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Impacts of energy management practices on energy efficiency and carbon emissions reduction: A survey of malaysian manufacturing firms

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ABSTRACT

Carbon dioxide (CO_2) is the most prevalent Greenhouse gas (GHG) produced by human activities. Industrialization has been among the primary factors for increased CO_2 production, mostly through the consumption of electricity and the burning of fossil fuels. To investigate the current practices of energy management in Malaysian manufacturing firms, this study collected survey data from ISO 14000 certified firms. The study found that energy management practices are still very much in their infancy, and concern for carbon emissions is limited in the Malaysian manufacturing context. A lack of competitive pressure for developing environmentally friendly management practices generally prevails among industrial firms, although marginal improvements in energy management practices and energy efficiency are evident. The study found that energy audit and energy efficiency are two critical factors for reducing carbon emissions. The study also found that energy awareness, knowledge, and commitment are related to energy efficiency. One key outcome of the study was the development of a new theoretical model of energy management practices. The findings of this study have opened new research and development opportunities to identify alternatives to monetizing environmental concepts such as carbon emissions and energy efficiency.

1. Introduction

Atmospheric CO_2 concentration levels have been rising since tracking began in 1958. The data show that the burning of fossil fuels contributes about 67% of the total worldwide of CO_2 emissions into the atmosphere today. CO_2 is absorbed partly by the world's oceans, but, as emissions have climbed, the resultant acidification of those same oceans is increasingly leading to ecological and biological changes while the continuously rising atmospheric concentration leads to global warming and climate change (Cubasch et al., 2013). While CO_2 is not the only greenhouse gas contributing to the problem, it is the most abundant greenhouse gas produced by human activities (IPCC, 2005).

CO_2 is classified as a greenhouse gas and is created as a by-product of consuming non-renewable fossil fuels such coal, petroleum and natural gas as energy sources (Thollander et al., 2007). Environmental damage from CO_2 emissions leads to climate change, which further exacerbates economic risks from severe weather events such as floods that can, in turn, lead to the disruption of the supply chain and operational losses (Halldórsson and Kovács, 2010). The threat of economic loss and destabilization of global supply chains due to global warming and climate change has created a vested interest by both governments and the public to become aware of the downsides of unmanaged CO_2 emissions (Dincer, 1999). Because of the evaluation of the environmental and economic costs (Lam et al., 2010), international agreements on climate change have been signed. One example is the Kyoto Protocol and Intergovernmental Panel on Climate Change (IPCC), which created a commitment to reducing greenhouse gases emissions for the signatories.

Because evidence points to rising energy consumption as a primary cause of increased CO_2 production, managing energy efficiency is one key to creating more sustainable economic growth while simultaneously minimizing environmental and social impacts (Saboori et al., 2012). On the one hand, energy has been a critical driver of economic activities and rising energy consumption has traditionally been seen as a sign of strong national economic growth (Tugcu et al., 2012). On the other hand, evidence shows causal links between energy consumption and environmental and social health degradation. Some nations have been wary of making severe changes that upset the balance between economic growth and the well-being of its citizens and the environment (Ang, 2008).

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One pathway to achieve both goals is utilizing sustainable energy consumption practices that either slow or eliminate environmental degradation so that the earth's natural carbon sinks have the chance to re-absorb some of the CO_2 emissions in the atmosphere. Doing so will prevent further melting of the polar ice caps or degradation of biological diversity from acidification of ocean waters (Cubasch et al., 2013). Manufacturing and industrial activity are among the primary consumers of energy and thus responsible for a large part of the world's CO_2 emissions (Abdelaziz et al., 2011). As a result, political and social pressure has grown on industrial firms to re-examine their practices considering energy awareness and strive towards greater energy efficiency (Okereke, 2007). According to Yuan et al. (2016), external factors such as legal protection, policy guidance and fiscal incentives are the main measures to promote the development of energy performance contracting.

Energy usage and management have substantial impacts on the sustainable development of manufacturing firms and enhanced energy efficiency is critical (Gahm et al., 2016). Energy efficiency improvement has been touted in several studies as the most cost-effective way to help preserve the environment and, simultaneously, provide cost savings and reputational boosts to a firm. However, several researchers have found that energy efficiency holds a low priority when firms make investment and management decisions, due to economic and technical barriers (Palm and Thollander, 2010; Thollander et al., 2007; DeCanio, 1998). Many firms do not voluntarily participate in carbon or energy management and require clear policies or financial incentives to do so. Several studies about counteracting the reluctance of firms to adopt a more environmentally friendly stance have been conducted. Such studies have examined the efficacy of tightening regulations (Larsen et al., 2012), creating punitive regulations, certifications (Bunse et al., 2011), raising awareness or developing technical capabilities (Bradford and Fraser, 2008). Other external pressures involving strategic decisions in energy management include rising energy prices, risks to energy security, or market rejection of non-environmentally friendly goods (De Groot et al., 2001; Bunse et al., 2011).

