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An Investigation of Drivers for Industrial Energy Conservation – A Step Towards Sustainable Industrial Development in Pakistan

Muhammad Tahir Hassan *

Abstract *The industrial sector of a country is considered to be one of the most significant contributors to its economic and social growth. Pakistani industrial sector has been suffering from energy deficiency due to energy crises for the last two decades, and as a result, its performance has been badly affected. The current performance of this sector can be increased by the adoption of energy conservation measures (ECMs) which would lead to economic, social, and environmental benefits. This paper explores the significant drivers for the adoption of ECMs in manufacturing SMEs of Pakistan. It also evaluates the relative significance of these drivers in various contexts and provides a foundation to determine where to address effective policy efforts accordingly. For the investigation of a possible correlation of significant cited drivers with the type of industry (variable), a one-way ANOVA analysis and Tukey posthoc tests are also carried out.*

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Introduction and Background

Energy plays an important role in most human activities and global developments. Easily accessible supply of energy is one of the key determinants of the social and economic development of a country. Along with the modern and developed human lifestyle, the requirement for energy has also been increased to maintain the world's social and industrial activities. Most of the global energy requirement is fulfilled by fossil fuels which are not only limited in nature but also produce severe environmental impact. Moreover, the uneven distribution of their reserves around the globe has created energy security issues in many developing countries. Pakistan is one such country that has been suffering from energy security issues for almost two decades. The country is facing a significant gap in the demand and supply of electricity and natural gas. In 2018, the electricity shortfall touched 6000 MW to 7000 MW and was managed by 4-5 hours of forced load shedding (Lin et al., 2019).

The relationship between the utilization of energy in various ways and its impact on the environment plays a fundamental part in concerns regarding sustainability. The share of energy used by industries all over the world is estimated at around 40% resulting in more than 35% of CO_2 emissions results in a substantial amount of addition in greenhouse gases (Worrell et al., 2009). The use of industrial energy varies across countries and depends upon the degree and combination of various economic activities and industrial advancement.

The Industrial sector in Pakistan uses more than 37% of its total primary energy (see figure 1). Meanwhile, a huge amount of energy is lost during various industrial processes resulting in a significant degradation in its level of operational productivity (Asif, 2009). The currently ongoing energy crises in the country also severely affected Pakistani industries by disruption in the supply of electricity and natural gas (Asif, 2009). Due to the enormous use of energy in the industries, the industrial sector of Pakistan needs to focus on energy conservation and efficiency improvement for sustainable industrial development in the country.

*Assistant Professor, Department of Mechanical Engineering, Bahauddin Zakariya University, Multan, Punjab, Pakistan.
Email: tahirqureshi@bzu.edu.pk

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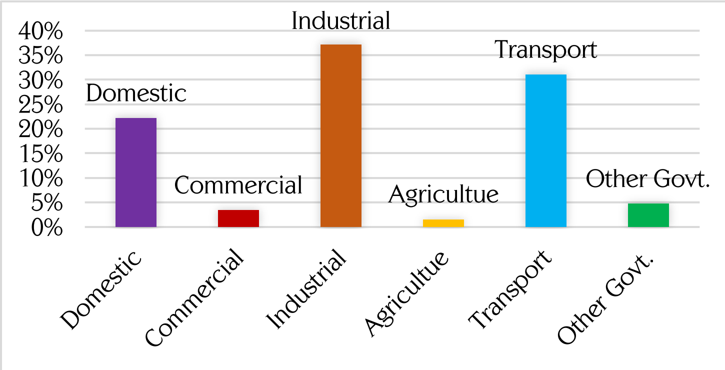

Figure 1: Energy consumption in Pakistan by sector (Hydrocarbon Development Institute of Pakistan., 2019)

Previous research points out that various driving forces can attract industries to introduce ECMs (Trianni et al., 2016). There are several factors that influence these drivers, such as people's responses to incentives (Steger & Bleischwitz 2011). In order to deal with finance-related barriers, several specific economic incentives are widely used (Trianni et al., 2016). Although a wide range of studies has been conducted in many countries to explore barriers, there are limited investigations of driving forces for ECMs (Brunke et al., 2014; Trianni et al., 2016). Trianni et al. (2016) suggested the need for various approaches to investigate drivers for improvement in industrial energy efficiency.

