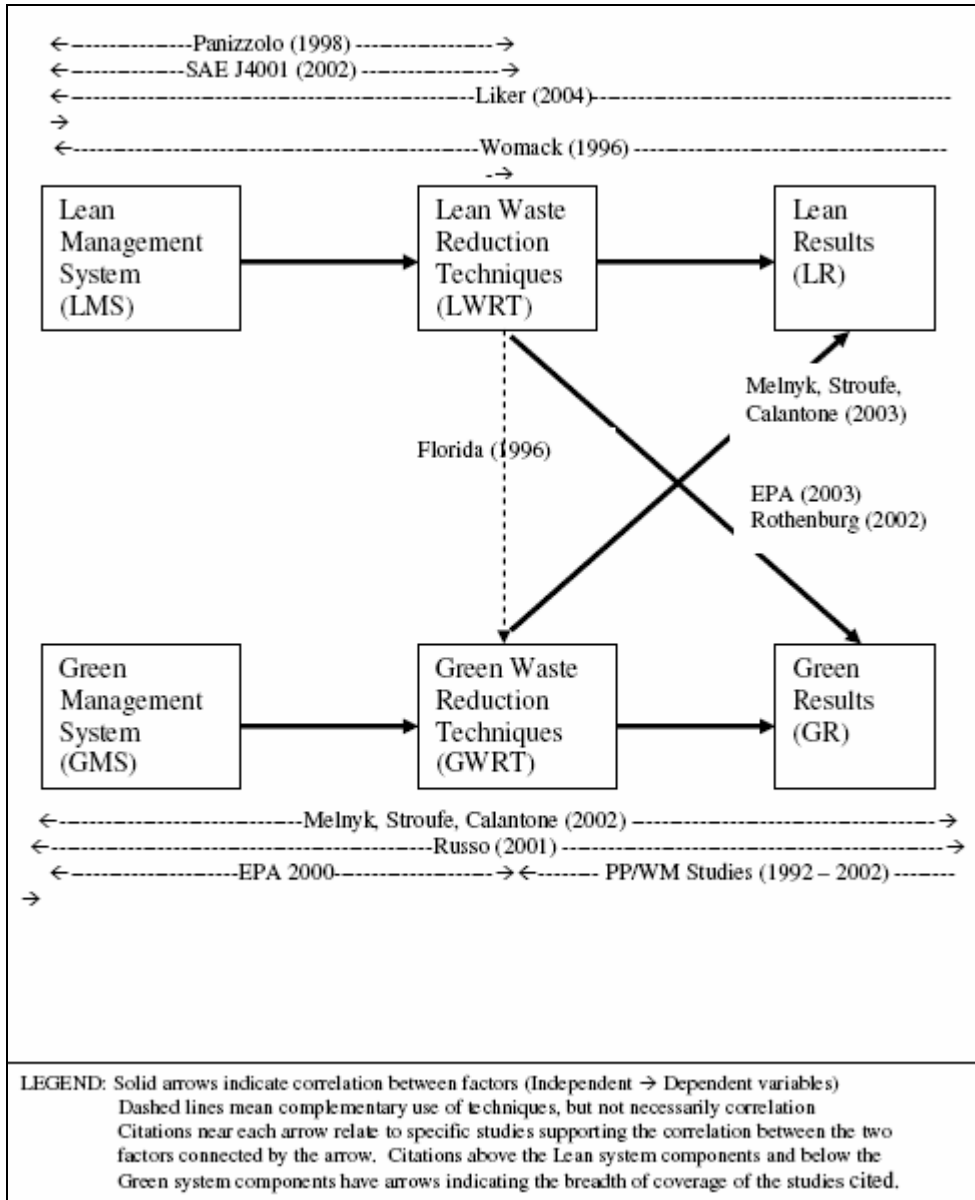


Figure 2. Lean and green framework (adapted from Bergmiller 2006)

Every literature mentioned in this section managed to prove to us the significant inter-relationship between LMM and GMM. Based on our analysis, they agreed on the combination of lean and green will contribute to environmental sustainability. However, none of the literatures include the elements of sustainability into their theoretical framework. Currently, sustainability is seen as a factor, the drive or even as the product of lean and green manufacturing management. In this paper, we would like to highlight the importance to include the theory and the knowledge of sustainability in the framework of lean and green manufacturing.

## The Concept of Sustainability

The concept of sustainability has become increasingly apparent as the ecological crisis has been further linked to human activities and, similarly, the environmental catastrophe was clearly correlated with the economic, social, political, and cultural crises. Because natural, economic, and social systems are all interdependent, it is logical that they must all be addressed when creating sustainable solutions to the environmental crisis (Mebratu, 1998). The most well accepted definition was given by the United Nations as:

"The development that meets the needs of the present without compromising the ability of future generations to meet their own needs which contains two key concepts:

- 1) The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
- 2) The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."

Due to its integrated nature, sustainability has been classified into three inter dependent and mutually reinforcing pillars of economic, social, and environmental (Peets & Watts, 1996; United Nations, 2005).