External pressure to conform has been studied extensively under institutional theory, which states that firms will only consider changing their organizational practices based on pressure that works to either limit or expand the acceptance of new practices (Darnall et al., 2009; Darnall et al., 2010). In this sense, a recent surge in the adoption of ISO 14000 standards among manufacturers has been the result of customer pressures driving sustainable manufacturing (Jovanović and Filipović, 2016). The tightening of regulations in European nations has also driven some to export their carbon footprints to Asia (Schaltegger and Csutora, 2012). The opening of new markets is ripe for manufacturing firms to engage in and create differentiation from their competitors via cleaner practices, improve technology and manufacture new products (Subramanian and Gunasekaran, 2014). Yet, even with all these pressures, manufacturing firms have not fully adopted environmental considerations in their manufacturing operations.

Research studies have shown that industrial adoption of energy efficiency has lagged, and some companies have exhibited low organizational and managerial commitment to supporting innovation and investment into energy efficiency. Largely, this has been the result of factors such as limited technical knowledge (Plambeck, 2012), lack awareness for identifying the potential benefits of energy saving (Bunse et al., 2011), lack of motivation by decision makers to break predefined processes that risk operational losses (Tonn and Martin, 2000) or by employees seeking to avoid change (Kannan and Boie, 2003).

Although the benefits of energy efficiency have been well studied, such study, however, has mostly been done in the context of developed nations including the Netherlands (Phylipsen et al., 2002), Sweden (Thollander et al., 2007) and Germany (Kannan and Boie, 2003). In Asian countries, CO_2 emissions are only just gaining interest over economic development as environmental degradation and human health issues have become more apparent to the public (Rao and Holt, 2005).

While pressure is mounting to account for CO_2 emissions in manufacturing, firms often find that implementing effective carbon reduction programs is difficult, partly due to the complexity in determining the sources and causes of excessive carbon emissions (Nakajima et al., 2014) and partly due to the lack of visible direct financial benefits (Schaltegger and Csutora, 2012), This is true especially for smaller firms with low energy intensity (Lee, 2012) unless conclusive evidence can prove the benefits of such a reduction for the sustainability of the firm (Cote et al., 2008). Even though energy management standards represent good practice, appropriate models are often lacking for best energy performance practices (Jovanović and Filipović, 2016). This lack of models for best practices and empirical studies for energy management with respect to manufacturing firms is particularly severe in emerging countries.

This deficiency was among the motivations for this current study. This study was conducted among Malaysian manufacturing firms in part because the government has encouraged industry to participate in reducing carbon emissions. The Malaysia Energy Efficiency Action Plan presents a strategy for a well-coordinated actions and guidelines for cost-effective implementation of energy efficiency measures in the industrial, commercial and residential sectors. The hope is that this policy will lead to reduced energy consumption and economic savings for the consumers and the nation (KeTTHA, 2014). Along this line, governmental programs were launched to encourage energy intensive manufacturing firms to perform energy audits under the auspices of the Malaysian Industrial Energy Efficiency Improvement (MIEEIP) Programme, partially funded by the United Nations Development Programme (Akker, 2008). Because of these audits, several key barriers were identified that have prevented wide-spread adoption of energy efficient practices These included: 1) low energy prices; 2) a lack of finance for energy efficiency; 3) a lack of an overall national plan for energy efficiency; 4) a lack of a champion to drive energy efficiency; and 5) a lack of consistency in embarking on energy efficiency (KeTTHA, 2014).

Based on low interest of the manufacturing industry in being actively involved in the national energy efficiency program, this study investigates the current practices of energy management in the manufacturing industry and environmental outcomes such as energy efficiency and lower carbon emissions. The findings of this study contribute to further development of theoretical knowledge about energy management and low carbon emissions management. It also strives to provide practical contributions, which may then be applied to production processes and distribution in industry.

This paper has the following sections. The first section highlights the motivation for the study. The rest of the paper is structured as follows. A review of the Malaysian manufacturing greenhouse gas emissions is first discussed and the major variables are then articulated. Then the development of hypotheses is discussed and related to the theoretical model. The next part describes the sampling method and the data collection procedure. This is followed by the analysis of the data and the results. The conclusions, theoretical contributions, managerial and social implications are also presented. Lastly, the constraints and challenges are presented to provide suggestions for improvements and for future research.

2. Literature review

2.1. Malaysian manufacturing greenhouse gas emissions

The primary cause of greenhouse gas emissions in Malaysia manufacturing firms can be traced to three sources: 1) electricity consumption, 2) the direct combustion of fuels in the manufacturing process and 3) fuel consumed in logistical activities (Hosseini et al., 2013). Efforts in the past to reduce carbon emissions through government sponsored programs such as the Malaysian Industrial Energy Efficiency Improvement Project have managed to reduce 0.3% of the total industrial