Sudhakara Reddy (2013) defined drivers as the factors that encourage energy efficiency investment. A similar explanation of drivers by Worrell et al. (2003) includes the factors encouraging the adoption of energy-efficient technologies.

Thollander & Ottosson (2008) made a notable contribution in this area and attempted to categorize drivers to industrial energy efficiency into different types according to their specific nature, such as market-related, organizational, energy policy-related and behavioural. They considered drivers as opposed to the barriers and defined them as factors that promote investments that will save energy and cost as well. In the light of previous research, Cagno & Trianni (2013) defined drivers as "*factors facilitating the adoption of both energy-efficient technologies and practices, thus going beyond the view of investments and including the promotion of an energy-efficient culture and awareness*".

A recent study (Trianni et al., 2016) attempted to highlight mutual relationships of barriers and drivers and defined drivers in a novel way as: "*factors promoted by one or more stakeholders, stimulating the sustainable adoption of energy-efficient technologies, practice and services, influencing a portion of the organization and a part of the decision-making process in order to tackle existing barriers*".

Methodology

The main objectives of this research work were fulfilled using a questionnaire-based survey. A total of 350 manufacturing SMEs were selected for the survey on a random basis in the following six sectors: light engineering, plastic products, ceramics, foundries, auto and spare parts and textiles. Light engineering SMEs include manufacturers of fans, washing machines, room air coolers, spin dryers, stabilizers, light fittings, heaters, electric geysers and oven manufacturing units. These six sectors were selected as representative of energy-intensive and non-intensive industries.

Table 1. Taxonomy of drivers adapted from Thollander & Ottosson (2008), Trianni et al. (2013), Cagno & Trianni (2013)

No.	Driving forces	Category	Origin
1	Cost reduction by decreasing energy use	Economic	INTERNAL
2	A long term energy strategy	Economic	

No.	Driving forces	Category	Origin
3	Energy efficiency advice through Seminars, journals etc.	Informative	
4	People with real ambition	Organizational	
5	Top management' commitment	Organizational	
6	Sustainable business	Organizational	
7	Improved working conditions	Organizational	
8	Environmental profile of company (ISO14001 certification)	Regulatory	
9	Easy access and support from energy experts	Informative	
10	Client/customer demand	Informative	
11	The threat of rising in energy price	Economic	
12	Competition from International Companies	Economic	
13	Energy efficiency investment loan schemes	Economic	
14	Subsidies for energy efficiency	Regulatory	
15	Tax exemption	Regulatory	EXTERNAL
16	Publicly funded energy audits	Regulatory	
17	Pressure from environmental NGOs	Regulatory	
18	Energy efficiency requirement by the Pakistani government	Regulatory	
19	Energy crises in the country	Regulatory	
20	Emission tax on energy use	Regulatory	

Data was collected from energy managers or other senior representatives responsible for energy issues in the companies. A total of 192 responses was received: light engineering 39, foundries 30, plastic products 34, textiles 29, auto and spare parts 28 and ceramics 32. The overall response rate was 55%, which is comparable with similar studies such as Thollander and Ottosson (2010) and Vicini (1998).

The questionnaires were based on previous similar studies such as those of Brunke et al. (2014) and Trianni et al. (2014) and some specific regional context. For the investigation of drivers for ECMs, a list of most relevant drivers was prepared, adapted and categorized according to their nature and origin based on previous studies such as those of Brunke et al. (2014) and Trianni et al. (2016) (see table 1). This categorization suggests the possible required action be taken for a particular driver by relevant stakeholders and the origin of the driving force, whether it will be within or outside of the organization.

Using a Likert scale, the respondents rated the potential drivers for ECMs in their organizations as extremely important (scored 1), very important (0.75), important (0.5), fairly important (0.25) or not important (0).

