A Study of Green Factory Practices in Malaysia Manufacturing Industry

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***Abstract*— Green Factory is a management tool for eliminate environment burden such as waste, chemical and pollution. Economic development grew too fast has effected major impact to environment. Carbon dioxide, loss of biodiversity, degradation of natural resources, global warming, ozone layer depletion and deforestation have effected on the environment. Based on world statistics, Malaysia has produced 29 million tonnes carbon dioxide and ranked 26th (0.66%) of the 215 countries in the world. 110 world leaders including Malaysia has agreed to work for reducing carbon dioxide gas in the Copenhagen Climate Change Summit 2009. Five main criteria for Green Factory have been identified; (1) Solar power generation systems, (2) Fuel cells system, (3) Cogeneration systems, (4) Air conditioning units and (5) Recycling system. A study was conducted to manufacturing companies that adopted Green Factory practices to assess its their green practices for minimizing environmental problems. The samples were 300 companies in Malaysia. Finally, 20% response rate has been received, with 60 respondents. Based on descriptive result, recycling shows the highest level of practices, followed by solar power cogenerations system, air conditioning units and fuel cells system. This study result shows Green Factory has significant relationship with environment performance (r=0.684, P<0.05) and business performance (r=0.510, P<0.05). Overall, the survey result shows green factory practices has significant impact on Malaysia manufacturing companies. In conclusion, Green Factory can be used as effective tool for improving not only for environment performance but also for business performance.**

***Keywords*—** *Total Quality Management, Green Factory and Malaysia Manufacturing Companies.*

1. Introduction

Environment issues is a challenging to the world society in recent years as a result of many pollutions and unstable climate occurred. Environmental awareness amongst world society are growing in importance for them to live healthier, greener and more environmentally friendly in standard of living. Green Factory is an effort to control and reduce the environmental impact in the manufacturing sector. Based on [1], control is very important to reduce waste of resources and curb unnecessary spending at every stage of operations. In particular, each plant should develop a plan and strategy to reduce the environmental impact in their production activities such as reducing carbon dioxide (CO2), waste

generation, water and releasing chemicals to the environment. The scoring system for Green Factory was introduced in 2008. The aim is to enhance the level of implementation measures throughout manufacturing plant. Under this system, the plant rated themselves on a scale of one to five across 19 items of environmental activities which classified into six basic groups; (1) reduction of emissions, (2) improving environmental performance, (3) reduced activity, (4) risk reduction, (5) development and human resource management and (6) visualize progress to address any issues and improvements [2]. In 2014, this system has been upgraded to allow each plant to implement its own assessment which is more effective to measure the impact and environment burden in their company [3].

Nowadays, the environmental impact is considered an important and strategic for business operations with aiming to reduce costs and develop products which are better quality and environmentally friendly [4]. Green factory is not only viewed as environment management tool but also improving business performance. The scope of Green Factory starts from development of a product until entire product cycle which involves practices such as eco-design, cleaner production, recycling and reuse [5]. The main focus of these practices is reducing expenses associated with the production, distribution, consumption and divestment [6]. Malaysia has enjoyed a favorable socio-economic development and the success has been recognized by the international community. Economic development grew rapidly had major implications to environmental change in Malaysia. The manufacturing industries are the economy's main source of growth in Malaysia. However, industrialisation has negative effect on the surroundings due to the increase in the pollution, waste and consumption of natural resources. Global warming effects the world climate change arising because of instability of carbon dioxide emissions. Emissions of carbon dioxide is produced by burning fossil fuels such as coal and petroleum and natural gas. Based on data from the Carbon Dioxide Information Analysis Center, (2010), fossil fuels is a major source of carbon dioxide emissions in the world and reached 74% of total emissions. According to Giri, (2008), carbon dioxide is also the highest gas emissions by 70% compared to other gases. Fossil fuels is used in many activities such as production, processing and combustion for electricity generation or for other industrial purposes. In addition, this study also discusses the weaknesses of ISO 14000 implementation which has many deficiencies to deal with environmental problems. Many non-profit government organization (NGO) believes that ISO 14000 is too general in addressing environmental problems because of limited criteria established while the rest is based on organization initiatives [7].