Economic sustainability focuses on the section of the natural resource base that provides physical input, both renewable and exhaustible, into the production process. Environmental sustainability focuses more on the physical aspects which takes into the consideration of production process, emphasizing environmental life-support systems such as atmosphere, water, and soil. Social sustainability addresses poverty and human development. Environmental sustainability, or the maintenance of the life-support system, is the predominant prerequisite for social sustainability (Goodland, 1995; Goodland & Herman, 1996; Khalili, 2011)

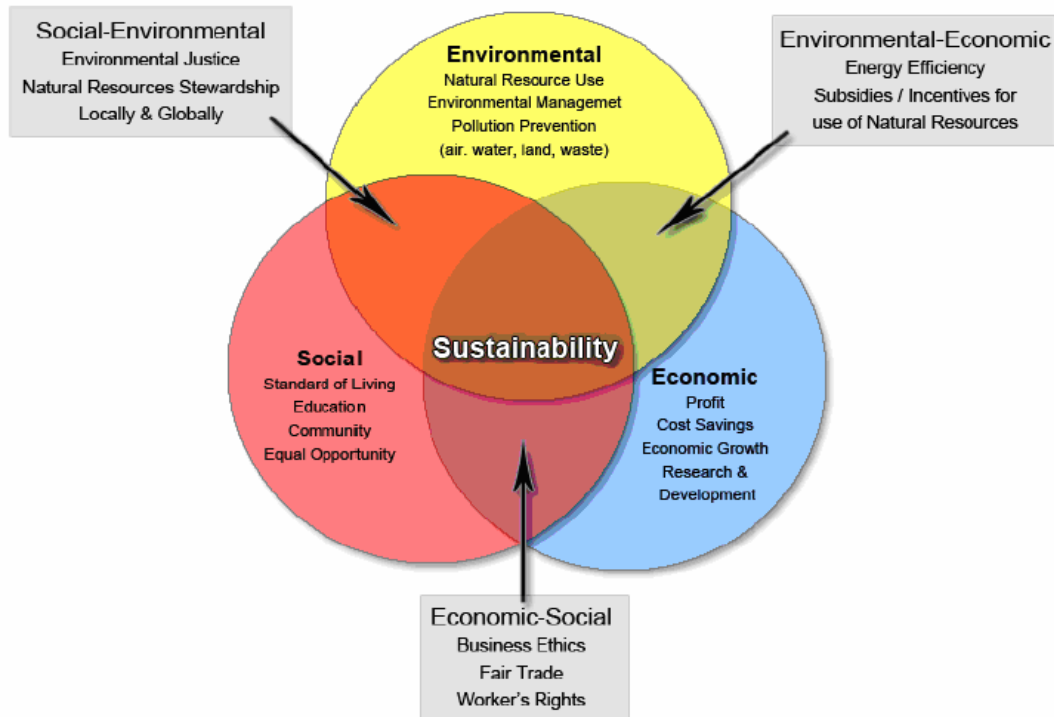


Figure 3. The three spheres of sustainability

The concept of sustainability accounts for a more comprehensive approach in improving the environmental health as it looks from three different perspectives (Khalili, 2011). In designing a framework for the direction of sustainable development, we must identify the drawbacks of the existing system. The industries that generate incomes are changing from being resource based to knowledge based. Technological change has encouraged a shift in manufacturing production from western industrialized nations to plants in Asia and Latin America (Gutowksi, 2006; Bell & Cheung, 2009). As the manufacturing industries have direct and indirect relationship with these three spheres of sustainability, the inclusion of the sustainability elements is indeed necessary for the lean and green manufacturing management framework.

### Automotive Industry and Environment

The current global automotive industry has evolved since 100 years ago starting with standard mass assembling of Fordism, followed by customized, vertically integrated mass production industry of GM's productive model, and went through the lean manufacturing system which also can be known as Toyotism. In present, it faces its fourth generation which is 'Green' revolution (Wad, 2009). In light to conserve the environment through reducing harmful emissions and consuming less non-renewable resources the automotive world is making strides in producing environmentally friendly cars.

Pioneered by Toyota, hybrid technology was embarked by combining combustion engine with an electric engine. In addition to the hybrid electrical vehicles (HEVs), new technologies included plug-in hybrid electrical vehicles (PHEVs), electrical vehicles (EVs) with battery-based electrical

propulsion (BEVs) and with plug-in mechanism (PEVs), and finally fuel cell electrical vehicles (FCEVs) based on hydrogen (Chanaron 2009). The technological revolution is evolving from hybrid electrical vehicles to electrical vehicles and eventual hydrogen fuel cell technology. However, it was estimated that it will take 20 years to have an invulnerable EV technology. Thus, many automakers still continue improving the fuel efficiency and reducing hazardous emission (Just-auto, 2009).

According to the Malaysian Automotive Association (MAA), the local automotive industry is expected to hit another all-time total industry volume (TIV) high of 618,000 units in 2011 as the positive trends continue this year. Although, the environmental-friendly hybrid car were only sold for 120 units in 2010, the fact that the Malaysian Government recently announced the exemption of excise duties of hybrid car and the rising fuel price, have become push factors for the rapid increasing demand of hybrid car in 2011 (Mahalingam, 2011). The fact clearly shows that Malaysia is also moving towards environmental sustainability, specifically via automotive sustainability itself.

## **Discussion and Conclusion**

Malaysia is making a huge step en route for environmental sustainability, where the usage of green technology is a necessity. The application of green technology in the field of manufacturing management can be demonstrated by the concept of sustainable lean and green manufacturing management. In the meantime, the manufacturing of the automotive industry is always related with the deterioration of the environment due to the raw material usage, energy usage, fossil fuel dependency and indispensable waste (Ing, 2007; Tiwari, 2010; Sinha, 2010). Based on this challenge together with the mission to accomplish business goals, the concept of sustainable lean and green manufacturing management can be best applied as an alternative to the organizations to improve their overall performance.

This paper intends to promote the ideas and the knowledge behind sustainable lean and green manufacturing management and to show its benefits to the researcher and practitioner of the manufacturing management. Based on the theory and the knowledge of each aspects of LMM, GMM and sustainability development, a conceptual framework will be suggested as a continuation from this paper. This conceptual framework hopefully may help the decision makers in related organizations particularly, the automotive industry to have a clear understanding regarding this matter.

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