Results and Discussion

Figures 2 shows the results based on the responses regarding the perceived significance of driving forces for improvement in energy conservation measures (ECMs). In accordance with approaches used in similar studies such as Thollander & Ottosson 2008 and Brunke et al. 2014, the driving forces with average scores equal or greater than 0.5 are considered significant while the rest of the drivers having scored less than 0.5, may be regarded as less important.

Results reveal that the two most significant ranked drivers for the adoption of ECMs are: cost reduction by lowering the use of energy and the threat of a rise in prices of energy with an almost equal average score of 0.80 (see figure 2). More than 70% of respondents selected "Very important" or "Extremely important" options for both drivers, which are categorized as "Economic drivers". A similar result can be found in studies by Thollander & Ottosson (2008) in the Swedish pulp and paper industry and Lee (2015) in the Korean steel industry, which identified both drivers as highly significant for the implementation of ECMs.

Cost reduction by decreasing energy use is considered a prerequisite for the long-term survival of an enterprise. Companies driven to lower energy consumption can, in turn, successfully reduce the cost of production. Thollander & Ottosson (2008) found that implementation of this specific market-related driving force depends on the decision making by enterprises (Thollander et al., 2008). Similarly, with increased energy prices, companies may start thinking regarding energy cost in the overall production cost and be more open to reducing their energy use (Trianni et al., 2016). A driver, reducing cost by a reduction in energy use, may also be considered as a basic need for the long-term existence of a company (Thollander et al., 2008).

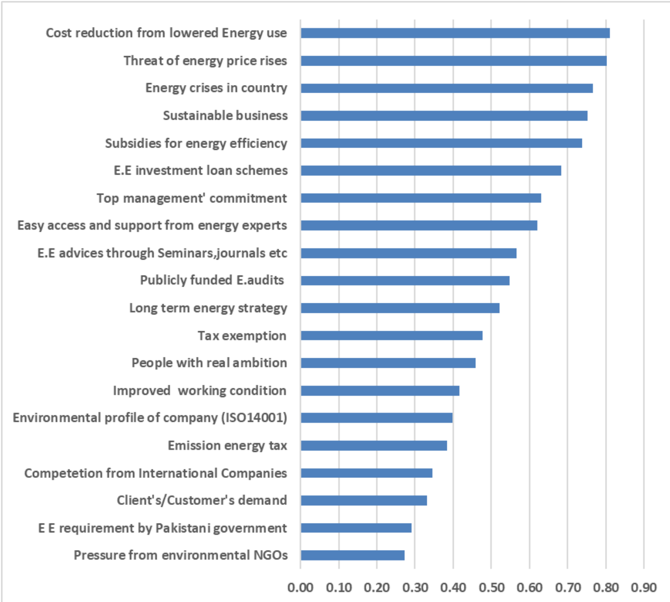

Figure 2: Ranking of Perceived Drivers for Industrial ECMs (Overall SMEs)

"Energy crises in the country" was considered as the third most significant driving force followed by "sustainable business" with averages scores of 0.77 and 0.75, respectively. These two specific drivers were included in the questionnaire taking into account the ongoing energy crises in the country that have badly affected the industrial sector of Pakistan (Khalil et al., 2014; Maaz Mufti et al., 2016). Due to a shortfall of energy, enterprises seem to be more inclined to save available energy. Batool et al. (2016) found that the growth of the manufacturing sector in Pakistan was significantly reduced due to the energy crises in the country. In this scenario, the survival of their businesses became a high priority, and enterprises started thinking to conserve and manage available energy.

The next significant perceived driver is "subsidies for energy efficiency" followed by "energy efficiency loan schemes" with average scores of 0.74 and 0.68, respectively. Both external drivers are in the regulatory category (see table 1). Allocation of funds to promote improved energy efficiency projects and development of the energy market is broadly acknowledged as an applicable driving force for energy conservation measures (Trianni et al., 2016).