'Green' is defined as generation of the maximum value under least impact on environment such as energy consumption and pollution. This refers to resources and energy efficiency as well as efficient production [8]. In addition, the implementation of Green Factory is an effort to control and reduce the environmental impact and energy consumption in the manufacturing sector. According [9], there are five main criteria in the implementation of the Green Factory; (1) Solar power generation systems, (2) fuel cells system, (3) cogeneration systems, (4) air conditioning units and (5) recycling system.

Solar Power Generation Systems

Solar energy is one of renewable energy system and the most environmentally friendly method to generate electricity. Developing countries such as Asian countries have experienced rapid growth over the past two decades and this led to high demand for electrical energy consumption in domestic market [10]. According to Kusakabe, (2008), one of the method to overcome the problem of energy generation is to use solar energy as an alternative energy as well as solar energy does not cause pollution to the environment.

Fuel Cells System

Fuel cells system is a power source that use and apply in power generation. This alternative way use hydrogen from hydrocarbon fuels [8]. Fuel cell technology has developed into a most significant energy source for future. Fuel cell systems acts as an electrochemical device that is capable of converting energy into electricity and heat without combustion. Basically, fuel cells system acts like batteries but it do not run out or need to be recharged. It produces energy in the form of electricity and heat as long as fuel is supplied [11]

Cogeneration systems

The cost of high energy consumption has directed many industries and commercial buildings reduce their energy consumption. Cogeneration system is combination between electricity generation and thermal energy to generate economic power. Cogeneration is a known technology for energy conservation in industry [12]. According Sevencan et al., (2008), co-generation system of power and heat generation can do together and save energy in economic advantage as well as generate low-carbon power generation.

Air Conditioning System

Air conditioning system involves high energy consumption. In addition, consumer need to know

minimal surrounding for their comfort to reduce the negative impact to the environment. Air conditioning system must use an appropriate temperature, which is not too cold in reducing energy consumption and environmentally friendly [7]

Recycling System

Recycling refers to a way conversion from waste generation by human activities to material that can be used or exploited in different way (Kusakabe, 2008). Process of recycling and reuse of materials are the best method for reducing the quantity of waste and saving disposal waste to landfill [13]. According to [7], recycling has positive impact on healthy environment, reducing pollution, cost, resource, energy and forests.

Green Practices

Green practices refers to activities which protect the environment and nature in development and application of products, equipment's and systems. In addition, the purpose of green practices is to minimise negative effects of human activities. Based on Authors, green practices refers to the act or operation of a product, equipment or system to meet criteria which minimise negative environmental impact, low emissions of greenhouse, safe to use and provide a healthy environment. There are four major factors in implementation of green practices, namely energy, environmental, economic and social [4]. Energy consumption should be at the minimum level to meet green practices which seek to reduce dependence on energy and promote energy efficiency. Green practices also has significant impact on the environment with minimising burden to the environment. In addition, green practices promote application of new green technology and contribute to economy development.

The hypotheses in this study are;

H1: There positive relationship between green criteria and environment performance.
H2: There positive relationship between green criteria and business performance.
H3: There positive relationship between green practices and environment performance
H4: There positive relationship between green practices and business performance.

2. Methodology

A seven-point Likert scale have been applied in the instrument for collecting data. The instrument has been validated by the experts in green practices. First, pilot study have been conducted and then revisions have been made for improving the instrument. Based on Federation of Malaysian Manufacturers (FMM) and the foreign companies' directory list in Malaysia, 300 companies have been selected for final survey. The selected companies were based on ISO 14001 certification. The target respondents are manager involving in green practices in the company.

3. Result

Based on 300 surveys, final received response is 65 surveys which equal to 21.6% of response rate. However, 5 surveys have been excluded because of missing value issue. The final usable question is 60 which equal to 20.0%.

Descriptive Result

Based on Table 1, mean scores for the main criteria Green Factory is 4.0233 which shows moderate levels of practices. Recycling shows high level of practices, followed by solar power cogenerations system, air conditioning units, solar power system. However, fuel cell system shows low level. The highest in the criteria is recycle, followed by the air conditioning unit system, cogeneration systems, solar power generation and fuel cell systems. The lowest rank is fuel cell systems.

