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Factors influencing the energy intensity of automotive manufacturing plants

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ABSTRACT

Intensifying market pressure, new legislations, increasing environmental consciousness and rising energy prices are a major concern for manufacturing companies worldwide. Especially the energy demand in manufacturing and consequently the energy costs and related environmental impacts of production are in focus of decision makers. In this context, multi-national companies like automotive manufacturers are interested to know how a specific plant performs in comparison to others and which factors influence its energy performance. Against this background, this paper provides an insight how the multiple linear regression approach can be used to identify and quantify factors influencing the energy intensity of automotive plants. The presented model aims at supporting strategic decision making and forecasting of the future energy demand of an automotive plants.

1. Introduction

The global energy consumption has been steadily increasing over the past decades and will continue to do so, as the International Energy Agency (IEA) forecasted in its world energy outlook (International Energy Agency, 2012: 341). Thus, energy demand and energy efficiency are in focus of governmental and non-governmental organizations. A variety of legislations like the Energy Efficiency Directive in the European Union (European Parliament, Council of the European Union, 2012) and Energy Savings and Industrial Competitiveness Act of 2013 in the USA (113 th US Congress, 2013) have been passed. These legislations aim at promoting a lower energy intensity in all economic sectors, e.g. commercial, transport, residential and industrial sectors and raise the pressure to lower their energy demand.

Especially the industrial energy demand which accounted for over 50% of the world's total energy consumption in 2011 is getting into focus of the company stakeholders like the owners, the public and employees (International Energy Agency, 2015). This demand for energy is fulfilled by fossil fuels with a share of over 80% in 2010 (International Energy Agency, 2012: 51). Based on rising energy demand and due to the depletion of natural resources industrial energy prices have been increasing between 2004 and 2012 by 60% within the OECD countries (International Energy Agency, 2013: 39). In addition to the economic impact of energy consumption the environmental impact by using non-renewable fossil resources is an increasing concern to the public. Especially greenhouse gas emissions driving climate change are in focus of society. The consequences of climate change are described in a report by the intergovernmental panel on climate change, among these consequences are extreme weather conditions, rising water levels and melting of polar caps (Field et al., 2014: 12).

The described market/society push and policy pull as well as implementation of environmental programs as part of companies' strategies brings energy efficiency on the table of industrial managers. Through energy efficient manufacturing a reduction of energy costs, increasing competitiveness and decreasing environmental burdens can be accomplished. To achieve energy savings, energy and environmental strategies were introduced in a number of companies in recent years (Albino et al., 2009: 2–5). These strategies often include the introduction of an energy management system. Requirements and guidelines for such a management system are described in the norm Energy Management Systems ISO standard 50001:2011 (ISO, 2011: 12). A main goal of an energy management system is to reduce the overall energy demand of the organization. To achieve this goal it is necessary to

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know the important factors which influence the overall energy performance of manufacturing plants (Gesellschaft Energietechnik, 2003).

These developments in terms of more energy efficient manufacturing push companies to improve their EnPI (energy performance indicator) continuously. In this context automotive manufacturers are also pressured to lower the energy intensity of their production and to reduce CO_2 emissions. In the automotive industry, energy costs account for approximately 9–12% of the total car manufacturing costs (Fysikopoulos et al., 2012: 1). Therefore, these companies are not only affected by the demand for more sustainable production by its stakeholders but also have a chance to reduce costs. That is especially interesting in competitive market environments. This competition results in a need for differentiation compared to their competitors (Marschner, 2004: 1–4). As an example of the rising competition in Fig. 1 (WardsAuto InfoBank, 2015).

The diversity has been growing from 5 major car companies to 14 companies which together account for a market share of more than 90%. This increasing competitiveness is not only reality in the US but also in other markets like the European or German market where new companies from Asia raise their market shares (Hüttenrauch and Baum, 2008: 52). Because of these increasing market pressures, rising energy prices and the legislative developments, the need for energy efficiency improvement in car manufacturing is apparent. To improve the energy intensity of car manufacturing the external and internal factors with an impact on the energy performance have to be known. Thus, there is a need for quantifying these factors to cope with possible negative impacts and predict the energy intensity of new automotive plants based on these influencing factors for setting future energy performance goals.