"Top management commitment" and "easy access and support from energy experts" were perceived as seventh and eighths significant drivers for improved energy efficiency. Adoption of profitable ECMs is not often possible due to the less competence of firms (Trianni et al., 2016). Therefore, commitment and support from management is a significant driver for the execution of projects related to ECMs. The external driver, "easy access and support from energy expert", belongs to the category of informative driving forces. This particular driver is specifically relevant to overcome technical issues, such as long disruption in the production line during the installation of specific equipment

(Trianni et al., 2016). In this type of situation, easy access and support from energy experts can help enterprises to overcome such risks (Patrik Rohdin et al., 2007).

The next significant cited drivers include "energy efficiency advice through seminars, journals etc.", "publicly funded energy audits" and "long-term benefits". Trianni et al. (2016) highlighted the significance of education and training regarding the proper use of ECMs. Even after the implementation of ECMs, it may not be possible to exploit full energy-saving potential without appropriate awareness and required knowledge on the use of such measures. Cagno & Trianni (2013) suggested that internal programs of training conducted by enterprises may motivate a proper usage of energy-efficient equipment and improve the awareness and culture regarding energy efficiency.

Respondents perceived "publicly funded energy audits" as an important driving force with an average score of 0.55. This external drive is a type of regulatory driver that is directly dependent on public policies. According to Abdelaziz et al. (2011), external energy audits and sub-metering help enterprises examine their energy utilization pattern and point out zones where utilization of energy is possible to be decreased.

"Long term energy strategy" is an internal economic driver that has been frequently regarded as a significant driver for the adoption of ECMs in the literature (Brunke et al. 2014; Thollander & Ottosson 2008; Trianni et al. 2016 etc.). According to Trianni et al. (2016), this driver can help enterprises in encouraging energy efficiency investments and in making strategies and priorities for the successful execution of EM systems.

Figure 3 shows the average scores calculated by responses from SMEs for each category of driver. Results reflect that related economic factors were considered as the most significant driving forces by SMEs, with an overall average score of 0.63. Organizational drivers were perceived as the second most important factor (average score 0.56), followed by Informative (0.51) and Regulatory (0.48) drivers. It may be noted that apart from overall average scores, two Regulatory drivers, i.e., energy crises in the country and subsidies for energy efficiency, are highly ranked by SMEs with average scores of 0.77 and 0.74, respectively.

Overall results reflect that SMEs perceived the external driving forces to be more significant such as the threat of rising energy price, energy crises in the country, subsidies, investment loan schemes, external support from energy experts, energy efficiency advice and public-funded energy audits.

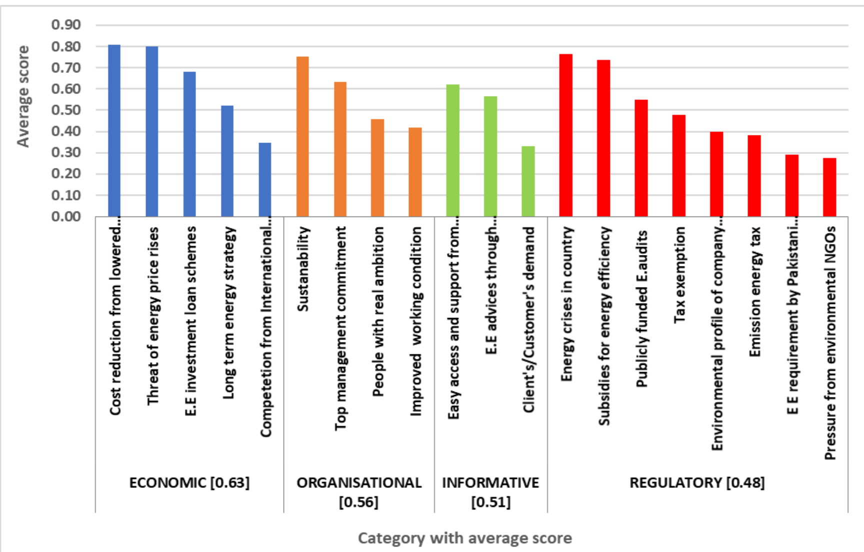

Figure 3: Significant perceived drivers according to categories (SMEs of Pakistan)

Drivers by the Industrial Sector

Figure 4 represents the differences in average scores (made by respondents) according to enterprises' types for significant ranked drivers.