Table 1: Descriptive result for Green Factory Criteria

Criteria	Min	Std deviation	Level	Rank
Solar power generation systems	3.4867	1.61827	Moderate	4
Fuel cells system	2.2233	1.58257	Low	5
Cogeneration systems	3.8500	1.54552	Moderate	3
Air conditioning units	4.2400	1.06456	Moderate	2
Recycling system	5.3167	0.93177	High	1
Overall	**4.0233**	**1.34853**	Moderate	

Based on Table 2, mean scores for green practices is 5.29 which shows high levels of practices. Energy saving, material savings and energy saving shows high level of practices. The highest in the practice is energy saving, followed by material saving and water. The result shows there are no significant difference amongst the practices.

Table 2: Descriptive result for Green Factory practices

Practices	Min	Std deviation	Level	Rank
Energy saving	5.4167	0.74587	High	1
Material saving	5.3867	0.75722	High	2
Water saving	5.0600	0.83670	High	3
Overall	**5.2878**	**0.77993**	High	

Correlation Result

Based on Table 3, the result shows Green factory has significant relationship with environment performance (r=0.404, P<0.05) and business performance (r=0.38, P<0.05). Based on environment performance, recycling systems shows the highest relationship (r=0.652, P<0.05), followed by cogeneration system (r=0.425), solar power generation system (r=0.416), air conditioning unit (r=0.280, P<0.05) and fuel cell system (r=0.247, P<0.05). Based on business performance, recycling systems shows the highest relationship (r=0.539, P<0.05), followed by solar power generation system (r=0.468, P<0.05), cogeneration system (r=0.390, P<0.05), and fuel cell system (r=0.211, P<0.05) and air conditioning unit (r=0.187, P>0.05). This result shows that recycling system is the most important criteria in green factory. It is not only improve environment performance but also business performance. The second important is solar power generation systems. The least important is fuel cell systems which author believed it is new technology and it takes some investment for implementing it rather than other criteria.

Based on green practices result, the result shows Green factory practices has significant relationship with environment performance (r=0.684, P<0.05) and business performance (r=0.510, P<0.05). Based on environment performance, energy saving shows the highest relationship (r=0.736, P<0.05), followed by water saving (r=0.698) and material saving (r=0.618). Based on business performance, water saving shows the highest relationship (r=0.590, P<0.05), followed by energy saving (r=0.490) and material saving (r=0.450). The result shows Green Factory practices is well implemented in Malaysia manufacturing companies.

Table 3: Correlation result between Green Factory criteria and Performance

			Performance	
			Environment performance	Business Performance
Green Factory creteria	Solar power generation systems	r	0.416**	0.468**
		p	**0.001 (Sig)**	**0.000 (Sig)**
	Fuel cells system	r	0.247	0.211*
		p	**0.057(Not Sig)**	**0.056 (Not Sig)**
	Cogeneration systems	r	0.425**	0.390**
		p	**0.001 (Sig)**	**0.002 (Sig)**
	Air conditioning units	r	0.280**	0.187
		p	**0.030 (Sig)**	**0.153 (Sig)**
	Recycling system	r	0.652**	0.539**
		p	0.000 **(Sig)**	0.000 **(Sig)**
Total			**0.404**	**0.379**
Green Factory practices	Energy saving	r	0.736**	0.490**
		p	**0.000 (Sig)**	**0.000 (Sig)**
	Material saving	r	0.618**	0.450**
		p	**0.000 (Sig)**	**0.000 (Sig)**
	Water saving	r	0.698**	0.590**
		p	**0.000 (Sig)**	**0.000 (Sig)**
Total			**0.684**	**0.510**

4. Discussion

This study result shows Green Factory has significant relationship with environment performance (r=0.684, P<0.05) and business performance (r=0.51, P<0.05). Overall, the survey result shows Green Factory practices is well implemented in Malaysia manufacturing companies. This finding has rejected the misperception of Green Factory practices which only for improving environment performance and not for business performance. The Green Factory has significant impact on energy, material and water saving which contributes to reduce cost of manufacturing operation.

5. Conclusion

This study proved that Green criteria and practices has significant relationship towards environment performance and business performance.

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