Consequently, the aim of this paper is to show a methodology for analyzing and quantifying internal and external factors influencing the energy intensity of automotive plants. To do so, the paper is structured as follows. In section 1 the introduction and context of this paper are presented. Section 2 gives a short overview of the current energy intensity of automotive companies and developments in research. In the following section 3 the general methodology is shown, whereas the application of this methodology is shown in section 4. A short summary and outlook is given in the last section of this paper which shows also further research possibilities.

2. Energy key performance indicators in the automotive industry

2.1. Energy intensity of automotive plants and companies

As indicated above, for original equipment manufacturers (OEMs) in the automotive sector, energy intensity of their production is of increasing importance. Therefore, measuring and improving energy intensity becomes an essential task. One approach towards improving the energy performance of a company is the implementation of an energy management system. To implement such a management system it is necessary to define an energy performance indicator (EnPI), to set goals and to improve this indicator (ISO, 2011: 13). Most OEMs have chosen the energy intensity ratio as an EnPI; this ratio is defined by the energy consumed by a company, brand or factory divided by a specific metric, e.g. cars manufactured or revenue in a certain time period.

$$EnPI = \frac{Energy\ Consumed}{Metric\ Unit} \quad (1)$$

This indicator is mostly presented to the public on an annual basis in a company's sustainability or environmental report. According to the Global Reporting Initiative guidelines, used voluntarily by most automotive companies, these reports should include a variety of energy and environmental indicators (Global Reporting Initiative, 2013: 93).

Based on a review of environmental reports, Fig. 2 gives an overview on the range of energy intensity as typical EnPI in the

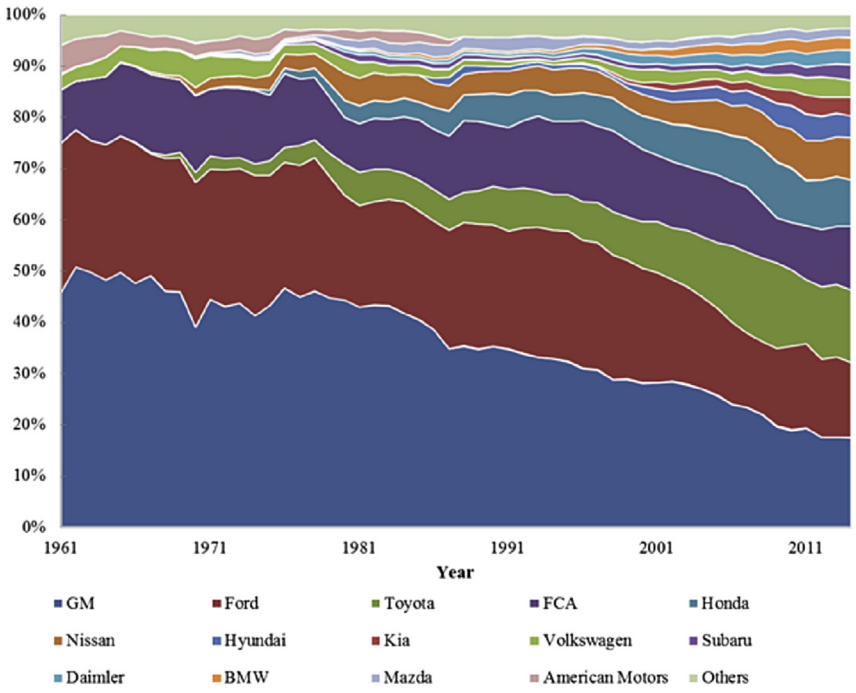

Fig. 1. Market share of automakers in the US 1961–2014 (WardsAuto InfoBank, 2015).

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