There is little difference between the industry sectors in their perceptions, apart from the three drivers "environmental profile of company", "competition from international companies" and "client's demand". For these drivers, respondents from one sector (Textiles) considered them as significant with average scores of 0.6 or more, whereas the other sectors ranked them as much less significant with average scores of mostly less than 0.35.

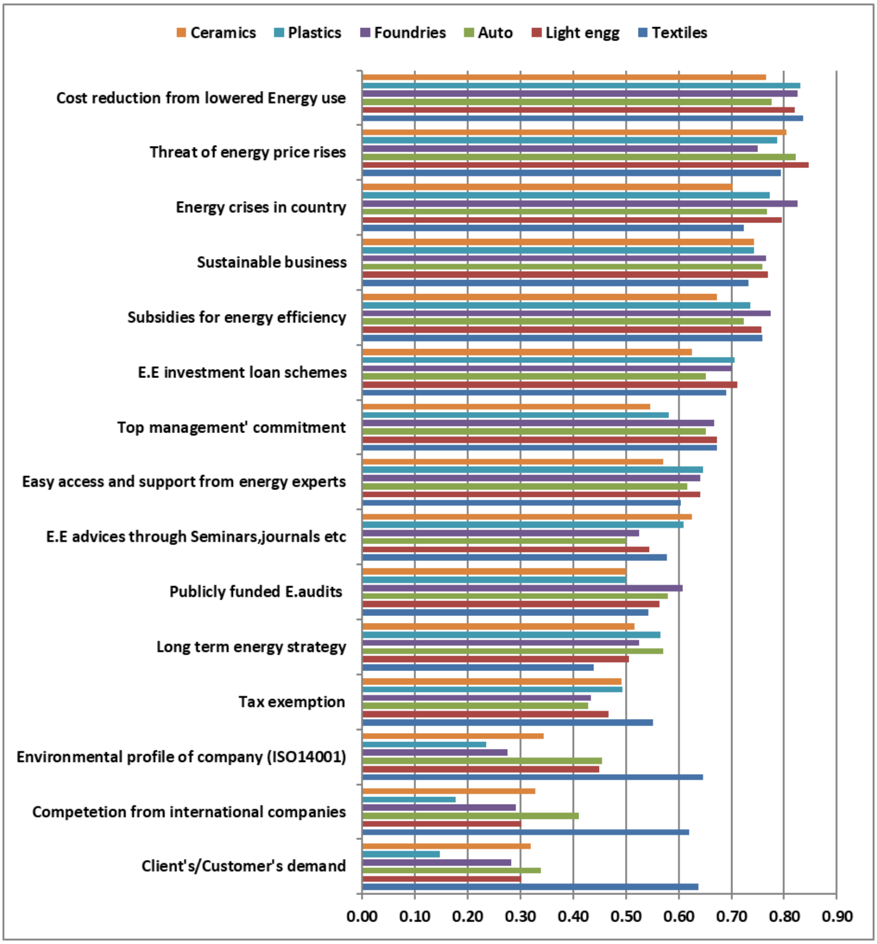

Figure 4: Comparative ranking of significant perceived drivers by enterprises' type

Results presented in figure 4 are validated by two statistical tests, namely the One-way ANOVA and Tukey post hoc tests. Table 2 highlights the drivers where the ANOVA F-statistic is greater than the critical value. In such a case, it demonstrates that the difference between categories (industry sectors) is statistically significant, and the associated p-value is the probability that this result would occur by random chance.

The ANOVA analysis shows substantial variances in three particular perceived drivers from the various sectors of SMEs where the p-value is calculated to be less than 0.05 and F-static is higher than F-critical (see table 2). These drivers include "client's requirement", "environmental profile of company" and "competition from international companies".

Table 2: Significant perceived drivers compared with enterprises' type (one-way ANOVA's df1, df2, F-statistic, p-value)

Perceived drivers	Enterprises' type df1=5; df2=186; F-critical=2.26 F-critical=2.26	
	F-statistic	p-value
Client's requirement	8.793	0.000
Environmental profile of company (ISO14001 certification)	6.819	0.000
Competition from International Companies	6.555	0.000

The Tukey posthoc test examines the differences further. It gives the mean differences in scores between each pair of industries and the probability of a chance occurrence (the p-value). Table 3 confirms statistically what is clearly visible in figure 4, the three drivers "environmental profile of company", "competition from international companies" and "client's demand" are regarded much more important by the Textile sector than the other industrial sectors. It should be noted that all the other ANOVA and Tukey posthoc results yielded non-significant results, i.e., with $p > 0.05$.

This suggests that the Textile sector operates in a different context than the other five industrial sectors. The drivers "environmental profile of company", "client's demand" and "competition from international companies" rank 8th, 9th and 10th respectively for the Textile industry, but much lower for the other industries. Overall, these three drivers were considered as less significant with average scores less than 0.4 respectively but were ranked highly significant (with average scores above than 0.6) by respondents of the Textile sector.

Strict environmental regulations at the potential market where companies intend to sell their manufactured goods, push enterprises to obtain environmental certification (ISO14000 etc.) and adopt energy efficiency measures (Waide et al., 2008). Pressure from NGOs and environmental organizations build public opinion regarding the company's environmental policy (Trianni et al. 2016).

Table 3: Comparison of highest ranked drivers by sector, based on Tukey posthoc test (Mean difference, p-value)

Perceived drivers (Dependent Variable)		Mean difference	p-value
Client's requirement	Textiles X Plastics	0.491	0.000
	Textiles X Foundries	0.355	0.000
	Textiles X Light Engineering	0.337	0.000
	Textiles X Ceramics	0.318	0.001
	Textiles X Auto and spare parts	0.299	0.003
Environmental profile of company (ISO14001)	Textiles X Plastics	0.411	0.000
	Textiles X Foundries	0.372	0.000
	Textiles X Ceramics	0.303	0.004
Competition from international companies	Textiles X Plastics	0.444	0.000
	Textiles X Foundries	0.329	0.001
	Textiles X Light Engineering	0.320	0.002
	Textiles X Ceramics	0.293	0.005

Bleischwitz et al.(2009) found that energy efficiency measures as a competitive tool among enterprises is a significant driver for the implementation of ECMs, and it makes energy efficiency issue of primary importance. According to findings of research in the European Foundry Industry by Thollander et al. (2013), keeping in view of international competition, enterprises started investing in ECMs to enhance their competitiveness. The two drivers, "client's requirement" and "environmental profile", maybe more relevant when companies are expected to highlight their green image.

One possible reason for variation in significance level for these particular driving forces may be that Textile is the major export-oriented sector in Pakistan with a contribution of 64% share in the country's exports (Abid, 2016) and accounts for up to 57 % of the GDP (Masood et al., 2015). It appears that all three driving forces highlighted here seem to be somehow specific to export concerns of the Textile sector while other sectors perceive these drivers as less significant.

Conclusion

In this study, most of the listed drivers and other criteria used were similar to those used by previous researchers, and so the results can be considered broadly comparable. Overall results showed that two economic-related drivers, such as cost reduction by decreasing energy use and the threat of a rise in the price of energy, are considered as the strongest driving forces by the SMEs. Regulatory and organizational factors are also perceived as highly relevant drivers, such as energy crises in the country, sustainable business, and subsidies for energy efficiency. In general, SMEs regarded external factors as of the highest importance for improved energy efficiency. A significant difference between the sectors in their perception is found for three drivers, i.e., the environmental profile of the company, competition from international companies and client's demand. These environment-specific factors were regarded as more important by export-oriented organizations, in particular the Textile industry. The results suggest that companies have started perceiving energy conservation measures as a promising field in order to improve their productivity. However, enterprises seem to welcome any external support from the Pakistani government in terms of technical assistance, subsidies, easy loan schemes and tax exemptions for energy conservation projects.

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